4 ENVIRONMENTAL CONSEQUENCES

4.1 ENVIRONMENTAL CONSEQUENCES ASSOCIATED WITH OCS OIL AND GAS ACTIVITIES

This programmatic environmental impact statement (PEIS) evaluates 8 alternatives, including no action (see Chapter 2). All of the action alternatives identify Outer Continental Shelf (OCS) Planning Areas in the Gulf of Mexico (GOM), Cook Inlet, and the Arctic where lease sales may occur under the 2012-2017 OCS Oil and Gas Leasing Program (the Program). Chapter 3 of this PEIS describes the nature and condition of natural and socioeconomic resources that have a potential to be affected by oil and gas (O&G) activities within those OCS Planning Areas under the Program. In general, O&G development follows a four-phase process, beginning with (1) exploration to locate viable deposits, (2) development of the production well and support infrastructure, (3) operation (oil or gas production), and (4) decommissioning of the well once it is no longer productive or profitable. Seismic exploration, geological, and hazard surveys are generally the first industry activities to occur during a new Program. Exploration drilling, development drilling, and platform installation typically begin several years after the first lease sale. Based on historical data, peak exploration drilling is expected to occur 5 to 10 years after the Program is approved, although a decreasing number of exploration wells will be spudded over the entire 40- to 50-year window of the Program. The peak in development drilling and platform construction operations generally lags the peak in exploration drilling, but also peaks within the first 10 years. Peak production associated with lease sales held under the new Program is expected to occur about 20 years after the Program's approval. The OCS activities potentially authorized under the new 5-year program will be occurring in context of comparable exploration and development operations pursued under previous 5-year programs, lease sales, and plan approvals. One lease sale only contributes to a relatively small percentage of OCS activity in the GOM at any given time (MMS 2007a). In 2009–2011, production was occurring as a result of 95–98 different lease sales, and exploration and development wells were spudded as a result of approximately 54–60 different lease sales.

Since lease- and project-specific details are not known at this time, the analyses in this PEIS take a programmatic approach and evaluate resources on a larger, more regional scale rather than at a lease-block scale (the scale at which project-specific impacts could occur). The evaluation of environmental consequences presented in this PEIS focuses on those resources most likely to be affected during future O&G development under each of the alternatives considered in this PEIS. Some information is currently unavailable or incomplete, such as a complete understanding of affected environment baseline changes in the GOM from the Deepwater Horizon (DWH) event, or the dynamic influence of climate change in the Arctic. However, this information is not essential in order to make a reasoned choice among alternatives at this programmatic stage (see Section 1.4.2, Incomplete and Unavailable Information). Exploration and development scenarios have been prepared that identify potential levels of O&G development that may occur as a result of lease sales in the GOM, the Cook Inlet, and the Chukchi and Beaufort Sea Planning Areas under the Program. These scenarios are presented for each alternative later in this chapter and are used for the programmatic impact analyses of this

PEIS. More detailed, location-specific impact analyses would be conducted in subsequent lease sale-specific National Environmental Policy Act (NEPA) analyses.

The programmatic evaluation of environmental or socioeconomic impacts presented in this PEIS provides useful information for considering the effects of O&G development on the resources of the OCS (and associated coastal environments) under each alternative. The programmatic analyses identify the types of activities that typically occur during exploration, development, production, and decommissioning; the resources that could be affected by those activities; and the nature and relative magnitude of effects those resources could incur.

4.1.1 Routine Operations and Common Impact-Producing Factors

Impacts from OCS O&G development originate from the specific activities that occur following OCS leasing, and both activities and impacts will vary by the phase of O&G development. In general, the major activity types under a given lease include exploration drilling, development drilling, and production of wells (see Table 4.4.1-1). The onset and timing of different activity types that may result from a lease sale in the Program will vary within and between planning areas over the 40- to 50-year life of the Program. For example, relatively more exploration drilling is expected to occur in the first 5–10 years of the Program, which will then be followed by relatively more development drilling and production later in the Program (see Section 4.4.1). Each phase will have a set of impact-producing factors (some unique to a particular phase) that represent O&G development activities that produce physical or environmental conditions that may affect one or more natural, cultural, or socioeconomic resources, and these may vary within each phase depending on the specific activity. For example, an impact-producing factor associated with exploration is noise, which will differ in its nature, magnitude, and duration depending on how it is generated. Noise generated by seismic survey equipment will differ in magnitude, frequency, and duration from noise generated during exploration well drilling or by ship traffic. The resources that could be affected by noise and the nature and magnitude of potential effects will also vary, depending on the source and characteristics of the noise (duration, frequency, magnitude) that is generated.

The nature, magnitude, and duration of each impact-producing factor (and any subsequent environmental effects) will also vary among the four phases of O&G development. For example, noise generated by seismic survey equipment will be relatively short term in duration but very high in magnitude, and will cease once the survey portion of the exploration phase is completed. Similarly, noise from the explosive removal of a platform during the decommissioning phase would be of very short-term duration (effectively a one-time event). In contrast, noise from ship and helicopter traffic that supports production platforms could be generated for 20 years or more, depending on the production lifespan of the platform. Table 4.1.1-1 presents the major categories of impact-producing factors associated with O&G development on the OCS. It is important to note that many impact-producing factors can be associated with multiple O&G development phases, and can be subject to mitigation measures to help reduce impacts.

TABLE 4.1.1-1 Impact-Producing Factors Associated with OCS O&G Development Phases

	O&G Development Phase				
	Exploration				
Impact-Producing Factor	Seismic Survey	Exploration Well	Development	Operation	Decommissioning
Noise	X	X	X	X	X
Seismic noise	X	X			
Ship noise	X	X	X	X	X
Aircraft noise	X	X	X	X	X
Drilling noise		X	X		
Trenching noise			X		
Production noise				X	
Offshore construction			X		
Onshore construction			X		
Platform removal					X
Traffic	X	X	X	X	X
Aircraft traffic		X	X	X	X
Ship traffic	X	X	X	X	X
Drilling Mud/Debris		*X*	*X*		
Bottom/Land Disturbance		X	X		
Drilling		X	X		
Pipeline trenching			X		
Onshore construction			X		
Air Emissions		X	X	X	X
Offshore		X	X	X	X
Onshore			X	X	X
Explosives					X
Platform removal					X
Lighting		X	X	X	
Offshore facilities		X	X	X	
Onshore facilities			X	X	
Visible Infrastructure		X	X	X	
Offshore		X	X	X	
Onshore			X	X	
Space Use Conflicts	X	X	X	X	
Offshore facilities	X	X	X	X	
Onshore facilities			X	X	
Accidental Spills		X	X	X	X

The following discussions summarize the general types of activities that may be expected during each of the four O&G development phases and identify likely impact-producing factors for each phase. These impact-producing factors, the resources that each may affect, and the nature, magnitude, and duration of possible effects are discussed in more detail in the resource-specific impact sections presented later in this chapter.

4.1.1.1 Exploration

During exploration, typical activities include the conduct of geophysical seismic surveys and possibly the drilling of exploration wells. During seismic surveys, one or more airguns (or other sound sources) are towed behind a ship at depths of 5–10 m (16–33 ft) and produce acoustic energy pulses that are directed towards the seafloor. The acoustic signals then reflect off subsurface sedimentary boundaries and are recorded by hydrophones, which are typically also towed behind the survey ship. Following analysis of the acoustic data, one or more exploratory wells may be drilled to confirm the presence and determine the viability of the potential hydrocarbon reservoirs identified by the survey. Drilling of an exploration well typically involves the use of a mobile offshore drilling unit (MODU) (such as a jackup rig, a semisubmersible rig, or drillship) and the placement of infrastructure (such as a drilling template and a blowout preventer) on the seafloor to aid in the drilling. Both the seismic surveys and exploration well drilling involve the use of ships, whether to tow airguns and hydrophones or to bring drilling equipment and other support materials to the well location.

Impact-producing factors associated with exploration include noise, ship traffic, drilling mud and debris, seafloor disturbance, air emissions, lighting, visible infrastructure, and space use conflicts (Table 4.1.1-1). Noise will be generated by operating airgun arrays, vessel traffic, drilling, and support aircraft traffic. Resources of primary concern from noise impacts are marine mammals, sea turtles, and fish.

Ship traffic during the seismic surveys or in support of exploration well development has the potential for collisions with marine mammals and sea turtles, while the presence of ship and support aircraft traffic could affect normal behaviors of nearby biota (especially marine mammals). The disposal of drilling mud and debris during exploration well development will also affect local water quality and possibly biota.

Exploration well drilling will involve seafloor disturbance, primarily through the placement of drilling support infrastructure. This disturbance may affect overlying water quality as well as benthic biota and archeological resources (if present). Air emissions from the MODUs may affect local air quality, while MODU lighting may affect birds and sea turtles. Depending on location, MODUs may also present a visual impact. The conduct of seismic surveys and exploration well development could conflict with other uses of the marine environment at that location.

4.1.1.2 Development

Once exploration has confirmed the presence of a commercially viable reservoir, the next phase of O&G development is the construction of the production platform and drilling of production wells. Temporarily abandoned exploration wells may also be completed for production. Production wells are drilled using MODUs, and the type of production platform installed will depend on the water depth of the site and, to a lesser extent, on the expected facility lifecycle, the type and quantity of hydrocarbon product (e.g., oil or gas) expected, and the number of wells to be drilled. The number of wells per production platform depends on the type of production facility, the size of the hydrocarbon reservoir, and the drilling/production strategy for the drilling program. Production platforms may be fixed, floating, or subsea (only in deep water). Fixed platforms rigidly attached to the seafloor are typical in water depths up to 400 m (1,312 ft), while floating or subsea platforms are typically in waters deeper than 400 m (1,312 ft). Floating platforms are attached to the seafloor using line-mooring systems and anchors. Development will also include installation of seafloor pipelines for conveying product to existing pipeline infrastructure or to new onshore production facilities. In shallower waters (<60 m [<200 ft]), pipelines are typically buried to a depth of at least 0.91 m (3 ft) below the mudline. Pipelines may also be buried (trenched) in deeper waters, depending on conditions along the subsea pipeline corridor.

Impact-producing factors of development include noise, ship and helicopter traffic, drilling mud and debris, seafloor and land disturbance, air emissions, lighting, and visible infrastructure. During the development phase, noise will be generated during drilling, by ship and helicopter traffic, pipeline trenching, and onshore construction. Resources that could be affected by development-related noise include marine mammals, sea turtles, marine and coastal birds, and fish. Marine mammals and sea turtles could be affected by collisions with ship traffic supporting platform construction and drilling, while the presence of ship and helicopter traffic could disturb normal behaviors of marine mammals and birds.

The disposal of drilling muds and fluids may affect local water quality and aquatic biota. Some amount of seafloor disturbance will occur as a result of drilling, platform mooring, and pipeline trenching, which would result in some loss of habitat and biota as well as reductions in overlying water quality. Seafloor disturbance could also affect archeological resources if present in the project area. Air emissions from platforms where drilling is occurring as well as at onshore construction sites could affect local air quality. The lighting of offshore platforms could affect birds, while lighting at onshore facilities could affect sea turtles. Visual impacts may be incurred for some developments, depending on the location and nature (size) of the offshore platform or onsite facilities. Development of production wells and platforms as well as of new pipelines and onshore processing facilities could result in some space use conflicts in the project area.

4.1.1.3 Operation

Following completion of the production wells and platform, the facilities are operated to extract the hydrocarbon resource and transport it to onshore processing facilities. In recent years, offshore processing facilities, including floating production, storage, and offloading (FPSO) and liquefied natural gas (LNG) processing facilities, have also played a role in storage and processing. During the operation phase, activities center on maintenance of the production wells (workover operations) and platforms. Impact-producing factors associated with normal operations include noise, ship and helicopter traffic, air emissions, lighting, and visible infrastructure (Table 4.1.1-1).

During normal operations, noise will be generated by maintenance activities and by ship and helicopter traffic and may affect marine mammals and fish. Collisions with support ships could affect marine mammals and sea turtles, while ship and helicopter traffic could disturb normal behaviors of nearby biota. As noted for the development phase, lighting of onshore facilities could affect sea turtles, while lighting of offshore platforms could affect birds. Any visual impacts identified for the development phase could continue for the duration of the operation phase. Similarly, some of the space use conflicts incurred during the development phase would continue through production.

4.1.1.4 Decommissioning

Following lease termination or relinquishment, all facilities and seafloor obstructions are required to be removed. Facilities and obstructions may include, but are not limited to, platforms, production and pipeline risers, umbilicals, anchors, mooring lines, wellheads, well protection devices, subsea trees, and manifolds. All bottom-founded infrastructure is severed at least 5 m (15 ft) below the mudline. Production infrastructure could be removed using explosive or nonexplosive methods. After a facility is removed, the site is required to be cleared of all seafloor obstructions created by lease-holding and pipeline right-of-way operations.

After a pipeline is purged of its content, it may be decommissioned in place or physically recovered. Pipelines that are out of service for less than one year must be isolated at each end, and when out of service for more than one year but less than five years must be flushed and filled with inhibited seawater. Pipelines out of service for five years or more may be decommissioned in place when the regional supervisor determines that the pipeline does not constitute a hazard (obstruction) to navigation and commercial fishing operations, unduly interfere with other uses of the OCS, or have adverse environmental effects.

Impact-producing factors associated with decommissioning include noise, ship and helicopter traffic, air emissions, and explosives. Noise would be generated during either explosive or nonexplosive structure removal, as well as by ship and helicopter traffic supporting removal activities, and could affect marine mammals, sea turtles, and fish. Ship traffic could result in collisions with marine mammals and sea turtles, while ship and helicopter traffic could disturb behaviors of biota in the vicinity of the platform undergoing decommissioning. Air emissions could affect local air quality. Pressure from explosive detonations could injure marine mammals, sea turtles, and fish. Some additional space use conflicts could arise with explosive platform removal.

4.1.2 Accidental Events and Spills

4.1.2.1 Expected Accidental Events and Spills

A variety of accidental events or spills may be expected to occur during OCS O&G exploration and development activities (Table 4.1.2-1). During normal operations, ship and platform activities generate a variety of solid waste materials, such as plastic containers, nylon rope and fasteners, and plastic bags. The accidental release of such solid waste materials could affect marine mammals, sea turtles, and birds. While sanitary and domestic wastes produced in ships and platforms are routinely processed through onsite waste treatment facilities, the accidental discharge of such releases could affect local water quality and biota.

Ships supporting platform activities may accidentally collide with MODUs or platforms, releasing diesel fuel, which could affect water quality and biota. Loss of well control results in the uncontrolled release of a reservoir fluid that may result in the release of gas, condensate or crude oil, drilling fluids, sand, or water. Historically, most losses of well control have occurred during development drilling operations, but loss of well control can happen during exploratory drilling, production, well completions, or workover operations (Holand 2006; Izon et al. 2007). Oil and condensate spills may also occur directly from platforms, drilling ships, and support vessels or from ruptured pipelines following hurricane, trawl, or anchor damage. Releases associated with loss of well control have the potential to be the greatest in size and duration, as witnessed with the DWH event; these may affect water quality, biota, and space use.

While oil spills are unplanned accidental events, some spills may be reasonably expected to occur during the 2012-2017 OCS Leasing Program and associated O&G development phases, given historical spill rate frequencies and projected OCS activity levels. Depending on the phase of O&G development and the location, magnitude, and duration of a spill, natural resources that may be affected include marine mammals, marine and coastal birds, sea turtles, fish, benthic and pelagic invertebrates, water quality, marine and coastal habitats, and areas of special concern (such as marine parks and protected areas). In addition, spills may also affect a variety of socioeconomic conditions such as local employment, commercial and recreational fisheries, tourism, sociocultural systems, and subsistence. Spill scenarios for small and large platform and pipeline spills in the GOM, Cook Inlet, and Arctic planning areas have been developed for use in this PEIS. The scenarios and underlying assumptions regarding expected accidental spills are presented in detail in Section 4.4.2.1.

4.1.2.2 An Unexpected Accidental Spill — Catastrophic Discharge Event

In contrast to accidental spills that may be reasonably expected to occur during the Program, there is a low potential for a catastrophic accidental spill to occur. A scenario for a low probability, catastrophic discharge event (CDE) is presented for each program area in Section 4.3.3. Although unexpected, if such a spill were to occur, its effects could be catastrophic and adverse impacts be reasonably foreseeable to be incurred by affected resources.

TABLE 4.1.2-1 Expected Accidental Events and Spills That May Be Associated with OCS O&G Development Phases

	O&G Development Phase				
	Exploration				
Accidental Event or Spill	Seismic Survey	Exploration Well	Development	Operation	Decommissioning
Solid waste release	X	X	X	X	X
Sanitary waste release	X	X	X	X	X
Vessel collisions	X	X	X	X	X
Loss of well control		X	X	X	
Oil spills (non-CDE)		X	X	X	X

4.1.3 Assessment Approach

4.1.3.1 Routine Operations and Expected Accidental Events and Spills

The environmental consequences discussed in subsequent sections of Chapter 4 address the potential impacts that could be incurred as a result of routine operations and expected accidental events and spills under any of the seven action alternatives (Alternatives 1–7). Because Alternative 1, the Proposed Action, encompasses the six OCS Planning Areas considered for inclusion in the Program, OCS oil and gas activities that could occur following leasing under Alternative 1 may be expected to have the potential to cause impacts over the greatest geographic area. Any such potential impacts could also occur under the other action alternatives (Alternatives 2–7), as each represents a subset of the planning areas included in the proposed action. Thus, the analyses presented in Chapter 4, while focused on the proposed action, are fully applicable to each of the other action alternatives.

It is not possible to identify specific impacts from future OCS O&G development activities without development-specific location and design details. There are, however, general impacts that are typical of offshore O&G development, regardless of where development occurs. For example, the placement of a seafloor pipeline crossing shallow waters to a landfall will require trenching, which will disturb the seafloor and affect the overlying water quality, regardless of whether that pipeline is located in Cook Inlet or in the Western GOM Planning Area. The potential effects of pipeline placement will, however, differ between shallow and deep waters and by the nature of the seafloor communities present along the actual pipeline route.

As previously discussed, lease- and project-specific details are not known at this time. Thus, the analyses in this PEIS take a programmatic approach and evaluate resources on a larger, more regional scale rather than at a lease-block scale (the scale at which project-specific impacts could occur). Thus, the evaluation of environmental consequences presented in this PEIS has focused on those resources most likely to be affected during future O&G development on the OCS under the alternatives presented in Chapter 2.

For each resource, the impact-producing factors identified in Tables 4.1.1-1 and 4.1.2-1 were further examined and refined to identify aspects of those factors specific to the resource under evaluation. The analyses also identified, as applicable, important components of each resource to further refine the relationship between the impacting factors and the resource. For example, for sea turtles, the impact analyses identified four life stages (eggs, hatchlings, juveniles, and adults), four habitat types (nesting, foraging, overwintering, and nursery), and three important behaviors (courtship/nesting, foraging, migration) that could be affected by OCS O&G development activities. The impact analyses then focused on the impact-producing factors that could affect any of these life stages, habitats, or behaviors. Table 4.1.3-1 illustrates the refinement and linkage of impacting factors and important resource components.

TABLE 4.1.3-1 Relationships among Development Phase Impacting Factors and Habitats, Life Stage, and Behavior of Sea Turtles

	Sea Turtle Resource Component										
	Habitat Disturbance or Loss				Life Stage Affected				Behavior Affected		
Development Phase and Impacting Factor	Nesting	Foraging	Overwintering	Nursery	Eggs	Hatchlings	Juveniles	Adults	Foraging	Courtship/ Nesting	Migration
Vessel noise						X	X	X	X		
Aircraft noise											
Drilling noise							X	X			
Trenching noise							X	X	X		
Onshore construction noise								X		X	
Offshore air emissions											
Onshore air emissions											
Aircraft traffic											
Vessel traffic						X	X	X			
Hazardous materials					X	X	X	X			
Solid wastes					X	X	X	X			
Drilling mud/debris						X	X	X			
Bottom disturbance from drilling											
Bottom disturbance from pipeline trenching		X	X	X			X	X	X	X	
Offshore lighting											
Onshore construction	X				X	X		X		X	
Onshore lighting	X					X		X		X	
Explosive platform removal						X	X	X			

4.1.3.2 Unexpected Catastrophic Discharge Event

As previously discussed (Section 4.1.2.2), there is a low potential for a catastrophic accidental spill to occur. A CDE is discussed in detail in Sections 4.3.3 and 4.4.2. Although a CDE is not expected for the proposed action or for any of the alternatives, should such an event occur, it would be expected to affect a variety of resources. Effects which have catastrophic consequences, even if the probability of the occurrence of the catastrophic event is low, are reasonably foreseeable. The assessment approach employed to characterize CDE impacts is similar to that used for assessing impacts of expected accidents. Subsequent sections of Chapter 4 address the potential effects that could result if a CDE were to occur. The impacts would be similar in nature to those from expected accidental spills, differing only in the magnitude, extent, and duration of potential impacts. However, the occurrence of a CDE is unlikely and unexpected, given the projected level of activity of the proposed action.

4.1.4 Definition of Impact Levels

The conclusions for the resource analyses use a four-level classification scheme to characterize the impacts that could result from routine operations and expected accidental events and spills during OCS O&G development under the alternatives presented in this PEIS. Although CDE-level accidents are not expected to occur under any of the alternatives, the PEIS discusses the types of effects that could be incurred if such an unexpected accident were to occur. The CDE impact evaluations presented in the PEIS use the same classification scheme to characterize impacts as used to characterize impact levels of routine operations and expected accidental spills.

4.1.4.1 Impact Levels for Biological and Physical Resources

The following impact levels for biological and physical resources are used for the analysis of water quality, air quality, marine and terrestrial mammals, marine and coastal birds, fish resources, sea turtles, coastal and seafloor habitats, and areas of special concern (such as essential fish habitats [EFHs], marine sanctuaries, parks, refuges, and reserves). For most biota, these levels are based on population-level impacts rather than impacts on individuals. For species listed under the ESA, the impact levels consider impacts on individuals, when appropriate, as well as populations.

- Negligible: No measurable impacts.
- Minor:
  - Most impacts on the affected resource could be avoided with proper mitigation.
  - If impacts occur, the affected resource will recover completely without mitigation once the impacting stressor is eliminated.

- Moderate:
  - Impacts on the affected resource are unavoidable.
  - The viability of the affected resource is not threatened although some impacts may be irreversible, or
  - The affected resource would recover completely if proper mitigation is applied or proper remedial action is taken once the impacting stressor is eliminated.

- Major:
  - Impacts on the affected resource are unavoidable.
  - The viability of the affected resource may be threatened, and
  - The affected resource would not fully recover even if proper mitigation is applied or remedial action is implemented once the impacting stressor is eliminated.

4.1.4.2 Impact Levels for Socioeconomic Resources and Societal Issues

The following impact levels are used for the analysis of population, employment, and income; land use and infrastructure; commercial and recreational fisheries; tourism and recreation; sociocultural systems; environmental justice; and archeological and historic resources.

- Negligible: No measureable impacts.

- Minor:
  - Adverse impacts on the affected activity, community, resource could be avoided with proper mitigation.
  - Impacts would not disrupt the normal or routine functions of the affected activity or community.
  - Once the impacting stressor is eliminated, the affected activity or community will, without any mitigation, return to a condition with no measureable effects.

- Moderate:
  - Impacts to the affected activity, community, or resource are unavoidable.
  - Proper mitigation would reduce impacts substantially during the life of the project.
  - A portion of the affected resource would be damaged or destroyed.
  - The affected activity or community would have to adjust somewhat to account for disruptions due to impacts of the project, OR
  - Once the impacting stressor is eliminated, the affected activity or community will return to a condition with no measurable effects if proper remedial action is taken.

- Major:
  - Impacts on the affected activity, community, or resource are unavoidable.
  - Proper mitigation would reduce impacts somewhat during the life of the project.
  - For archeological resources, all of the affected resource would be permanently damaged or destroyed. For other socioeconomic and cultural resources, impacts could incur long-term effects.
  - The affected activity or community would experience unavoidable disruptions to a degree beyond what is normally acceptable, and
  - Once the impacting agent is eliminated, the affected activity or community may retain measurable effects for a significant period of time or indefinitely, even if remedial action is taken.

4.2 RELATIONSHIP OF THE PHYSICAL ENVIRONMENT TO OIL AND GAS OPERATIONS

4.2.1 Physiography, Bathymetry, and Geologic Hazards

4.2.1.1 Gulf of Mexico

4.2.1.1.1 Physiography and Bathymetry. The GOM is a small ocean basin measuring 900 km (660 mi) from north to south and 1,600 km (990 mi) from east to west with a mean water depth of about 1,615 m (5,300 ft) (Bryant et al. 1991; GulfBase 2011). The basin is almost completely surrounded by continental landmasses. Its shoreline runs 5,700 km (3,500 mi) from Cape Sable, Florida, to the tip of Mexico's Yucatan Peninsula, with another 380 km (240 mi) of shoreline on the northwest tip of Cuba (GulfBase 2011).

The continental shelf extends from the coastline to a water depth of about 200 m (660 ft). Width of the shelf varies, ranging from 10 km (6 mi) near the Mississippi Delta to about 280 km (175 mi) off the southern tip of Florida and the Yucatan Peninsula. Its topographic relief is relatively low. Extending from the edge of the shelf to the abyssal plain is the continental slope, a steep area with high topographic relief and diverse geomorphic features (canyons, troughs, and salt structures). The base of the slope occurs at a median depth of about 2,800 m (9,190 ft). The Sigsbee Deep, located within the Sigsbee Abyssal Plain in the southwestern part of the basin, is the deepest region of the GOM with a maximum depth ranging from 3,750 m (12,300 ft) to 4,330 m (14,200 ft). The GOM basin contains a volume of 2,434,000 km^3 (6.43×10^{17} gal) of water (Shideler 1985; GulfBase 2011).

Antoine (1972) has divided the GOM into physiographic provinces, the components of which correspond to the ecological regions delineated by the Commission for Environmental Cooperation (CEC) (Wilkinson et al. 2009). The physiographic regions presented below are organized from north to south. They are based on the CEC's nomenclature (Level II seafloor geomorphological regions[1]) and incorporate the physiographic descriptions of Antoine (1972), Bryant et al. (1991), Shideler (1985), Wilhelm and Ewing (1972), and GulfBase (2011).

Northern Gulf of Mexico Shelf and Slope. On its west side, the northern GOM shelf and slope extends from the Rio Grande (Texas) to Alabama and from 320 km (200 mi) inland of today's shoreline to the Sigsbee Escarpment. It encompasses the Texas-Louisiana Shelf and Slope and the Mississippi-Alabama Shelf (Figure 4.2.1-1). The major geologic feature in this province is the Mississippi Fan, which extends from the Mississippi River Delta to the central abyssal plain. The upper part of the fan (to a water depth of about 2,500 m or 8,200 ft) has a complex and rugged topography attributed to salt diapirism,[2] slumping, and current scour; the lower part of the fan by contrast is smooth, with a gently sloping surface that merges with the abyssal plain to the southeast and southwest. The Mississippi Canyon cuts the eastern side of the Texas-Louisiana Shelf to the southwest of the Mississippi River Delta. The submarine canyon is thought to have formed from large-scale slumping along the shelf edge. The area is characterized by thick sediments and widespread salt deposits.

To the east, the northern GOM shelf and slope extends from just east of the Mississippi River Delta near Biloxi, Mississippi, to the eastern side of Apalachee Bay (west Florida) and encompasses the West Florida Shelf and Terrace (Figure 4.2.1-1). The shelf in this region is characterized by soft terrigenous (land-derived) sediments. Sediments are thick west of DeSoto Canyon; Mississippi River-derived sediments cover the western edge of the carbonate platform of the West Florida Shelf. The Florida Escarpment, with slopes as high as 45° in places, separates the West Florida Shelf from the deeper GOM basin and also forms the southeastern side of DeSoto Canyon.

South Florida/Bahamian Shelf and Slope. This region is the submerged portion of the Florida Peninsula. The region extends along the West Florida coast from Apalachee Bay southward to the Straits of Florida and includes the Florida Keys and Dry Tortugas. Sediments become progressively more carbonate (ocean-derived) from north to south with thick accumulations in the Florida Basin. The basin may have been enclosed by a barrier reef system at one time. The Jordon Knoll, located within the Straits of Florida, is composed of remnants of the ancient reef system.

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1 The CEC's Level II seafloor geomorphological regions are determined by large-scale physiography (e.g., continental shelf, slope, and abyssal plain) and extend offshore to a depth of 370 km (200 mi). The designation of Level II regions is helpful to understanding marine ecosystems because it illustrates the importance of depth as a major determinant of benthic marine communities and shows how physiographic features can influence current flows and upwellings (Wilkinson et al. 2009). Other sections (e.g., Section 3.2 on Marine and Coastal Ecoregions) provide finer scale Level III region descriptions that take into account local variables such as water mass, regional landforms, and biological community types on the continental shelf.

2 Salt diapirism refers to a process by which natural salt (mainly halite but also including anhydrite and gypsum) in the subsurface deforms and flows in response to loading pressures from overlying sediments. Because of its low density, salt tends to flow upward from its source bed, forming intrusive bodies known as diapirs. Salt diapirs are common features of sedimentary basins like the GOM (Nelson 1991).

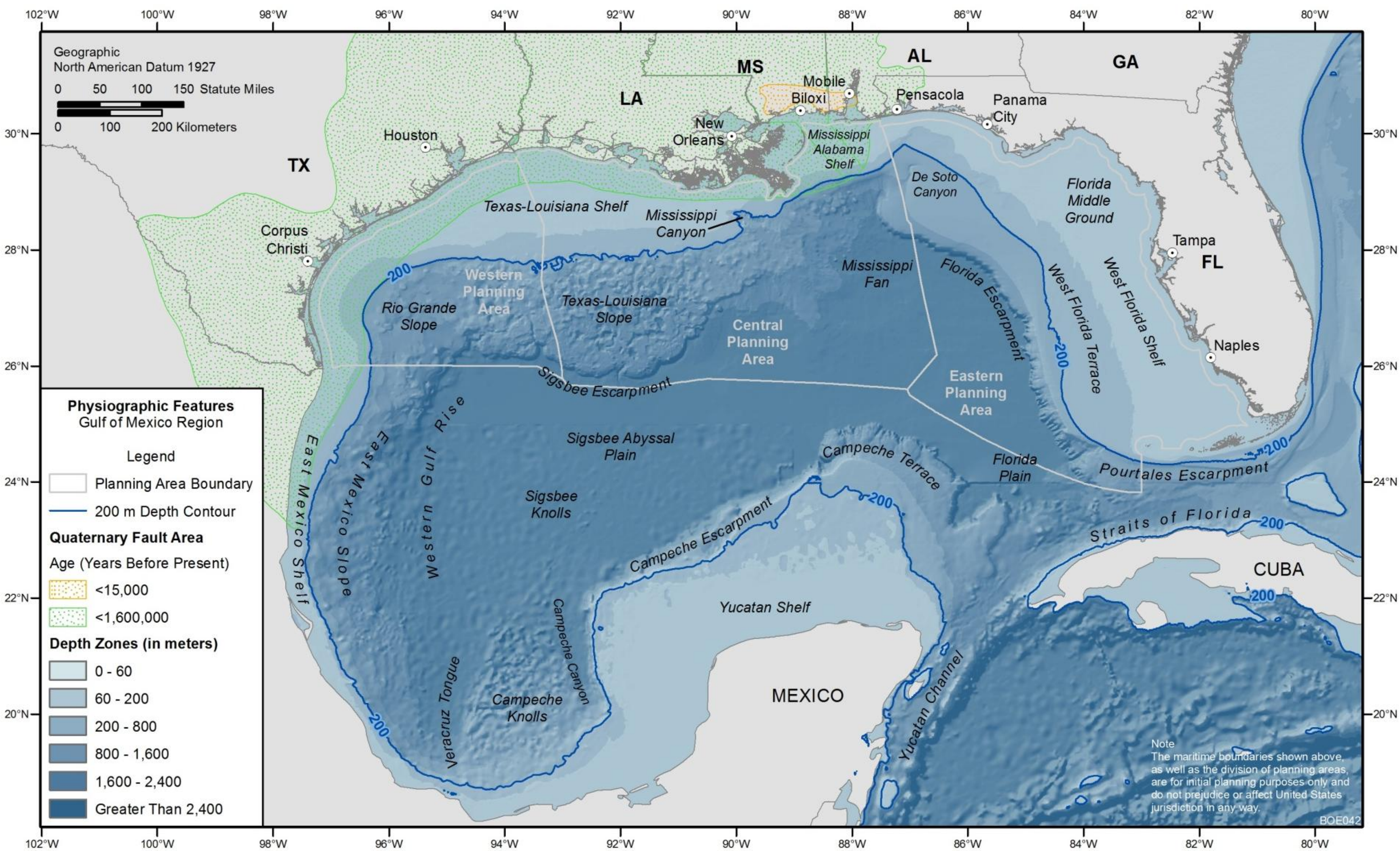

FIGURE 4.2.1-1 Physiographic Regions of the GOM (based on Bryant et al. 1991)

Gulf of Mexico Basin. The GOM Basin consists of the continental rise, the Sigsbee Abyssal Plain, and the Mississippi Cone. The continental rise is situated between the Sigsbee Escarpment and the Sigsbee Abyssal Plain (Figure 4.2.1-1). It is a large wedge of sediments originating from the unstable continental slope (deposited by gravity flows). The Sigsbee Abyssal Plain is the deep, flat portion of the GOM bottom just northwest of the Campeche Escarpment. It is 450 km (280 mi) long and 290 km (180 mi) wide and covers an area of more than 103,600 km^2 (40,000 mi^2). The plain is underlain by very thick sediments (up to 9 km, or 5.6 mi); the only major topographical features in this region are the small salt diapirs that form the Sigsbee Knolls. The Mississippi Cone lies between the Mississippi Canyon to the west and DeSoto Canyon to the east. It is the portion of the Mississippi River Delta that has accumulated at the base of the continental slope.

4.2.1.1.2 Geologic Hazards. Several types of geologic hazards are known to occur in the marine environment of the GOM region, most of which present a risk to offshore oil and gas activities because they contribute directly or indirectly to seafloor instability. As a result, seafloor instability is likely the principal engineering constraint to the emplacement of bottom-founded structures, including pipelines, drilling rigs, and production platforms.

Geologic hazards within the GOM are common on the northern continental slope (Figure 4.2.1-1) because of its high sedimentation and subsidence rates and the compensating movement of underlying salt. Geologic hazards are frequently concentrated in the areas along the edges of intraslope basins[3] where topography is high and complex. These intervening regions are created by shallow diapiric salt bodies and are steeply sloped and highly faulted. They are also areas of natural fluid and gas migration to the seafloor surface (Roberts et al. 2005). The potential geologic hazards in the GOM region are described below.

Irregular Topography. The regional topography of the continental slope is irregular, consisting predominantly of domes, ridges, and basins. On a more local scale, topographic features include slope failures, mounds, depressions, and scarps[4] (Roberts 2001b). Such features produce a wide range of potential hazards to drill rigs, bottom-laid and buried pipelines, and production platforms. The most topographically rugged province in the region is the Texas-Louisiana Slope, a 120,000-km^2 (46,300-mi^2) area of banks, knolls, basins, and domes where local slope gradients can exceed 20°. Topographic variability in this area is attributed to the movement of salt in the subsurface and the natural venting and seepage of petroleum and other fluids at the seafloor surface (Roberts et al. 2005; Bryant and Lui 2000; Kennicutt and Brooks 1990; Roberts et al. 1998).

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3 Intraslope basins are flat, featureless areas on the continental slope of the northwestern GOM where sediment depositional processes predominate.

4 Scarps (or escarpments) are steep bluff-like features formed by the downward displacement of sediments or rocks along a vertical fault plane.

Substrate types range from lithified (rock-like) hard bottoms[5] (bioherms, hardgrounds, carbonate banks, and outcrops) to extremely soft, fluid mud bottoms. Hard-bottom substrates are associated with topographic highs (most often created by salt diapirs) and present hazards to activities such as drilling, locating production platforms, and laying pipelines. The coral reefs of the Flower Garden Banks in the northwestern GOM are an example (Roberts et al. 2005; Roberts and Aharon 1994; Schmahl et al. 2011; see also Sections 3.7.2.1.2 and 3.9.1.2.1).

Bedforms and Bedform Migration. Bedforms are depositional features on the seabed that form by the movement of sediment caused by bottom currents. An extensive field of bedforms, ranging in size from small ripples and mudwaves to large furrows, is present at the base of the continental slope (along the Sigsbee Escarpment) in the GOM (Bean 2005; Bryant and Liu 2000). Large bedforms and their migration create potential navigation hazards and may undermine submarine pipelines. Numerous studies of these features relate their morphology and migration to water depth, availability of sediment, grain size, and current velocity (Whitmeyer and FitzGerald 2008).

Deep tow surveys conducted by Texas A&M University have found that the 30-m (98-ft) wide and 10-m (32-ft) deep furrows to the south of the Sigsbee Escarpment parallel the regional contours and extend for tens to hundreds of kilometers. These features indicate the long-term presence of high-velocity bottom currents along the base of the escarpment (Bryant and Liu 2000). Bean (2005) estimates current velocities in this region to be as high as 95 cm/s (37 in./s), significant enough to affect structures on the seafloor or in the water column. The bedforms have steep upstream-facing sides (where deposition takes place), suggesting they migrate in an upcurrent direction (Bean 2005).

Bottom Scour. Vigorous tidal circulation and storm waves have an important effect on the transport of sediments on the surface of the continental shelf. Episodic sediment movement caused by waves and ocean currents can undermine foundational structures and move unanchored bottom-laid pipelines (as reported by Thompson et al. 2005 and Coyne and Dollar 2005). Teague et al. (2006b) estimate that in 2004 Hurricane Ivan displaced as much as 100 million m^3 (3.5 billion ft^3) of sediment from a 35 by 15 km (22 by 9 mi) region in the storm's path, causing up to 36 cm (14 in.) of scour at moorings in areas over which the maximum wind stress occurred. Bottom scour occurs as a result of sediment resuspension by waves and current-driven transport of entrained sediments. Sediments entrained in bottom currents increase water density and mass, giving the strength to cause further scouring. In addition, wind-generated surface waves apply cyclic pressure to bottom sediments causing seabed motion (liquefaction).

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[5] Hard bottoms formed on diapiric high areas beyond the shelf edge during periods of lowered sea level in the late Pleistocene. During this time, the areas provided a substrate for the colonization of sedentary marine organisms. As sea level rose, the remains of the colonized organisms in these areas became fossilized, forming bioherms (e.g., fossilized coral reefs) and shallow banks (Roberts et al. 2005).

Fluid and Gas Expulsion. There are a wide range of natural fluid and gas[6] expulsion processes in seafloor sediments across the northern GOM continental slope. The geologic features related to these processes are variable and depend largely on the rate and duration of delivery as well as the composition of the fluid and gas expelled (Hardage 2011; Roberts 2001a). These include mud volcanoes, flows, and vents, resulting from rapid-flux or mud-prone processes; gas hydrate mounds and chemosynthetic communities, resulting from moderate-flux processes; and hard bottoms (carbonate mounds, hardgrounds, and nodular masses), resulting from slow-flux or mineral-prone processes (Roberts 2001a; Roberts et al. 2002). Below water depths of about 500 m (1,640 ft), moderate-flux processes dominate, promoting gas hydrate formation at or near the seafloor and creating conditions optimal for sustaining dense and diverse chemosynthetic communities. Rapid- and slow-flux processes may also occur on a more local scale at these depths (Roberts et al. 2002). Pockmarks — circular to oval depressions resulting from the removal of sediment near areas of rapid (and possibly explosive) gas expulsion — have been mapped along the northern continental shelf and slope. Some of these features are over 300 m (1,000 ft) in diameter (BOEMRE 2011l).

The main geologic hazard stemming from the processes of fluid and gas expulsion (seeps and eruptions) is seabed slope failure (submarine slumps and slides), especially on the continental slope and within active river deltas and submarine canyons. Fluid and gas releases lower sediment shear strengths and as a result can destabilize seabed structures such as cables, pipelines, and platforms.

Studies using high-resolution seismic and side-scan sonar have shown that the linear spatial distribution of seafloor features caused by fluid and gas expulsion can usually be correlated with faults intersecting the modern seafloor. Faults are important conduits for the upward natural migration of fluids and gases through the sedimentary column to the seafloor (Roberts 2001b). Neurater and Bryant (1990) report that it is the churning action of upwelling fluids and gases that causes a “slurry” of unconsolidated mud to form and migrate to the surface of the seafloor.

Along the Texas-Louisiana Shelf, shallow gas accumulations are most common in old channel systems. Shallow gas accumulations are also found in areas affected by salt uplift where numerous faults form pathways to near-surface sediments, creating small gas pockets that become sealed in thin clay layers (Foote and Martin 1981).

Natural Gas Hydrates. Gas hydrates are naturally occurring solids composed of hydrogen-bonded water lattices (also known as clathrates) that trap methane and other low-weight gas molecules (e.g., carbon dioxide, propane, and ethane). They form in deepwater ocean sediments within a surface-parallel layer referred to as the hydrate stability zone under conditions of high pressure and low temperature. In the GOM, gas hydrate deposits are found in

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6 Gases (predominantly methane) migrating from the seabed originate from both deep sources (termed thermogenic gases because they are heat-generated) and more shallow sources (termed biogenic or microbial gases because they are derived from the activity of microorganisms). Regardless of origin, high-pressure methane is highly mobile, flammable, and buoyant and poses a great hazard to drilling operations when encountered (Judd and Hovland 2007).

localized deepwater areas at or near the seafloor (intersecting the seafloor at a water depth of about 500 m, or 1,640 ft). They occur as a disseminated accumulation in the pore spaces of sedimentary units across vertical sections ranging in thickness from a few centimeters to several hundred meters. In more massive form, they occur in faults, fractures, and nodules and range in thickness from a few centimeters to several hundred meters. The size and shape of the hydrate stability zone are influenced by the presence of numerous salt features (Boatman and Peterson 2000; Roberts 2001b; MMS 2006a; Frye 2008).

Because they are pressure- and temperature-sensitive, gas hydrates (if present) can easily dissociate and rapidly release large amounts of gas during a drilling operation. Hydrate dissociation may trigger seafloor slumps and catastrophic landslides, which pose significant hazards for offshore oil and gas operations, including the loss of support for drilling and production platforms and pipelines, collapse of wellbore casings, and seafloor subsidence around wellbores where gas has leaked to the surface. As drilling operations in the GOM move into deeper waters, gas hydrate outcrops are likely to be encountered more frequently (Boatman and Peterson 2000; Roberts 2001b; MMS 2006a).

In addition to their natural occurrence in sediments, gas hydrates may also form on drilling equipment and in pipelines in deep water, trapping methane and other gas molecules and posing hazards such as drilling difficulties, blockages and pressure buildup in valves and pipelines, and an increased risk of well control loss (Boatman and Peterson 2000).

Shallow Water Flow. Shallow water flow is a deepwater drilling hazard that occurs when overpressured, unconsolidated sands are encountered at shallow depths, 460 to 2,100 m (1,500 to 7,000 ft) below the seabed (Huffman and Castagna 2001). When encountered, these sands are prone to uncontrolled flow, potentially damaging the well and causing well casing failure — which could result in the loss of the well.[7] In extreme cases, overpressured sands have been known to erupt, creating seafloor craters (due to collapse), mounds, and cracks. Shallow water flow sands are difficult to detect seismically because there is little contrast in acoustic impedance at sand/shale interfaces at shallow depths (Lu et al. 2005; Ostermeier et al. 2002); however, some investigators are having success using high-resolution multi-component seismic data to delineate anomalies to identify zones that might produce shallow water flow (e.g., Huffman and Castagna 2001).

Slope Failure. Submarine slope failures result from processes that reduce the shear strength of sediment on submarine slopes and/or increase the main driving force (gravity) that promotes the downslope movement of sediments. Hance (2003) summarizes the published literature on submarine slope failure and identifies 14 triggering mechanisms, a subset of which is relevant to the GOM shelf and slope: (1) sedimentation processes that involve rapid deposition, especially in offshore delta areas and at the base of submarine canyons; (2) increased fluid pressures resulting from the disassociation of gas hydrates and the release and accumulation of free gas; (3) ocean storm waves and subsurface current (internal) waves; (4) tidal events,

[7] Shallow water flow is estimated to have occurred in about 70% of all deepwater wells (Hoffman and Castagna 2001).

especially along coastlines; (5) human activities such as construction and dredging, usually along coastlines; (6) salt diapirism, which oversteepens soils on the flanks of diapirs; (7) mud-related volcanic activity; and (8) sediment creep, a process involving the slow movement of large masses of sediment.

Mudflows occur within well-defined gullies along the submerged portion of the Mississippi Delta, creating unstable conditions vulnerable to failure. Areas between the mudflow gullies have lower sedimentation rates and are considered to be generally stable. Active deposition takes place downslope of the gullies. Damage to pipelines and production facilities due to mudflow overruns has been documented in this region (Hitchcock et al. 2010). Other forms of sediment instability along the delta front include collapse depressions, submarine landslides, and shelf-edge slumps (Coleman et al. 1991; Coleman and Prior 1988).

Nodine et al. (2006) also reported pipeline damage by mudslides within (and confined to) the mudflow lobes along the delta front during Hurricane Ivan in 2004.

Faulting. Faulting occurs on a range of scales within the GOM continental shelf and slope, from major growth faults[8] that cut across thousands of meters of sedimentary section to much smaller faults related primarily to salt movement in the shallow subsurface. Vertical offsets along faults create steep scarps on the seafloor, leading to various forms of subaqueous mass movement (falls, slides or slumps, flows, and turbidity flow) that contribute to the seafloor's irregular topography. Faults also provide pathways for the upward migration and expulsion of fluids and gas at the seafloor surface (Roberts 2001b; Coleman and Prior 1988).

Active faults could pose a hazard to oil and gas activities in areas of rapid deposition and subsidence (such as the Mississippi Delta), especially in areas where formation fluids such as water and oil are withdrawn. In the GOM, fault activity is thought to be most prevalent on steep slopes at the shelf edge where sediment accumulation creates loading stress that is periodically relieved by sudden faulting and associated with active salt diapirs on the upper slope (Foote and Martin 1981).

4.2.1.2 Alaska – Cook Inlet

The Cook Inlet Planning Area encompasses the lower half of Cook Inlet (referred to as lower Cook Inlet) and Shelikof Strait. The following descriptions of physiography, bathymetry, and geologic hazards address physiographic features and geologic processes throughout Cook Inlet (including the upper inlet) for completeness.

8 Growth faults are normal (extensional) faults that form at the same time massive volumes of sediments are accumulating within an area of high deposition, such as the Mississippi Delta. The fault plane is typically well-defined and is linear or concave and fairly steep. Growth faults exhibit greater offset with increasing depth and extend more than 150 m (500 ft) below the sea floor. They are most common on the outer shelf and upper slope where sediment accumulation and subsidence are greatest (Foote and Martin 1981; MMS 2006a; Teague et al. 2006b).

4.2.1.2.1 Physiography and Bathymetry. Cook Inlet is a northeast-trending, 350-km (220-mi) long tidal estuary on the south-central coast of Alaska. It is situated between the Kenai Peninsula and Alaska Peninsula and extends from Anchorage to the Gulf of Alaska (Figure 4.2.1-2). The inlet is composed of three distinct physiographic regions: the head, the upper inlet, and the lower inlet. The head region lies at the northernmost end of Cook Inlet and consists of two long and narrow bays: Knik and Turnagain Arms, both of which have extensive tidal marsh flats during low tide. Knik Arm begins at the confluence of the Knik and Matanuska Rivers, about 50 km (31 mi) inland; it ranges in width from about 2 to 10 km (1.2 to 6.2 mi). The Port of Anchorage is located on the southeast shore of Knik Arm, at the mouth of Ship Creek. Turnagain Arm extends about 75 km (47 mi) inland to the railroad depot at Portage; it ranges in width from about 2 to 26 km (1.2 to 16 mi). Fire Island is located at the midpoint between Knik and Turnagain Arms, just off the coast of Anchorage (Mulherin et al. 2001).

Upper Cook Inlet is about 95 km (59 mi) long and extends from Point Campbell to the East and West Forelands (Figures 4.2.1-2 and 4.2.1-3). It ranges in width from 20 to 30 km (12 to 19 mi) and narrows to 16 km (10 mi) between the Foreland peninsulas. Several shallow shoals occur in this region, including Middle Ground Shoal, just north of the Forelands and north of the inlet's midline; Beluga Shoal, due south of the mouth of Susitna River, at the inlet's midline; and Fire Island Shoal, due west of Fire Island. Water depths in upper Cook Inlet are generally less than 37 m (120 ft), with the greatest depths at Trading Bay, the largest bay in the upper inlet, just east of the mouth of McArthur River (Mulherin et al. 2001; ADNR 2009a).

Lower Cook Inlet is about 200 km (120 mi) long and lies between the Foreland peninsulas and the inlet's mouth, which opens to the Gulf of Alaska between Cape Douglas on the Alaska Peninsula and Cape Elizabeth on the Kenai Peninsula (Figures 4.2.1-2 and 4.2.1-4). There are several islands within the lower inlet, including Augustine Island, in Kamishak Bay; Chisik Island, at the mouth of Tuxedini Bay; and Kalgin Island, about 30 km (19 mi) south of the Forelands. The Barren Islands and Chugach Islands are located at the inlet's mouth. The bathymetry is characterized as having sloping sides forming a central depression (Cook Trough) that gradually deepens to the south and widens as it approaches the Cook Plateau near the mouth of the inlet. The depression bifurcates to the north into two channels, divided by a narrow shoal (Kalgin Platform) extending southward from Kalgin Island. The Cook Plateau lies between the lower end of the Cook Trough and the top of Cook Ramp, a gently sloping ramp delineating the sandy sediments to the north and muddy sands to the south. The Cook Plateau and parts of the Cook Ramp are covered by bedforms of various sizes. The ramp slopes from a water depth of about 70 m (230 ft) to about 120 to 130 m (390 to 430 ft) as it approaches the north end of the Shelikof Trough (Mulherin et al. 2001; ADNR 2009a; Bouma 1981; Bouma et al. 1978a).

The Chinitna Platform covers most of the western part of lower Cook Inlet (Figure 4.2.1-2). Its surface is smooth with numerous small topographic highs and lows. Most of the bottom is hard and covered by coarse-grained sediment and shells (although embayments may have muddy bottoms). Augustine Island is located on the platform, and a shallow area, known as the Augustine Apron, encircles the island (Bouma 1981).

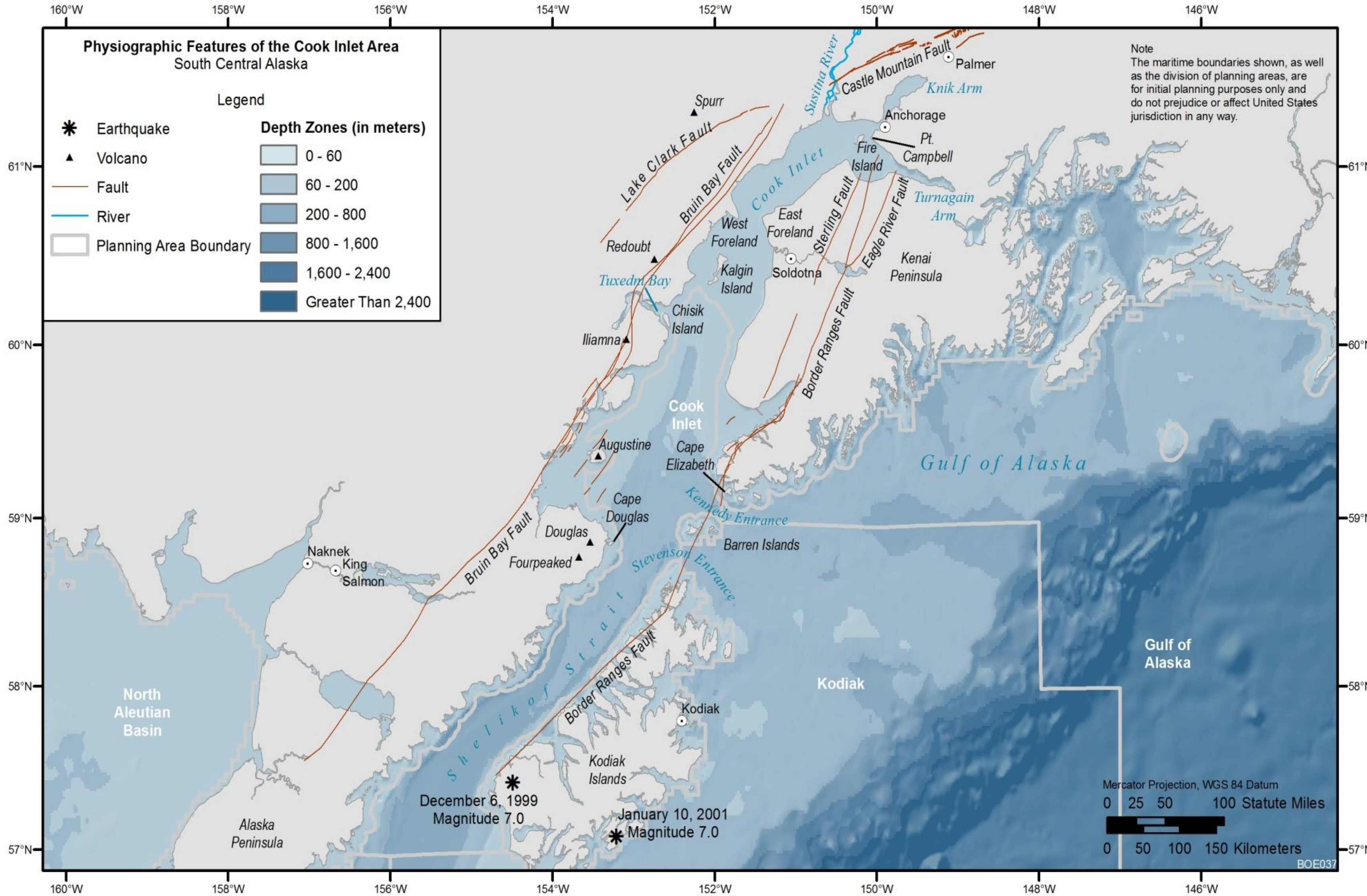

FIGURE 4.2.1-2 Physiographic Features of Cook Inlet (Earthquake data from USGS 2011a; map data for faults from Labay and Haeussler 2001; Troutman and Stanley 2003; and Clough 2011.)

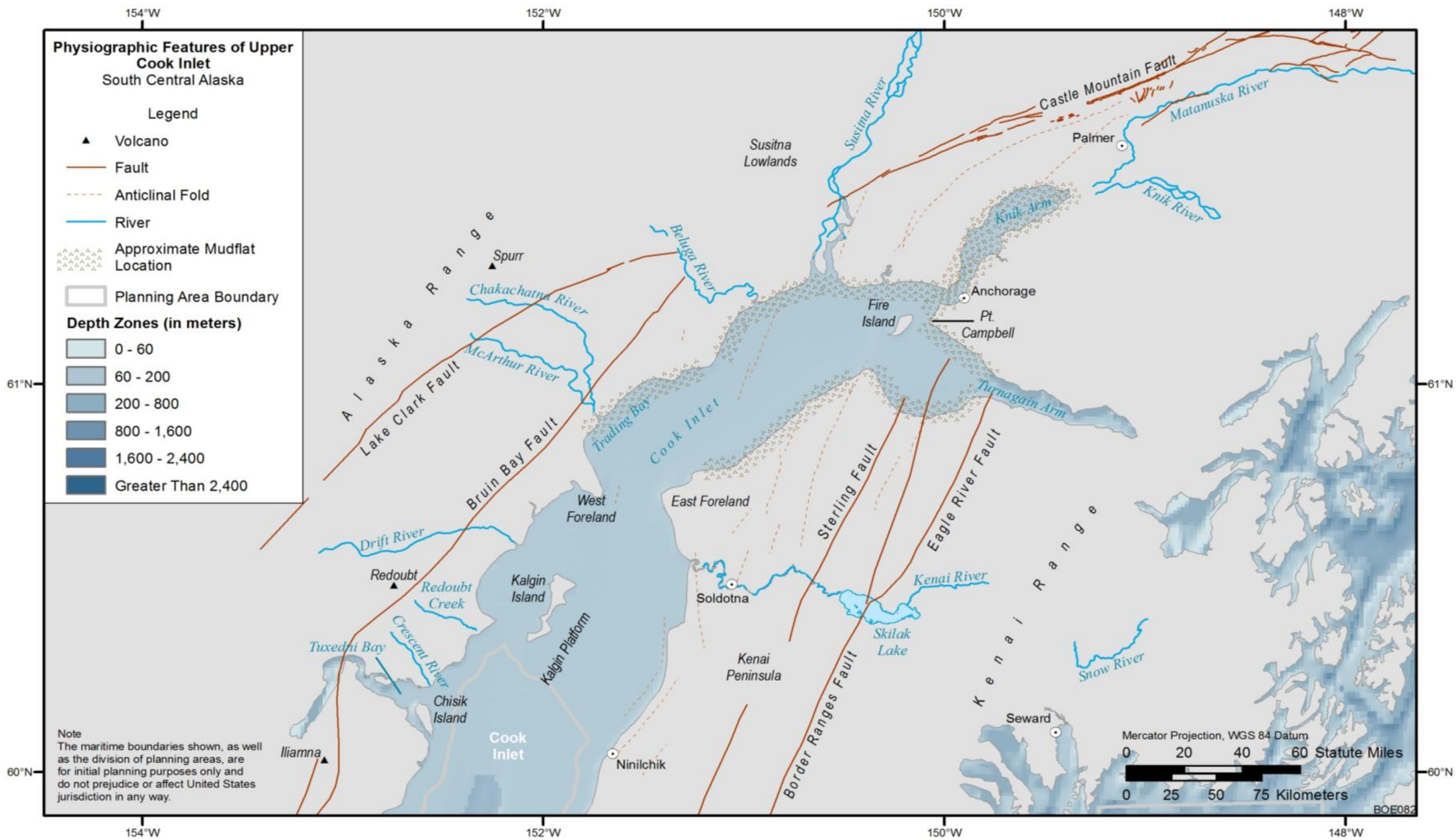

FIGURE 4.2.1-3 Upper Cook Inlet (Map data for faults from Labay and Haeussler 2001; Troutman and Stanley 2003; and Clough 2011; mudflat data from Mulherin et al. 2001.)

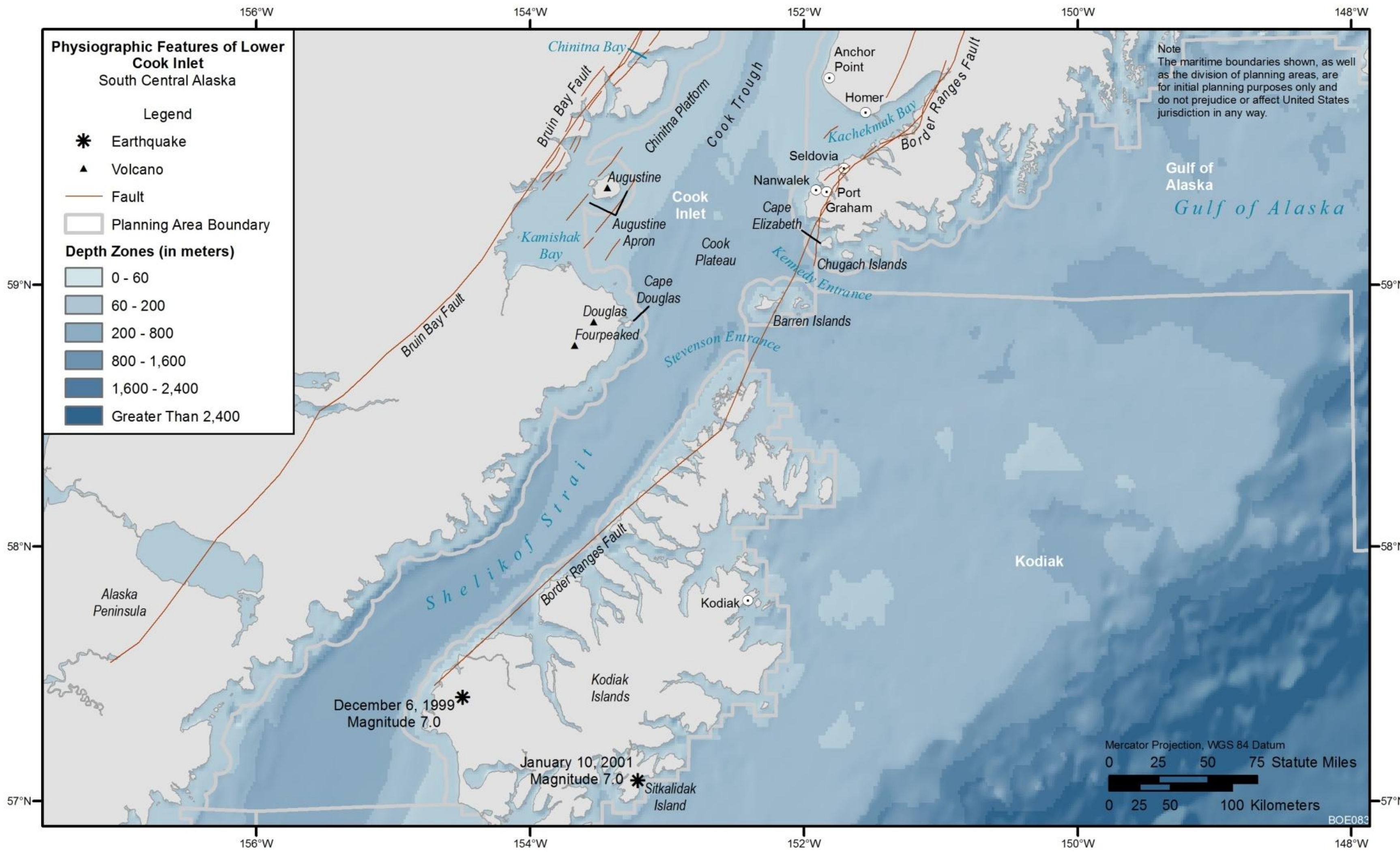

FIGURE 4.2.1-4 Lower Cook Inlet (Earthquake data from USGS 2011a; map data for faults from Labay and Haeussler 2001; Troutman and Stanley 2003; and Clough 2011.)

There are three entrances to the lower inlet from the Gulf of Alaska; these are the Kennedy and Stevenson Entrances on either side of the Barren Islands off the northeastern end of the Kodiak Islands and the opening of Shelikof Strait on the inlet's southwestern end.

Shelikof Strait lies between the Kodiak Island group and the Alaska Peninsula and also has a northeast orientation (Figure 4.2.1-2). The strait is about 200 km (120 mi) long, with an average width of about 45 km (27 mi). The seafloor in this region consists of a flat, central platform (coinciding with the Shelikof Trough) that slopes gently to the southwest. The platform is flanked by narrow marginal channels than run alongside the Kodiak Islands and the Alaska Peninsula. Relief on the platform and within the marginal channels can be as high as 100 m (330 ft) locally. Water depths in Shelikof Strait increase gradually in a southwestward direction, ranging from about 80 m (260 ft) at the mouth of Cook Inlet to more than 300 m (980 ft) off the west end of the Kodiak Islands (Hampton et al. 1978; Bouma 1981; Hampton et al. 1981). Deep subsurface faults (offsetting rocks of Tertiary age or older) occur along the margins of Shelikof Strait and run parallel to the shorelines of Kodiak Island and the Alaska Peninsula. Shallow faults are more recently active and occur throughout the strait — along its margins, as growth faults, and in association with structural highs (horsts or remnant volcanic necks) — and trend predominantly to the northeast (Hoose and Whitney 1980).

4.2.1.2.2 Geologic Hazards. Several types of geologic hazards are known to occur in the marine environment of Cook Inlet and Shelikof Strait and may present a risk to offshore oil and gas activities because they are dangerous to navigation or potentially damaging to marine structures. The potential geologic hazards in Cook Inlet and Shelikof Strait, except for sea ice, which is addressed in Section 4.2.2.1.1, are described below.

Seafloor Instability. The generally shallow nature and large tidal range of Cook Inlet (9 m [30 ft]) produce rapid currents. The Coriolis effect is also pronounced at this latitude, and during peak flow, all these factors combine to create strong cross-currents and considerable turbulence (strong currents and turbulence are also generated as tides flow through the constricted Forelands area). High current velocities and turbulence keep fine sediments (silt and clay) in suspension, so they are transported far from their source in the head region — the Susitna and Knik Rivers — and then back again with the incoming tide. As a result, bottom sediments throughout most of the inlet are predominantly coarse-grained (cobbles, pebbles, and sand) with only minor amounts of silt and clay. Grain size distribution in the inlet, which reflects the type and energy of transportation during the tidal cycle, is as follows: (1) sand, in the head region to the east of the Susitna River; (2) sandy gravel and gravel, in the upper inlet and the upper part of the lower inlet (to Chinitna Bay); and (3) gravelly sand with minor silt and clay, in the lower inlet as far as the Barren Islands (Sharma and Burrell 1970).

MMS (1996b) concluded that the bottom sediments in Cook Inlet provide a stable substrate with no unusual geotechnical issues. This conclusion was based on the nature of bottom sediments in Cook Inlet (mainly coarse-grained), the low rate of sediment accumulation, and the low relief of the seafloor. Previous studies found no areas of soft, unconsolidated sediments or evidence of failed or unstable slopes.[9]

Bedforms and Bedform Migration. Bedforms are depositional features on the seabed that form by the movement of sediment by strong bottom currents. Bedforms are common in Cook Inlet and occur as sand waves, dunes, sand ribbons, sand ridges, and megaripples with wavelengths ranging from 50 to 800 m (160 to 2,600 ft) and heights from 2.0 to 14 m (6.6 to 46 ft). The type of bedform occurring at a given location depends on factors such as sediment size and availability, water depth, and current velocity (Hampton 1982a). Bedform migration and the strong bottom currents that cause it are known to be hazardous to offshore operations in upper Cook Inlet because they undermine or bury bottom-founded structures such as anchors and pipelines (Bouma et al. 1978b; Bouma and Hampton 1986; Whitney et al. 1979; Bartsch-Winkler 1982). Several pipeline failures in Cook Inlet have been attributed to sediment movement that results from current-sediment interaction (ADNR 2009a).

The largest bedform fields in lower Cook Inlet occur in its central and southern parts (especially on Cook Plateau and Cook Ramp) where bottom current velocities may be as high as 50 cm/s (20 in./s) (Whitney and Thurston 1981; Bouma et al. 1978b; Bouma 1981). Studies conducted in the lower inlet indicate sand grains move mainly during storm events and in response to ebb and flood cycles, especially during spring tide (Bouma and Hampton 1986).

Shallow Gas. Shallow gas is a hazard to drilling operations when encountered because it increases the potential for loss of well control. Shallow gas-charged sediments[10] have been documented in Cook Inlet, and loss of well control incidents have occurred at the Steelhead platform (well M-26; 1987–1988) and Grayling platform (well G-10RD; 1985) in upper Cook Inlet north of the West Foreland. The incident at the Grayling platform stopped on its own as a result of well bore collapse that naturally sealed off the escaping fluids and gases. At the Steelhead platform, however, some injuries to workers and damage to the platform occurred as a result of escaping gases that caught fire (ADNR 2009a).

Whitney and Thurston (1981) delineated shallow gas-charged sediment areas at depths of less than 50 m (160 ft) below the seafloor in lower Cook Inlet based on high-resolution seismic profiles. The areas occur to the west of the Barren Islands between bathymetric contours 150 km

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[9] Studies of sediments in the head region (at the northernmost end of Cook Inlet), however, do indicate soft sediments (e.g., in Knik Arm) that have unstable banks and bottoms and a high liquefaction potential. Surface bedforms are common features in these sediments (Bartsch-Winkler 1982).

[10] Natural gas (predominantly methane) in Cook Inlet sediments likely originates from the decay of trapped organic matter in recent sediments and seepage from deeper sources, as reported by Molnia et al. (1979) for the Gulf of Alaska. Gas from deeper sources in the Cook Inlet basin has two types of occurrences: (1) the shallow reserves of biogenic gas in the Sterling, Beluga, and upper Tyonek Formations of the nonmarine Kenai Group of Tertiary age, at depths less than 2,300 m (7,500 ft); and (2) the oil-associated (thermogenic) gas in the lower Tyonek Formation, the Hemlock Conglomerate, and the West Foreland Formation at the base of the Tertiary section, having migrated from underlying marine source rocks of Jurassic age (Claypool et al. 1980). Regardless of origin, high-pressure methane is highly mobile, flammable, and buoyant and poses a great hazard to drilling operations when encountered (Judd and Hovland 2007).

and 180 km (93 mi and 110 mi) and to the southeast of Augustine Island between bathymetric contours 20 km and 100 km (12 mi and 62 mi) (Whitney and Thurston 1981). Although areas of gas-charged sediments can be identified in high-resolution marine seismic data, the concentrations of gas in sediments are highly variable over small lateral and vertical distances (Hampton 1982b).

Hoose and Whitney (1980) mapped possible gas-charged sediments in the shallow subsurface at the northeast end of Shelikof Strait (also based on high-resolution marine seismic data).

Seismicity. Seismicity in the Cook Inlet region is related to movement along the Alaska-Aleutian megathrust fault as the northwestward-moving Pacific plate subducts into the mantle beneath the North American plate (Figure 4.2.1-5). Shallow crustal earthquakes are generated as a result of deformation of the overriding North American plate; deeper earthquakes occur along the interface of the plates (Benioff Zone) that extends from the trench to depths of 40 to 60 km (25 to 37 mi), deepening to the northwest. Within the subducting Pacific plate, earthquakes can be as deep as 300 km (186 mi) (Rhea et al. 2010).

Major fault systems occur along the margins of the Cook Inlet basin. They include the Castle Mountain, Lake Clark, and Bruin Bay Faults, located to the north and northwest, and the Border Ranges Fault, on the Kenai Peninsula to the southeast (Figure 4.2.1-2). The faults have a northeast strike and are among the largest strike-slip fault systems in Alaska. Of these, only the Castle Mountain Fault has been active in recent times (with several earthquakes with an inferred moment magnitude (M_W)[11] of 7.1 occurring in the past 4,100 years along the southern slopes of the Talkeetna Mountains) (Labay and Haeussler 2001; Haeussler et al. 2000). There is no evidence of recent or Quaternary movement along the Lake Clark or Bruin faults. Haessler and Saltus (2004) identified a 26-km (16-mi) right-lateral offset on the Lake Clark Fault that likely occurred in the past 34 to 39 million years (Late Eocene), based on aeromagnetic data. The Border Ranges fault system is considered to be inactive. The most recent activity on the Border Ranges fault system likely occurred less than 24 million years ago (Neogene); some investigators suggest activity may have been as recent as several thousand years ago (Stevens and Craw 2004).

Numerous anticlinal folds present throughout the Cook Inlet basin are also potential sources of earthquakes. The folds are discontinuous, fault-cored (transpressional) structures that result from active deformational processes within the basin. The folds are generally oriented subparallel to the margins of the basin (Figures 4.2.1-3 and 4.2.1-4). Haeussler et al. (2000) have identified 22 such structures that, if active, are large enough to generate earthquakes of M 6.0 or greater. Fault slip rates along these structures are estimated to be on the order of a few millimeters per year or less, suggesting earthquake recurrence intervals between 50 and 6,000 years. The highest magnitude earthquakes in Alaska are associated with the

[11] Moment magnitude (M_W) is used for earthquakes with magnitudes greater than 3.5 and is based on the moment of the earthquake, equal to the rigidity of the earth times the average amount of slip on the fault times the amount of fault area that slipped. Moment magnitude is the preferred magnitude for all earthquakes listed in USGS databases. It replaces the more general usage of "M," which is used to describe historical earthquakes in the literature. An "M" denotes a magnitude consistent with the Richter scale (USGS 2010).

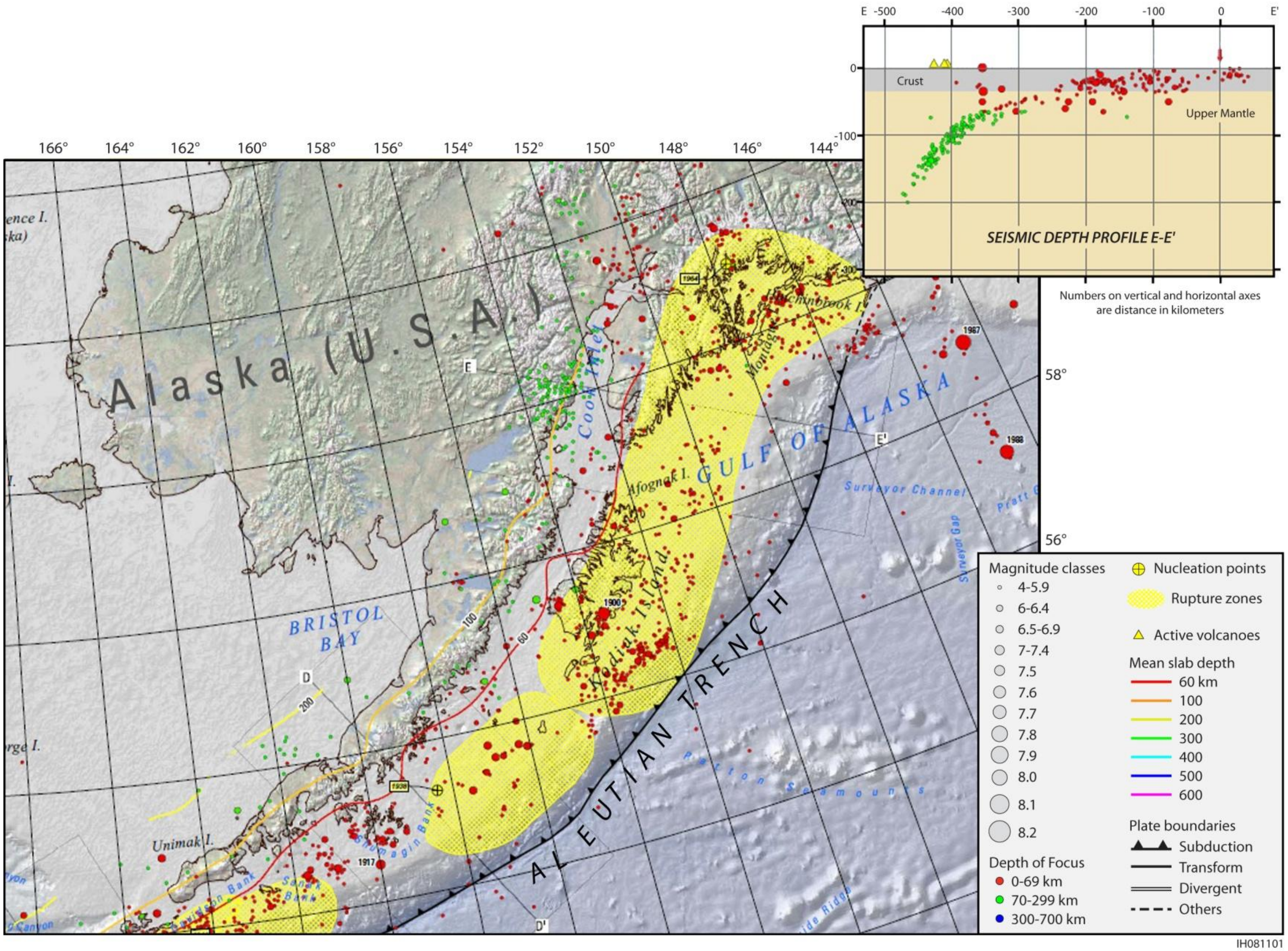

FIGURE 4.2.1-5 The Alaska-Aleutian Megathrust Fault and Subduction Zone (Aleutian Trench) with Seismicity Depth Profile across Cook Inlet (modified from Rhea et al. 2010)

Alaska-Aleutian megathrust zone and are common in the Aleutian Islands, the Alaska Peninsula, and the Gulf of Alaska. Since 1900, six earthquakes over magnitude 8.4 have occurred in these regions (some of which predate oil and gas activities in Cook Inlet) (Rhea et al. 2010).

Since 1973, more than 1,200 earthquakes with magnitudes greater than 3.0 have been recorded in the Cook Inlet region (USGS 2011a). Of these, 10 had magnitudes greater than 6.0. The two largest earthquakes occurred in 1999 and 2001 and were located on Kodiak and Sitkalidak Islands (Figure 4.2.1-2). Each earthquake registered a M_W of 7.0 (Figure 4.2.1-2).

Cook Inlet lies within an area where the peak horizontal accelerations of 0.30 and 0.40 g have a 10% probability of exceedance in 50 years (USGS 1999). Shaking associated with this level of acceleration is generally perceived as very strong to severe, and the potential for damage to structures is moderate to heavy (Wald et al. 2006). Given the high intensity of ground shaking and the high incidence of historic seismicity in the Cook Inlet region (i.e., 1,200 earthquakes in the past 40 years with 10 exceeding M 6.0), the potential for liquefaction in inlet sediments is also likely to be high, but only in areas like the head region and upper inlet where sediments are composed of glacial silt and fine sands, as demonstrated by the widespread liquefaction documented in Turnagain Arm during the Great Alaska Earthquake of 1964 (there was little damage to oil and gas-related structures within the inlet). Areas like the OCS where bottom sediments are more coarse-grained are not likely to be affected (Greb and Archer 2007).

Earthquakes greater than M 6.0 pose a risk to the Cook Inlet region by triggering floods and landslides. Earthquakes greater than M 7.0 may trigger a tsunami and cause emergency events such as fires, explosions, and hazardous material spills and a disruption of vital services (water, sewer, power, gas, and transportation).

Volcanic Activity. There are four monitored volcanoes located in the Cook Inlet region (from north to south): Spurr, Redoubt, Iliamna, and Augustine (Figure 4.2.1-2; Table 4.2.1-1). These volcanoes are part of the Aleutian Island Arc, a chain of volcanoes extending from south central Alaska to the far western tip of the Aleutian Islands. Three of these volcanoes (Spurr, Redoubt, and Iliamna) are located to the west of Cook Inlet. Augustine is an island volcano in lower Cook Inlet; it is the most active volcano in the region. All but Iliamna have erupted several times in the past 150 to 200 years and may erupt again in the future (Waythomas et al. 1997; Waythomas and Waitt 1998). Because of their composition, volcanoes in the Cook Inlet region are prone to explosive eruptions. Hazards in the immediate vicinity of the eruption include volcanic ash fallout and ballistics, lahars (mudflows) and floods, pyroclastic flows and surges, debris avalanches, directed blasts, and volcanic gases. Lease areas in Cook Inlet would be out of the range of most of these eruption hazards except during very large eruptions (on the scale of the 1980 Mount St. Helens eruption), which tend to be rare events (Combellick et al. 1995; ADNR 2009a). Ash fall associated with the 2009 eruption of Redoubt forced the temporary closure of the Anchorage Airport (ADN 2009); however, there were no reports that it affected oil and gas operations or damaged infrastructure within or around Cook Inlet.

Drainages with headwaters near the three onshore Cook Inlet volcanoes are susceptible to lahars (mudflows) and floods during volcanic eruptions due to the permanent snow and ice

TABLE 4.2.1-1 Monitored Volcanoes near Cook Inlet[a]

Volcano	Description/Location	Historical Eruptions	Potential Hazards
Mount Spurr	Ice- and snow-covered stratovolcano on the west side of Cook Inlet, about 120 km (75 mi) west of Anchorage. Peak elevation is 3,374 m (11,070 ft).	1953 and 1992 (Crater Peak flank vent about 3.5 km [2 mi] south of summit).	Ash clouds, ash fall and bombs, pyroclastic flows and surges, and mudflows (lahars) that could inundate drainages on all sides of the volcano, but primarily on south and east flanks. Eruptions at the Crater Peak vent were brief and explosive, producing columns of ash.
Redoubt	Stratovolcano on the west side of Cook Inlet, about 170 km (106 mi) southwest of Anchorage. Peak elevation is 3,108 m (10,197 ft).	1902, 1966–1968, 1989–1990, and 2009.	Ash clouds, ash fall and bombs, pyroclastic flows and surges, debris avalanches, directed blasts, volcanic gases, tsunamis, and mudflows (lahars) and floods that could inundate drainages on all sides of the volcano, primarily on the north flank. The 1989–1990 eruption produced a lahar that traveled down the Drift River and partially flooded the Drift River Oil Terminal facility. Significant ash plume. Ash fall from the 2009 eruption forced the airport in Anchorage to close temporarily (ADN 2009); there were no reports of damage to oil and gas operations in Cook Inlet. Tephra from future eruptions could travel several hundred kilometers from the volcano (carried by prevailing winds to the northeast).
Iliamna	Ice- and snow-covered stratovolcano on the west side of lower Cook Inlet, about 225 km (140 mi) southwest of Anchorage and 113 km (70 mi) southwest of Homer. Peak elevation is 3,053 m (10,016 ft).	No historical activity.	Ash clouds, ash fall and bombs, pyroclastic flows and surges, debris avalanches, and mudflows (lahars) and floods that could inundate drainages on all sides of the volcano.
Augustine	Island stratovolcano in lower Cook Inlet, about 290 km (180 mi) southwest of Anchorage and 120 km (75 mi) southwest of Homer. Peak elevation is 1,260 m (4,134 ft).	Most active volcano in region with significant eruptions in 1812, 1883, 1908, 1935, 1963–1964, 1976, 1986, and 2006.	Ash clouds, ash fall and volcanic bombs, pyroclastic flows and surges, debris avalanches, directed blasts, mudflows (lahars) and floods, volcanic gases, tsunamis, and lava flows. A large avalanche on the volcano's north flank during the 1883 eruption flowed into Cook Inlet and may have initiated a tsunami at Nanwalek, about 90 km (56 mi) to the east.

[a] Volcanoes listed are monitored by the Alaska Volcano Observatory in Anchorage. Other volcanoes in the region west of Cook Inlet include Hayes and Double Glacier. The Hayes volcano is a stratovolcano remnant, almost completely ice-covered; no fumeroles have been observed. Most recent eruptions were more than 3,000 years ago. The Double Glacier volcano is a dome remnant surrounded by the Double Glacier; it is considered to be inactive. There are also numerous unmonitored volcanoes (e.g., Mt. Douglas and Fourpeaked Mountain) on the Alaska Peninsula to the west of the Kodiak Islands.

Sources: USGS 2011b; Waythomas and Waitt 1998; Waythomas et al. 1997; Till et al. 1990.

stored in snowfields and glaciers on the upper flanks of the volcanoes that can generate flooding upon melting. For example, the Redoubt eruption that occurred in 1989–1990 caused significant melting of the Drift Glacier, generating lahars that inundated the Drift River valley and threatened the Drift River Oil Terminal. Oil storage tanks were damaged (although the tanks did not rupture) and loading operations at the terminal (and associated pipeline and platform services) were interrupted for several months, but resumed once a protective dike was installed around the tank farm and support facilities. The interruption in operations at the terminal caused a significant financial impact to the area (Waythomas et al. 1997; ADNR 2009a; Kenai Peninsula Borough 2011). Drainages vulnerable to volcanically induced floods are the Chakachatna River drainage (from Trading Bay to the McArthur River), the Drift River drainage (from Montana Bill Creek to Little Jack Slough), Redoubt Creek, and the Crescent River. The Drift and Chakachatna Rivers are the most likely to host such floods. Volcanogenic mudflows and floods could affect roads and onshore and offshore infrastructure such as pipelines (Combellick et al. 1995; ADNR 2009a).

Other (more distal) volcanic-related hazards include volcanic ash clouds and tsunamis. Volcanic ash is ejected high into the atmosphere and stratosphere by explosive eruptions and drifts downwind, eventually falling to the ground. Hazards related to ashfalls include damage to mechanical and electronic equipment (e.g., engines, computers, and transformers) and, in more rare events, building collapse. Volcanic ashfalls in Cook Inlet are typically less than a few millimeters in thickness and occur with an average frequency of a few every 10 to 20 years (Combellick et al. 1995; ADNR 2009a).

An eruption from Augustine volcano in 1883 caused a debris avalanche that entered Cook Inlet and initiated a tsunami that caused four 4.6 to 9.1 m (15 to 30 ft) waves to hit Nanwalek about 90 km (56 mi) to the east (Waythomas and Waitt 1998; Kenai Peninsula Bureau 2011). Waves of 4.6 m (15 ft) also reportedly struck Port Graham. Boats were swept into the harbor and several residences were flooded, but damage was minor because the tide was low at the time (Kenai Peninsula Bureau 2011). While the risk of coastal damage from locally generated tsunamis is potentially high, the probability of occurrence is low. The configuration of Cook Inlet and its narrow entrances reduce the likelihood that a tsunami generated outside the inlet would create a significant hazard (Bouma and Hampton 1986).

Flooding. The U.S. Geological Survey (USGS) reports that floods in the Cook Inlet drainage basin result from intense, warm rains originating in the Pacific Ocean. They are also caused by the release of water from glacier-dammed lakes or ice jams (and by tsunamis and seiches, discussed in the next section). Nearly all major floods occur between July and early October, but they can also occur during snowmelt season (May to June) if the snowpack is above average (Brabets et al. 1999).

Since streamflow monitoring began in the late 1940s, at least four major floods have occurred in the drainage basin, covering large areas of the basin and causing considerable property damage (Brabets et al. 1999):

- *May 1971*. Snow cover was greater than average along the Alaska Range, and below-normal air temperatures delayed snowmelt until July, creating conditions conducive to flooding. Inundated areas included northeast and west Anchorage and parts of the Susitna and Matanuska River basins.

- *October 1986*. A large Pacific storm system moved onshore over south central Alaska, causing record-setting rainfall that caused flooding in the lower Susitna River Valley, with recurrence intervals greater than 100 years.

- *August 1989*. Record rainfall caused several streams in the Anchorage area to exceed prior record peak discharges. The Knik River also recorded a peak discharge at a 100-year recurrence.

- *September 1995*. Remnants of a tropical storm caused flooding along the Skwentna River, the Knik River and tributaries, the Kenai River, and along Glacier Creeks (Girdwood). Several rivers discharging to Knik Arm had peak flows estimated to have been greater than the 100-year flood.

Other floods in the Cook Inlet drainage basin have occurred from glacier-dam outbursts that result when glacial movement opens a pathway for water trapped behind a glacier to be released. Rivers on the west side of the upper inlet are subject to outburst floods of great magnitude as a result of sudden drainage of large, glacier-dammed lakes; among these are the Beluga, Chakachatna, Middle, McArthur, Big, and Drift Rivers. One of the largest outburst floods occurred in 1969 (and again in 2007) when water released from glacier-dammed Skilak Lake lifted ice on the frozen river and severely scoured the river banks as a surge of water and large chunks of ice travelled downstream. Outburst floods also occur on the Kenai River (east of Cook Inlet) where a glacier-dammed lake at the headwaters of the Snow River fails every two to five years. Historically, the Knik River near Palmer (at the northernmost end of Cook Inlet) has flooded when glacier-dammed Lake George fails. Such floods occur more frequently in the fall and can be especially severe if the lakes or the Kenai River are already high or frozen (Brabets et al. 1999; Combellick et al. 1995; ADNR 2009a; Kenai Peninsula Borough 2011; Post and Mayo 1971).

Ice jam flooding occurs during the spring breakup process when strong ice or constrictions in a river (bends or obstructions like islands or gravel bars) create jam points that cause moving ice along the breakup front to stop (NOAA 2011a). It also occurs when low-density ice masses (frazil ice) become trapped and pile up under surface ice. The ice stoppage causes water levels to rise and flood the adjacent land. Ice jams are more often associated with single-channel rivers in interior and northern Alaska than in rivers of the Cook Inlet drainage basin, but a flood from an ice jam downstream of Skilak Lake in the Kenai River watershed (east of Cook Inlet) occurred in 1969 after an outburst from Skilak Glacier at the head of Skilak Lake, creating a record high river stage (74.25 m [22.63 ft]) and causing severe damage in Soldotna. Ice jams are unpredictable and have the potential to be worse than 100- or 500-year events, causing heavy damage to bridges, piers, levees, jetties, and other structures along the riverbank (Brabets et al. 1999; NOAA 2011a; ADNR 2009a; Kenai Peninsula Borough 2011).

Hazards from flooding result from inundation, riverbank instability and erosion, high bedload transport, deposition at the river mouth, and channel modification and mainly affect onshore facilities (e.g., terminal facilities and pipelines) (ADNR 2009a). Assessing flood potential and community vulnerability is difficult because significant natural and man-made changes occur within floodplains over short time intervals. Federal Emergency Management Agency (FEMA) flood insurance rate mapping updates for Kenai Peninsula Borough are currently under way. A vulnerability assessment to identify the population, property, and environment that may be exposed to flooding is also planned for Seward (Kenai Peninsula Borough 2011).

Tsunamis and Seiches. A tsunami is a series of long ocean waves generated by the displacement of a large volume of water caused by earthquakes, volcanic eruptions, submarine landslides, or onshore landslides that rapidly release large volumes of debris into the water. Most tsunami waves affecting south central Alaska are generated along subduction zones bordering the Pacific Ocean where motion along a dip-slip fault and the elastic rebound of subducting crust, produced by an earthquake of magnitude greater than 6.5 on the Richter scale, causes vertical displacement of the seafloor. The great seismicity associated with the subduction zone of the Aleutian-Alaskan megathrust fault system makes the southern coastal region of Alaska, especially the Gulf of Alaska and the Aleutian Islands, highly susceptible to tsunamis (Costello 1985).

Tsunamis are typically not hazardous to vessels and floating structures on the open ocean because of their small wave heights (less than a few feet). However, they are potentially very damaging to coastal regions and nearshore facilities because wave heights can increase significantly as tsunamis approach shallow water. High, breaking waves that reach the shoreline at high tide cause much more damage than waves that are low and nonbreaking or that occur at low tide (Combellick and Long 1983; MMS 1992).

Because of the shallow, elongated configuration of Cook Inlet and its narrow entrances, the hazard from distant tsunamis is low. The hazard from local tsunamis is also low because there are no active surface faults in the inlet, no adjacent steep slopes to serve as sources of massive slides into the inlet, and no evidence of thick, unstable seafloor deposits that could fail and create massive underwater slides. Local landslide-generated tsunamis, however, can be quite large and potentially damaging, as demonstrated by the series of 4.6 to 9.1 m (15 to 30 ft) waves that reportedly hit Nanwalek and Port Graham on the east side of lower Cook Inlet as a result of a debris avalanche caused by the eruption of Augustine volcano in 1883 (Waythomas and Waitt 1998; Kenai Peninsula Borough 2011). Future eruptions of Augustine could potentially generate a tsunami in lower Cook Inlet if significant volumes of volcanic debris were to enter the sea rapidly (although this remains a topic of debate). Modeling studies indicate that a moderate wave is possible (with lead times of about 27 to 125 min), but the likelihood of a tsunami is considered to be low. None of the last five eruptions of Augustine volcano, including the latest one in 2006, resulted in a tsunami; nevertheless, the West Coast and Alaska Tsunami Warning Center and the Alaska Volcano Observatory continue to refine their public outreach strategy to deal with a volcanogenic tsunami because local consequences of such an event could be high (Neal et al. 2011; Waythomas and Waitt 1998; ADNR 2009a).

Seiches are periodic oscillations of standing waves in partially or completely enclosed water-filled basins like lakes, bays, or rivers triggered by changes in wind stress or atmospheric pressure and, less commonly, by landslides and earthquakes (McCulloch 1966). In Alaska, they may also be generated by the collapse of deltas into deep glacial lakes (Kenai Peninsula Borough 2011). An example is the Lituya Bay earthquake of 1958 (M_W 8.2), which caused a landslide at the head of Lituya Bay (on the Gulf of Alaska) and generated a seiche with a wave run-up of about 530 m (1,750 ft) (MMS 1992; Bouma and Hampton 1986).

During the Great Alaska Earthquake of 1964 (M_W 9.2), tsunamis were generated by uplift of the seafloor and seiches were generated by landslides in semiconfined bays and inlets (USGS 2011b; MMS 1992). Because the Kenai Peninsula is susceptible to earthquakes with magnitudes greater than M 6.0, the Kenai Peninsula Borough mitigation plan rates the coastal communities and facilities in lower Cook Inlet (south of the Forelands) as highly vulnerable to tsunamis — vulnerable communities include Port Graham, Nanwalek, Seldovia, Homer, Anchor Point, and Ninilchik. The tsunami risk for upper Cook Inlet, however, is considered low because of its relatively shallow depth and its distance from the lower end of the inlet (Kenai Peninsula Borough 2011).

4.2.1.3 Alaska – Arctic

4.2.1.3.1 Physiography and Bathymetry. The Arctic region is located along the Arctic coastline of Alaska. It is composed of the Beaufort Sea, Chukchi Sea, and Hope Basin Planning Areas (Figure 4.2.1-6). The Beaufort Sea stretches from the Alaska-Yukon border westward to Point Barrow. Here, the continental shelf has very low relief (on average 1 m/km; Craig et al. 1985) and extends 60 to 120 km (37 to 75 mi) from shore to water depths of 60 to 70 m (200 to 230 ft). Large-scale physiographic features are rare on the shelf, although barrier islands (rising several meters above sea level) and shoals (rising 5 to 10 m [16 to 33 ft] above the seabed) occur in a chain on the inner shelf along the 20-m (66-ft) depth contour, parallel to the shoreline. These features are migrating to the west at rates of about 20 to 30 m (66 to 98 ft) each year (MMS 2008c). Beyond the shelf is the Alaska rise and slope, an area where gravity-driven slope failures greatly influence the seafloor morphology (Grantz et al. 1994).

The Chukchi Sea is a broad embayment of the Arctic Ocean. It lies to the west of the Beaufort Sea, between Point Barrow to the east and Cape Prince of Wales to the west (Figure 4.2.1-6). The continental shelf in this region has low relief and a gentle slope to the north. Water depths range from about 30 to 60 m (98 to 200 ft) on the shelf and drop sharply to greater than 3,000 m (9,800 ft) into the Arctic basin to the north and east. There are several shoals on the shelf. Two prominent shoals, Herald Shoal to the west and Hanna Shoal to the east (at depths less than 20 m [66 ft] below sea level), are separated by a broad area that is about 35 to 40 m (110 to 130 ft) deep with a central channel. Isolated shoals also occur in the nearshore region (along the north and west coasts) in water depths of 20 to 30 m (66 to 98 ft). Hope Basin, a broad and shallow valley with water depths of about 50 m (160 ft), is located to the southwest of Point Hope (MMS 2008c). The outer edge of the shelf is dissected by gullies and large erosional features (Phillips et al. 1988).

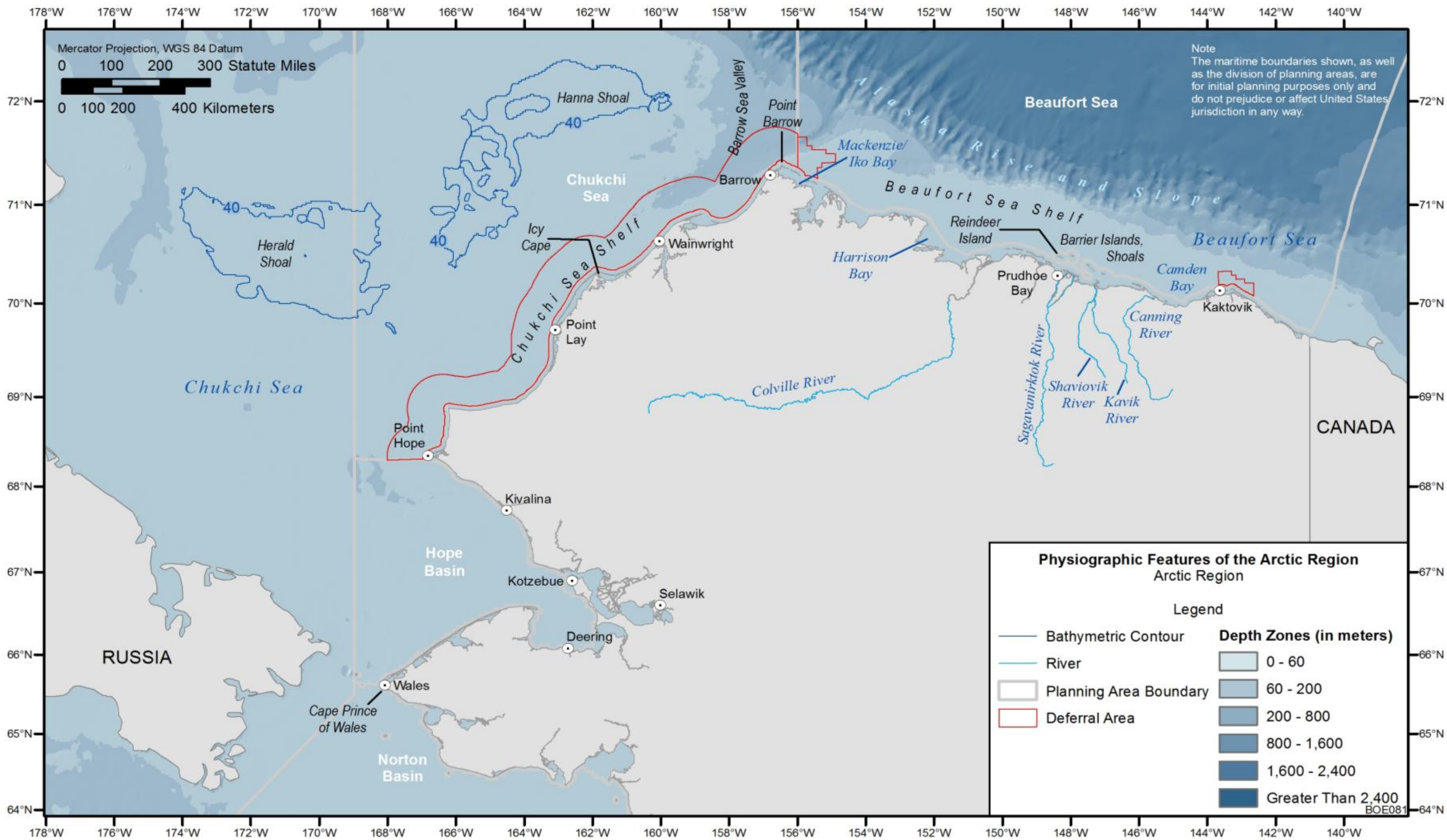

FIGURE 4.2.1-6 Physiographic Features of the Arctic Region

The Beaufort and Chukchi shelves are separated by the Barrow Sea Valley, a 200-km (120-mi) long, flat-bottomed basin incised by fluvial erosion during the Pleistocene epoch and interglacial marine currents (Figure 4.2.1-6). The valley ranges in depths from about 100 to 250 m (330 to 820 ft) (Craig et al. 1985; Phillips et al. 1988).

4.2.1.3.2 Geologic Hazards. Several types of geologic hazards are known to occur in the marine environment of the Beaufort and Chukchi Seas and may present a risk to offshore oil and gas activities because they are dangerous to navigation or potentially damaging to marine structures. The potential geologic hazards in the Arctic region, except for sea ice and permafrost, which are addressed in Sections 4.2.2.1.2 and 4.2.2.2, are described below.

Offshore and Coastal Currents. Marine currents along the central Beaufort shelf are primarily wind-driven and are strongly regulated by the presence or absence of ice. Sediment is transported by these currents along the barrier islands and the coastal promontories, although, because of the short open water season, the annual rate of longshore sediment transport is relatively low. The currents along the inner shelf generally flow to the west in response to the prevailing northeast wind, with current reversals occurring close to shore during storms. Farther from the shoreline, on the open shelf, the currents average between 7 and 10 cm/s (2.8 to 3.9 in./s). During storms, east-flowing currents have been measured with velocities of up to 95 cm/s (37 in./s), although typical storm current velocities are an order of magnitude lower. Under the ice in the winter, the currents are usually less than 2 cm/s (0.79 in./s), although some currents have been measured at up to 25 cm/s (9.8 in./s) in areas around grounded ice blocks (Hopkins and Hartz 1978; ADNR 2009a).

Geostrophic currents occur on the outer shelf, flowing parallel to the shelf-slope break. These currents have been measured at velocities of up to 50 cm/s (20 in./s) and can travel in both easterly and westerly directions. Since the tidal range on the central Beaufort shelf is small, approximately 15 to 30 cm (5.9 to 12 in.), the tidal currents exert only minor influences on the sedimentary regime. When the water flow on the shelf is restricted by bottomfast ice, these currents can act as important scouring agents (Craig et al. 1985; ADNR 2009a).

Offshore structures must be designed to withstand strong marine currents, loading from ice forces, and severe storms in the Beaufort Sea. Production platforms will typically be bottom-founded (gravity base) to withstand conditions that change with the seasons. Drillships for exploration are not bottom-founded; therefore, they can only operate in low ice cover conditions. Artificial or natural gravel islands must be fortified and built to withstand coastal currents as well as the forces of moving sea ice for the lifespan of the producing field. To this end, they may require periodic maintenance in response to heavy storms (ADNR 2009a).

Flooding. Floods due to seasonal snowmelt and ice jams occur annually along most of the rivers in the Arctic region and many of the adjacent low terraces. Spring ice breakup on rivers often occurs over the first few days of a three-week period of flooding in late May through early June. Up to 80% of the flow occurs during this period. The impact of flooding is in large part related to the magnitude and timing of seasonal ice breakup. The formation of ice jams is especially associated with catastrophic flooding. Some of the most damaging floods are associated with an above-average snowpack that is melted by rainstorms and sudden warming (ADNR 2009a).

Significant bank erosion may occur during flooding, depending on the amount of water and its level with respect to the river bank and the nature of the sediment (or ice) load. Ice carried along by rivers can produce significant erosion, especially if breakup occurs during a low river stage. Spring floodwaters inundate large areas of the deltas, and on reaching the coast spread over stable ground and floating ice up to 30 km (19 mi) from shore. When floodwater reaches openings in the ice often associated with tidal cracks, thermal cracks, and seal breathing holes, it rushes through with enough force to scour the bottom to depths of several meters (a process known as strudel scouring) (ADNR 2009a).

Along the Beaufort shelf, strudel scour craters have formed up to 6 m (20 ft) deep and 20 m (66 ft) across. In a study for the Northstar Pipeline, strudel scours were found in water depths of 2.2 to 5.4 m (7.2 to 18 ft), with the greatest scour occurring at depths of 3 to 4 m (9.8 to 13 ft). Sheltered coastal areas and bays adjacent to major rivers (such as the Colville, Sagavanirktok, and Canning) are particularly susceptible to strudel scouring. In these areas, deltas can be totally reworked by strudel scouring in several thousand years, although the scours can be filled in very rapidly (ADNR 2009a).

In addition to seasonal flooding, many rivers along the coast are subject to seasonal icing before spring thaw. This is due to overflow of the stream or groundwater under pressure, often where frozen or impermeable bed sections force the winter flow to the surface to freeze in a series of thin overflows, or where spring-fed tributaries overflow wide braided rivers. In areas of repeated overflow, residual ice sheets often become thick enough to extend beyond the floodplain margin. These large overflows and residual ice sheets have been documented on the Sagavanirktok, Shaviovik, Kavik, and Canning Rivers (ADNR 2009a).

Seasonal flooding of lowlands and river channels is extensive along major rivers of the Arctic region. Thus, measures must be taken before facility construction and field development to prevent impacts on structures and environmental damage (ADNR 2009a).

Barrier Island and Bedform Migration. Barrier islands along the Beaufort shelf consist of dynamic constructional islands and remnants of the Arctic coastal plain (ACP). As the barrier islands along the Beaufort shelf are migrating westward and landward due to erosion and redeposition by waves and currents, they are generally becoming narrower and breaking up into smaller segments (Hopins and Hartz 1978). During the open water season, longshore drift, storm surges, and ice push contribute to the erosion, migration, and breakup of these islands, which may permanently affect their size and influence on coastal processes.

Along the Chukchi shelf, asymmetrical bedform features, including small sand waves, larger shore-parallel shoals, and the grouped features of the Blossom Shoals, occur in water depths ranging from less than 15 m (50 ft) to approximately 60 m (200 ft) and extend to distances of up to 160 km (100 mi) offshore. The migration of sand waves and other bedforms can cause problems to offshore facilities by undermining or burying fixed structures, anchors, moorings for submersibles, and pipelines, which can rupture (Bouma and Hampton 1986).

Overpressured Sediments. Along the Beaufort and Chukchi shelves, extremely high pore pressures are likely to be found in deep basins (Kaktovik, Camden, and Nuwuk) where Cenozoic strata are very thick. For example, in the Point Thomson area, pore pressure gradients as high as 0.8 psi/ft (far exceeding the normal gradient of 0.433 psi/ft) have been measured in sediments at burial depths of 4,000 m (13,100 ft) (Craig et al. 1985; ADNR 2009a).

Encountering overpressured sediments during drilling can result in a loss of well control or uncontrolled flow (if formation pressures exceed the weight of drilling mud in the well bore). Identifying locations of overpressured sediments by seismic data analysis and adjusting the drilling mud mixture accordingly reduce this risk (ADNR 2009a).

Shallow Gas Deposits and Natural Gas Hydrates. Shallow gas deposits have been mapped using high-resolution seismic data in isolated areas within the continental shelf and slope regions of the Beaufort and Chukchi Seas. A recent investigation by the Joint Russian-American Long-Term Census of the Arctic Project team identified a pockmark field on the Chukchi Plateau. The pockmarks are typically related to the explosive release of gas (or gas-saturated water or oil)[12] (Astakhov et al. 2010). On the middle and inner shelf, gas is concentrated in buried Pleistocene delta and channel systems, along active faults overlying natural gas sources, and in pockets within and beneath permafrost very near to shore. On the outer shelf and slope, shallow gas is likely to occur in association with a large body of gas hydrate and at the head of the landslide terrain on the outermost region of the shelf and upper slope. The origins of shallow gas may be biogenic or thermogenic; in either case, its presence poses a hazard to bottom-founded structures because it can reduce the shear strength of sediments. Loss of well control may also occur when drilling operations encounter overpressured gas below the seabed (Grantz et al. 1982a, b; ADNR 1999).

Natural gas hydrates are unique compounds consisting of ice-like substances composed of gas trapped by water molecules. They are common in offshore regions under low-temperature, high-pressure conditions as well as at shallower depths associated with permafrost. In the Beaufort and Chukchi Seas, gas hydrates have been found at shallow depths under permafrost along the inner shelf and onshore at Prudhoe Bay and at the Mount Elbert well in Milne Point where downhole coring and logging operations were recently completed (ADNR 2009a).

One of the main problems associated with gas hydrates is dissociation, which causes unstable conditions by increasing fluid pressure and reducing sediment shear strength. Natural mechanisms leading to gas hydrate dissociation include sea level decrease and sediment temperature increase. Man-made mechanisms include heat transfer during petroleum production that leads to melting of hydrates. During drilling, rapid decomposition of gas hydrates can cause a rapid increase in pressure in the wellbore, gasification of the drilling mud, and the possible loss of well control. If the release of the hydrate gas is too rapid, a loss of well control can occur, and the escaping gas could ignite. In addition, the flow of hot hydrocarbons past a hydrate layer

[12] On the Chukchi Plateau, pockmarks may indicate areas of rapid gas release; however, their size and morphology are also consistent with thermokarst depressions developed along the Arctic shoreline (Astakhov et al. 2010).

could result in hydrate decomposition around the wellbore and loss of strength of the affected sediments (ADNR 2009a).

Dissociation of gas hydrates is a potential cause of submarine slope failures. Acoustic records indicate a stretch of slumps in the Beaufort Sea along the shelf-edge break. The slumps extend for at least 500 km (310 mi) in an area of known gas hydrates and should be considered during exploration and development activities (ADNR 2009a).

Because gas hydrates and shallow gas deposits pose risks similar to overpressured sediments, the same mechanisms for well control should be employed to reduce the danger of loss of life or damage to the environment (ADNR 2009a).

Sediment Sliding, Slumping, and Subsidence. Locally high rates of deposition of unconsolidated sediments on the increased gradient of the continental shelf edge may form unstable slopes that lead to intensive soil movements such as slumping, gravitational creep, turbidity or debris flows, and mudslides. A chaotic sediment slide terrane exists along the length of the Beaufort shelf and upper slope, seaward to the 50- to 60-m (160- to 200-ft) isobath. The distinct landslide types in this area include large bedding-plane slides and block glides. Sediment slumping, possibly associated with permafrost melting, has been observed north of the Mackenzie Delta in Canadian waters and may also disrupt buried pipelines and damage drilling structures (Grantz et al. 1982b).

Sediment slumping may also occur in association with active faulting. Regionally high rates of deposition on the continental shelf may cause isostatic adjustments and deep-seated gravity faulting (active faulting). Active gravity faults related to large rotational slump blocks occur on the outer Beaufort shelf and upper slope due to increased gradients along the shelf-slope break (Grantz and Dinter 1980).

Seismicity. Ground shaking during a major earthquake can cause consolidation problems in artificial gravel islands used as drilling platforms and affect bottom-founded structures. Earthquakes can also cause vertical and/or horizontal displacement along faults, uplift or subsidence, surface tilt, ground failure, and inundation (due to tsunamis) — all of which may affect the integrity of development infrastructure.

Several types of shallow faults occur on the Beaufort shelf, including high-angle, basement-involved normal faults (Barrow Arch in Harrison Bay); listric growth faults; and down-to-the-north gravity faults along the shelf-slope break. There has been no seismicity associated with the high-angle faults in Harrison Bay in recent times (Holocene) and there is little evidence of Quaternary movement,[13] but these faults may act as conduits for gas migration. Slow movement (creep) and detachment occurring along listric growth faults could affect the integrity of infrastructure over time (Grantz et al. 1982a, b; Craig et al. 1985).

[13] Craig and Thrasher (1982) conclude that the upper extent of shallow faults in Harrison Bay is uncertain based on seismic data. The irregular surface of Pleistocene (Quaternary) sediments and the ice-gouged nature of the seafloor obscure any fault displacement of these sediments. Most faults terminate below the unconformity marking the Cretaceous-Pleistocene contact; therefore, tectonic activity is likely to have occurred only infrequently (if at all) in the Quaternary.

The Camden Bay area, located at the northern end of a north-northeast trending band of seismicity extending northward from east-central Alaska, is seismically active, and near-surface faults show marked evidence of Quaternary movement. Since monitoring began in 1978, numerous earthquakes ranging in magnitude from 1 to 6 have occurred in the area along the axis of the northeast-southwest trending Camden anticline (Craig et al. 1985; Grantz et al. 1982a, b).

Sediment-covered fault scarps in the northern Chukchi Sea suggest Quaternary movement along faults in this region (Thurston and Theiss 1987; Grantz et al. 1982a).

A search of the Alaska Earthquake Information Center (AEIC) database for the Chukchi Sea coastal zone region (including Wainwright) found that 303 earthquakes with magnitudes ranging from less than M 2.0 to M 5.3 occurred between January 1, 1898, and October 31, 2011. Most of these earthquakes (172, or about 57%) measured less than M 3.0; another 35 (or about 12%) measured M 4.0 or greater. Earthquakes with M 5.0 or greater occurred in 1968, 1993, 1995, 2006, and 2007 (AEIC 2012).

Earthquakes are frequently felt on the Russian Chukchi Peninsula (also known as the Chukotka Peninsula), especially along the coastal zone of the Chukchi Sea. The USSR has published a map of seismic zonation in which it places Chukotka Peninsula in a 6 to 7 MSK[14] zone (Avetisov 1996). A 6 to 7 MSK zone is rated as strong to very strong with serious damage to buildings in poor condition and isolated cracks in soft ground and landslides on steep slopes (Alden 2012).

The region along Alaska's northern coast lies within an area where the peak horizontal acceleration with a 10% probability of exceedance in 50 years is between 0.03 and 0.07 g (Wesson et al. 2007). Shaking associated with this level of acceleration is generally perceived as weak, and the potential for damage to structures is negligible (Wald et al. 2006).

4.2.2 Sea Ice and Permafrost

4.2.2.1 Sea Ice

4.2.2.1.1 Cook Inlet. Ice cover in Cook Inlet is seasonal, forming in the fall (October to November, although the lower inlet is usually still ice-free in December) and disappearing completely in the spring. However, the dates of onset and clearance can vary considerably from year to year. The U.S. Army Corps of Engineers' (USACE) report *Marine Ice Atlas for Cook Inlet, Alaska* (Mulherin et al. 2001) provides a description of the factors that favor and discourage ice growth. It notes that offshore platforms built in Cook Inlet follow ice design criteria specified by the American Petroleum Institute. Since 1984, the National Weather

[14] MSK is the Medvedev-Sponheuer-Karnik scale of seismic intensity that has been in use in Europe and India since 1964 (Alden 2012).

Service (NWS) has provided analysis and forecasts for the extent, concentration, and stage of development of ice to aid commercial navigation, as well as fishing and tourist activities in the inlet (NWS ice chart archives are maintained by the Alaska State Climate Center in Anchorage); the National Ice Center also prepares semiweekly analyses throughout the ice season.

There are four types of ice that form in Cook Inlet: pack ice, shorefast ice, stamukhi, and estuarine and river ice. Pack ice is freely floating sea ice that forms directly from the freezing of seawater. In the shallow and turbulent waters of Cook Inlet, a major component of pack ice is "frazil" ice, which occurs as low-density masses of slushy, unconsolidated ice on the water surface. Floating ice poses the greatest hazard to navigation and marine structures. Between 1964 and 1986, at least eight incidents involving sea ice in Cook Inlet were recorded by the U.S. Coast Guard (USCG), most resulting in damaged pilings and docks in the Port of Anchorage area. In 1988, a small crude oil spill resulted when a tanker was punctured by ice. Several similar ice-related incidents have been recorded since then (Mulherin et al. 2001).

Shorefast ice is unmoving ice that remains firmly attached to the shoreline or other stationary structures once it forms. It forms directly by the freezing of seawater and from the piling and refreezing of ice or the flooding of snow on top of the ice. One form of shorefast ice, "beach ice," forms during flood tide as water freezes with mud and bonds to the sea bottom. When the air temperature is colder than seawater, this ice becomes progressively thicker with each successive high tide, accumulating as much as 2.5 cm (1 in.) of ice per tidal flood. The ice usually breaks free before it reaches about 0.5 m (1.6 ft) in thickness. Once freed, it becomes floating (pack) ice and drifts into deeper water (Mulherin et al. 2001).

Stamukhi are a form of sea ice that have broken and piled upward (hummocked) due to winds, tides, or thermal expansion. Under the right conditions (e.g., repeated wetting and accretion of seawater), they form the massive ice blocks (ice cakes) common to Cook Inlet. Stamukhi as thick as 12 m (40 ft) have been reported. Their large size makes them very hazardous to shipping vessels (Mulherin et al. 2001).

Much of the ice in Cook Inlet derives from freshwater sources — estuaries and rivers — especially in the head region and upper inlet. Estuarine ice is similar to sea ice but is significantly stronger. It is commonly entrained in pack ice and presents the same hazards to navigation and marine (shoreline) structures. River ice is discharged into the inlet during spring breakup; ice pieces can be as thick as 2 m (6.7 ft) (Mulherin et al. 2001).

4.2.2.1.2 Arctic Region. The Beaufort shelf is ice-covered between mid-October and mid-June, with a typical ice-free period during August and September. Sea ice begins forming in late September to early October and becomes continuous nearshore by mid-October. This ice remains through the winter and starts to break up in July, but the nearshore region is not ice-free until early August. In recent years, breakup has occurred earlier by as many as 21 and 6 days along the Beaufort and Chukchi coasts, respectively. Ice-free coastlines now occur over a month earlier along the Beaufort coast (ADNR 2009a; MMS 2008c).

During the winter months, ice occurs within three main nearshore and offshore zones: the landfast zone, the shear zone (also called the active or stamukhi zone), and the pack ice zone. Landfast ice forms along the shore and develops seaward in the early fall, extending 25 to 50 km (16 to 31 mi) from shore by late winter. This ice is up to 2 m (6.6 ft) thick and is considered stable because it is relatively stationary (moving less than a few meters after it forms). Small movements of the ice are related to storm fronts, which cause narrow leads and rubble fields in this zone (Reimnitz and Barnes 1974; MMS 2008c; ADNR 2009a).

The shear zone (stamukhi zone) is a transitional zone between landfast ice and the highly mobile pack ice, occurring approximately 20 to 60 km (12 to 37 mi) from the coast in water depths of about 20 to 100 m (60 to 330 ft). Fragments of seasonal ice and multiyear ice ridges are common in this zone. Ice ridges range in thickness from 10 to 12 m (33 to 39 ft) with an average thickness of 6 m (20 ft). It is here where ice is constantly being reworked and shifted and ice gouging (discussed below) occurs most intensely (ADNR 2009a; MMS 2008c).

Seaward of the stamukhi zone is the pack ice zone, which marks the shoreward edge of the permanent polar ice cap. It consists of multiyear ice, ice ridges, and ice island fragments that migrate westward in response to the clockwise circumpolar gyre (Reimnitz and Barnes 1974; ADNR 2009a). The drift rate of ice in this zone can be as high as 20 km/day (12 mi/day) (MMS 2008c).

The Chukchi shelf is largely covered by ice between mid-November and mid-June; August and September are typically ice-free. Ice thicknesses in the region are generally less than 1.2 to 1.4 m (3.9 to 4.6 ft) during the annual cycle. Multiyear ice is common in the Chukchi Sea; extensive ridging (with a ridge frequency of 3 to 5 per kilometer and sail heights of 1.5 to 3.7 m [4.9 to 12 ft]) is also common (MMS 2008c).

Sea ice poses a potential hazard to coastal and offshore structures; for example, concrete island drilling structures could be pushed off location, ice could override a fixed structure, or a marine pipeline could be damaged where it comes ashore. Facilities exposed to the potential risks of each sea ice zone must be designed and fortified to accommodate ice forces (ADNR 2009a).

Ice Scouring (Ice Gouging and Strudel Scour). The continental shelf below the Beaufort and Chukchi Seas is vulnerable to ice gouging and strudel scour, both of which must be taken into consideration when siting and designing subsea pipelines. Ice gouging results when ice ridges or icebergs with deep keels, moving under the influence of forces such as wind and ocean currents, run aground and penetrate the seabed, leaving linear to curvilinear deep furrows. Strudel scour occurs in relatively shallow water in the spring during river breakup when overflood waters spreading over bottomfast ice sheets and draining with high velocity through holes in the ice sheet (e.g., tidal cracks, thermal cracks, and seal breathing holes) erode the underlying sediments, leaving behind circular or linear areas of scour in the seabed. The magnitude and frequency of strudel scour events are affected by the timing and location of overflooding river discharge (and the effects of ice jams) and the types of surface features present (e.g., drainage cracks and fissures). Pipelines should be trenched to depths below the predicted scour depth and should be designed to withstand the forces associated with the gouging process, which can cause significant soil displacement (MMS 2008c; ADNR 2009a).

Although ice gouges are found across the entire Beaufort shelf, they are concentrated in the stamuhki zone, between the 10- and 30-m (33- and 98-ft) depth contours, with the most intense gouging on the up-drift side of shoals and islands bordering the stamuhki zone. In this region, crossing frequencies of 1 to 6 gouges/km/yr and a maximum gouge depth of 3.9 m (13 ft) have been reported. Ice gouges have a general east-west orientation, reflecting the prevailing wind and surface current directions; however, on the inner shelf where shoals and other bottom features deflect the ice, orientations are more variable. Off Prudhoe Bay, the inner boundary of high-intensity ice gouging is controlled by the location of the island chains, about 15 to 20 km (9.3 to 12 mi) offshore. In Harrison Bay, where there are no barrier islands, ice gouges are concentrated in areas of abundant ice ridge formation (MMS 2008c; Craig et al. 1985).

Ice gouging is less frequent inshore of the stamuhki zone (with reported crossing frequencies ranging from 1 to 2 gouges/km/yr) (MMS 2008c). It is also less severe in this region because gouges are rapidly buried by sand waves or sediment sheets (loose, coarser grained sediments in the nearshore region degrade more rapidly than the more cohesive, fine-grained sediments offshore). The incidence of ice gouging also decreases with increasing water depth offshore of the stamuhki zone since the number of ice keels large enough to reach the bottom decreases. Along the outer shelf edge, strong geostrophic currents smooth the older ice gouges by eroding or filling them in (ADNR 2009a).

Little survey data on ice gouging features are available for the Chukchi Sea, and repetitive mapping that would allow observed gouges to be dated and gouge rates to be estimated has not been done. However, gouge geometry (depth and width) and density have been recorded over broad areas in the Chukchi Sea, to a maximum water depth of 60 m (200 ft). The most significant ice gouging occurs on the main part of the continental shelf at water depths of 30 to 60 m (98 to 200 ft) where surficial sediments consist of thin deposits of sand and gravel overlying stiff consolidated clay or dense sandy gravel. In this region, a maximum gouge depth of 4.5 m (15 ft) was observed within a water depth of 35 to 40 m (110 to 130 ft). Gouges may be many kilometers long and tens of meters wide, and their dominant orientation is northeast-southwest (MMS 2008c; Phillips et al. 1988).

The areas adjacent to the Herald and Hanna shoals have only limited ice gouging (no gouge depths were recorded). Nearshore areas where water is shallow (less than 30 m [98 ft]) have an average gouge depth of 0.8 m (2.6 ft) and also have a low ice gouging density (MMS 2008c; Toimil 1978). Nearshore sediments are reworked by waves and currents to the extent that ice gouge morphology is readily obliterated by erosion and/or burial (Barnes and Reimnitz 1979). In general, ice gouging is more prevalent in the northern part of Chukchi Sea because the extent and duration of ice cover is greater. In the southern part of the Sea, the longer open water season allows for more reworking of the seabed by wave and current action, which likely masks evidence of past gouging (MMS 2008c).

Ice Movement (Ice Ride-up, Ice Override, and Icebergs). Continuous, large-scale ice movements in the Beaufort Sea are caused by major current systems (e.g., the Beaufort Gyre), tidal currents, or geostrophic winds. Local, short-term movements result mainly from wind, wave, and current action, particularly during storms. During a single ice season, ice movements create zones of landfast and pack ice. Zone boundaries fluctuate with seasonal ice growth and movement. Ice movements at a given site may have a predominant direction due to geography and environmental conditions (ADNR 2009a).

On islands and coastal regions throughout the Beaufort Sea, both ice ride-up (or ice push) and ice override events erode and transport significant amounts of sediment. Ice ride-up occurs where strong wind or currents force ice blocks onshore, pushing the sediment from the coast into the ridges farther inland. These processes are particularly important to consider for the outer barrier islands, where ice ride-up ridges may be as high as 2.5 m (8.2 ft) and extend 100 m (330 ft) inland, and where man-made structures are along the coast. They also have the potential to alter shorelines and nearshore bathymetry, increasing the risk of damage to man-made structures by erosion. Several accounts of damage to structures due to ice ride-up events have been documented along the Beaufort coast. For example, in January 1984, ice overtopped the Kadluck, an 8-m (26-ft) high caisson-retained drilling island located in Mackenzie Bay (MMS 2003e; ADNR 2009a).

Ice override occurs both offshore and onshore wherever ice overrides rafted ice or ice ride-ups along the coastline. Ice override onshore will add an additional dead load to a buried pipeline in the transition area from offshore to onshore beginning where the ice contacts the sea floor. This dead load, along with the force being exerted by the ice and the strength of soil, must be considered in pipeline design (ADNR 2009a).

Icebergs in the Beaufort Sea are rare but may be present as a result of calving off Nansen Island. Natural ice islands have also been observed on occasion. Ice islands are produced by the breakup of portions of the Ellesmere Ice Shelf and occur as tabular icebergs of the Arctic Ocean. They are usually 40 to 50 m (130 to 160 ft) thick with lateral dimensions that range from tens of meters to tens of kilometers. The annual risk of an iceberg or ice island impacting an offshore production facility is estimated to be 1 in 1,000 years; however, there is no threat to exploration or development activities in more shallow, nearshore regions (MMS 2008c; ADNR 2009a).

4.2.2.2 Subsea and Coastal Permafrost (Arctic Region)

The presence of subsea permafrost has been confirmed in several nearshore areas of the Beaufort shelf, where the onshore Pleistocene section and upper portions of the Brookian sequence (with a permafrost layer of up to 460 m [1,500 ft] thick) is thought to continue northward beneath the Beaufort shelf, grading into unfrozen strata farther offshore (and thinning to the west toward the Chukchi Sea). Seismic data indicates that subsea permafrost occurs at least 15 km (9.3 mi) north of Reindeer Island and at least 25 km (16 mi) offshore of Harrison Bay. Depths to permafrost vary, but wells drilled on Reindeer Island encountered two layers of ice-bonded sediments — an upper layer from 0 to 18.9 m (0 to 62 ft) and a lower layer from 91 to 128 m (300 to 420 ft). Investigators have suggested that the lower layer represents relict Pleistocene permafrost, while the upper layer was likely formed under modern Arctic conditions (Craig et al. 1985).

Permafrost along the coast of the Chukchi Sea is sparse or nonexistent, and the extent and distribution of subsea permafrost is largely unknown. Although the presence of subsea permafrost has not been determined from most seismic data collected from the Chukchi Sea, ice-bonded sediments were detected in seismic data collected in 5 m- (16 ft-)deep water north of Icy Cape, midway between Point Lay and Wainwright (MMS 2007b). Temperature gradients measured by Osterkamp and Harrison (1982) in shallow boreholes (less than 50 m, or 164 ft) along the southern Chukchi Sea coastline near Wainwright and Barrow indicate that the shoreline is generally stable and that ice-bearing subsea permafrost in the southern Chukchi Sea is thin or absent beyond a 1.0 km (0.62 mi) distance offshore. The absence of offshore permafrost is attributed to either melting by relatively warm currents moving north from the Bering Sea or the presence of near-surface consolidated rock that inhibited permafrost from developing in the first place (MMS 2007b).

Thaw subsidence (also known as thermokarst subsidence) and frost heave associated with permafrost in the Arctic region can create potential hazards to onshore oil and gas operations, especially for foundations, gravel excavation, and pipeline routing (Craig et al. 1985). The geologic record during the last Arctic glacial-to-interglacial transition indicates that global warming played a key role in disrupting the thermal balance of permafrost and initiating regional thaw subsidence. And some of the thermokarst activity (e.g., melting of ice wedges) over the last 100 to 150 years can also be attributed to global warming (Murton 2008). Oil and gas-related activities may also contribute to this process. These include drilling through permafrost layers; building and maintaining crude oil pipelines; placement and operation of bottom-founded structures; and construction of artificial islands, causeways, and berms. Subsea permafrost that contains trapped gas may melt during the drilling of wells or the subsequent production activities in areas surrounding the borehole, causing subsidence and rupture of the well casings and potentially leading to loss of well control.

4.2.3 Physical Oceanography

4.2.3.1 Gulf of Mexico

The physical conditions of ocean waters have the potential to disrupt activities relating to oil and gas production that occur on the continental shelf and slope, as well as in deepwater regions of the GOM. Coherent water motions and breaking waves can fatigue and damage oil and gas platforms and facilities, limit the timing of supply boats and drilling operations, and suspend all operations during extreme conditions such as hurricanes or tropical storms (MMS 2005a; Kaiser and Pulsipher 2007). As waves approach deck heights of platforms and supply ships, they can put equipment and personnel at risk (MMS 2005b). Storm events can also produce large forces near the ocean bottom that can scour sediments and affect pipelines and platform structures (DNV 2007; Cruz and Krausmann 2008; Wijesekera et al. 2010). Additionally, water currents and waves affect the horizontal and vertical transport of spilled oil, as well as contribute to the physical conditions that control natural weathering processes such as evaporation, emulsification, and oxidation (NOAA 2002; NRC 2003b).

The GOM is a partially enclosed sea covering an area of approximately 1.5 million km^2 (579,153 mi^2) and is connected to the Caribbean Sea and the Atlantic Ocean. The bathymetry of the GOM can be generalized as having a wide continental shelf along its northern and southern edges, prominent escarpments, and a relatively flat ocean floor (Bouma and Roberts 1990; see Figure 4.2.1-1. Circulation patterns in the GOM are the result of complex interactions among the bathymetry of the basin and forcing mechanisms that include winds, atmospheric conditions, water density (related to temperature and salinity), and the Loop Current (described below) (e.g., Oey et al. 2004; Sturges and Kenyos 2008). The GOM can be characterized as a two-layered system with respect to circulation patterns having a surface layer of up to 1,000 m (3,281 ft) in depth and a deep layer reaching down to the ocean floor at depths of approximately 4,000 m (13, 123 ft) (Lugo-Fernandez and Green 2011).

A generalized depiction of major, depth-averaged circulation patterns and bathymetry of the GOM is shown in Figure 4.2.3-1. The Loop Current and its associated mesoscale eddies are the dominant circulation features (Oey et al. 2005). Effects associated with Earth's rotation set up a western boundary current that is a part of an anticyclonic (clockwise) circulation pattern found in the western half of the GOM (Sturges and Blaha 1975; Sturges 1993). Over the continental shelf of Texas and Louisiana, wind-driven downcoast currents are common, with an opposite current along the continental slope (Cochrane and Kelly 1986; Nowlin et al. 1998; Zavala-Hidalgo et al. 2003). Currents along the continental shelf off Mississippi-Alabama show a pattern of complex cyclonic and anticyclonic eddy pairs with strong inter-annual variability, and they are also influenced by the positioning of the Loop Current (Brooks and Giammona 1991; Jochens et al. 2002). Deepwater circulation follows a counterclockwise pattern and consists primarily of low-frequency waves that receive energy from the Loop Current and its eddies (Hamilton 1990, 2007). In addition to depth-averaged circulation patterns, surface circulation patterns that are primarily driven by winds, as well as heat fluxes and river flows, are important to oil and gas operations, especially with respect to forecasting oil spill trajectories (Ji et al. 2011). Figure 4.3.2-2 shows seasonal averages and the annual mean of surface current patterns in the GOM from 1993 to 1998.

Understanding the circulation patterns and physical oceanographic conditions is vital for improving oil and gas production and exploration activities with respect to preserving the environment (Ji 2004; Lugo-Fernandez and Green 2011). In the GOM, the energetic water currents and waves that have the greatest potential to affect oil and gas activities can be characterized as those associated with episodic weather events (e.g., hurricanes and tropical storms), large-scale circulation patterns including the Loop Current and its associated mesoscale eddies, vertically coherent deepwater currents, and high-speed jets (DiMarco et al. 2004).

4.2.3.1.1 Hurricanes and Tropical Storms. Tropical conditions normally prevail over the GOM from June until October, and in a typical year, 11 tropical storms will form in the region with approximately 6 reaching hurricane status (Blake et al. 2007). Hurricanes and tropical storms can increase surface current speeds to between 1 and 2 m/s (3.2 and 6.8 ft/s) in continental shelf regions (Nowlin et al. 1998; Teague et al. 2007), as well as produce current speeds of more than 0.5 m/s (1.6 ft/s) in deeper waters on the continental slope (Brooks 1983; Teague et al. 2007). Recorded wave heights during recent hurricanes have shown an increasing

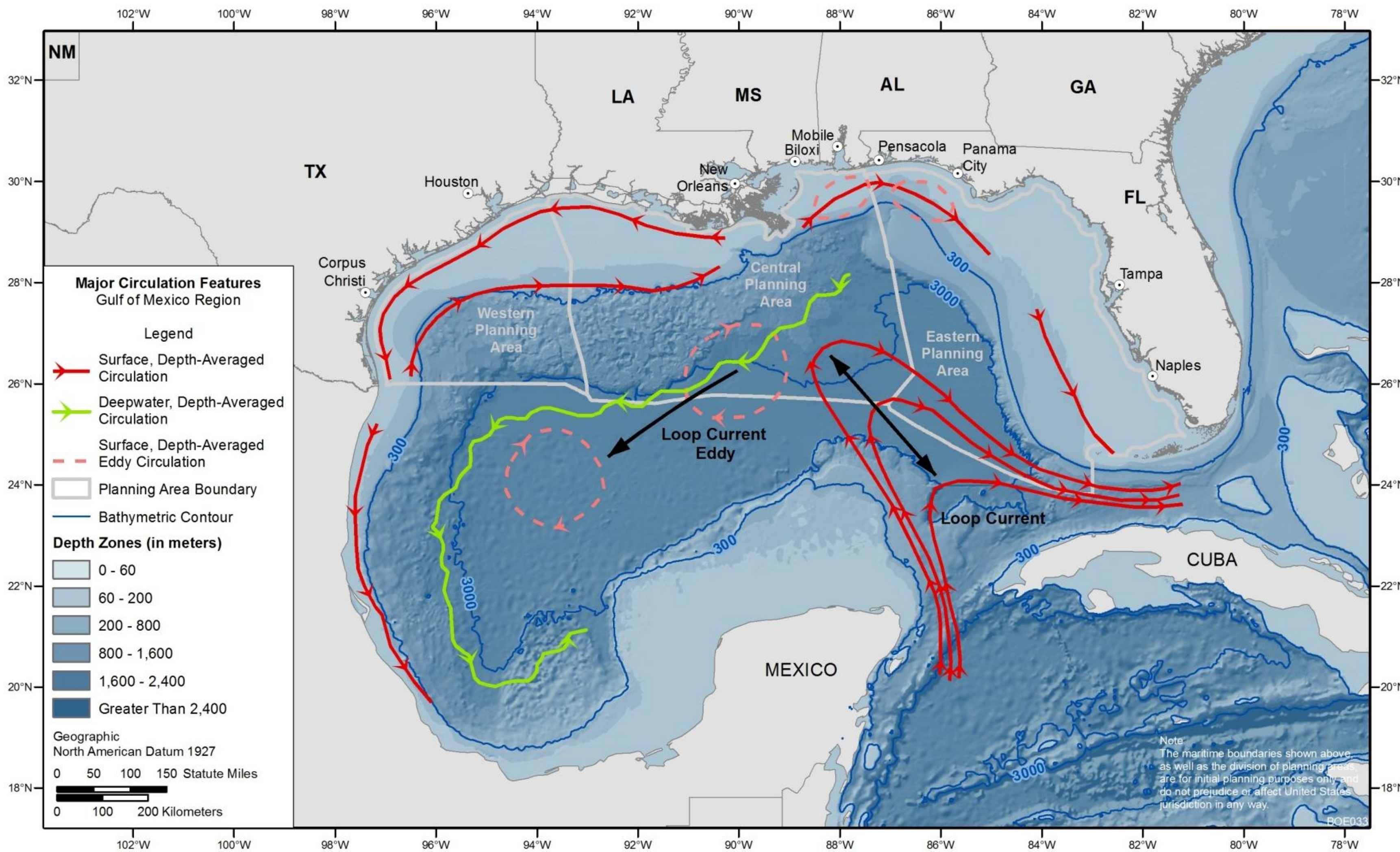

FIGURE 4.2.3-1 Generalized, Depth-Averaged Circulation Patterns in the GOM

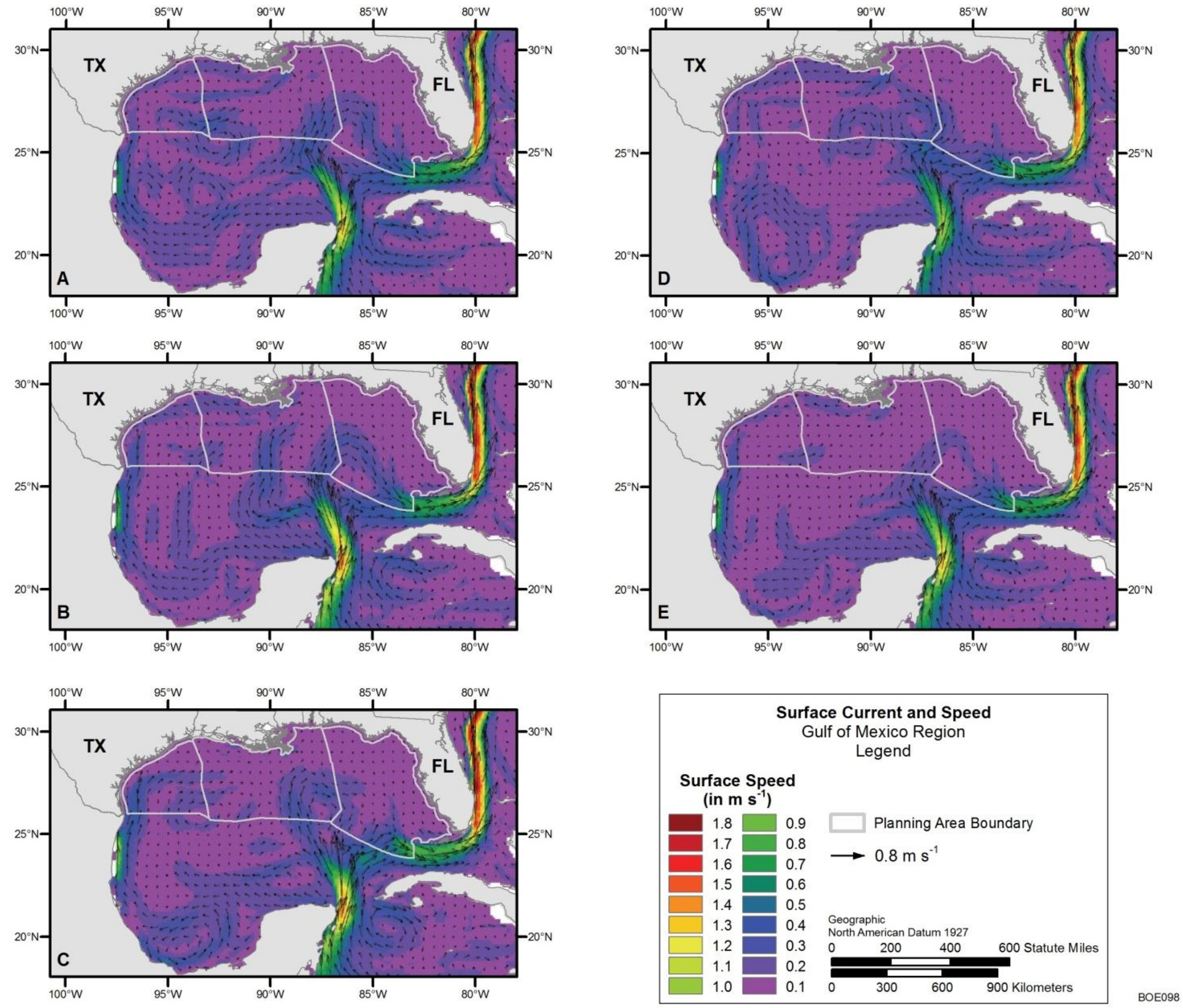

FIGURE 4.2.3-2 Surface Circulation Patterns in the GOM from 1993 to 1998: (a) Winter (January–March), (b) Spring (April–June), (c) Summer (July–September), (d) Fall (October–December), and (e) Annual Mean (January–December) (units are in m/s) (Ji et al. 2011)

pattern, with maximum wave heights exceeding 30 m (98 ft), which are greater than the current 100-year storm criteria for platform deck heights (MMS 2005b; Jeong and Panchang 2008). Storm surges can impact infrastructure along coasts and have been reported to range between 2 and 8 m (7 and 26 ft) for hurricanes reaching the northern coast of the GOM (NOAA 2011b).

Extensive observations of hurricane-induced currents and waves were not available until recent years, starting with Hurricane Ivan in 2004, which passed over an extensive array of instrumented moorings of the U.S. Naval Research Laboratory's Slope to Shelf Energetics and Exchange Dynamics (SEED) program (Stone et al. 2005; Teague et al. 2006a). As Hurricane Ivan approached the northern GOM in the fall of 2004, wind stresses produced downwelling conditions on the continental shelf with advective onshore surface currents and offshore currents in the lower portion of the water column (Mitchell et al. 2005; Teague et al. 2007). Current speeds on the continental shelf were often greater than 1.1 m/s (3.6 ft/s) with many flow reversals during the passage of the hurricane, and strong waves prevailed for up to 10 days in the wake of the hurricane's passage (Teague et al. 2007; Wijesekera et al. 2010). Sediment scour on the continental shelf was observed to be more than 100 million m^3 (81071 ac-ft) over a region of 525 km^2 (203 mi^2) (Teague et al. 2006b). Maximum wave heights associated with Hurricane Ivan reached 28 m (92 ft) with significant wave heights (average wave height of the upper-third-largest waves) reach 16 m (52 ft) (Jeong and Panchang 2008).

Hurricanes Ivan, Katrina, and Rita (2004 and 2005) were some of the most powerful hurricanes to enter the GOM (Stone et al. 2005) and were very damaging to oil and gas facilities and production operations (Cruz and Krausmann 2008). The strong winds, rapid currents, high waves, and sediment scour associated with Hurricane Ivan damaged offshore platforms, production wells, and pipeline systems resulting in a disruption of 10% of the GOM's production over a four-month period (MMS 2005c). Hurricanes Katrina and Rita resulted in more than 150 platforms (approximately 4% of the total number of platforms in the GOM) being damaged or destroyed primarily by effects associated with wave inundation (Cruz and Krausmann 2008). In response to these recent and severe hurricane events, industry and regulators are reexamining offshore oil and gas structural designs to improve their resistance to hurricanes, especially with respect to deck heights to resist wave inundation, as well as mooring anchors and pipeline designs to prevent damage by sediment scouring and mudslides (Abraham 2005; MMS 2005b).

4.2.3.1.2 Loop Current and Loop Current Eddies. The dominant circulation pattern in the GOM is the Loop Current, which can be generalized as a horseshoe-shaped circulation pattern that enters through the Yucatan Channel and exits through the Florida Straits (Figure 4.2.3-1). The Loop Current covers approximately 10% of the GOM's area (Hamilton et al. 2000; Lugo-Fernandez and Green 2011), has surface current speeds up to 1.8 m/s (5.9 ft/s) (Oey et al. 2005), and is present down to an 800-m (2,625-ft) depth (Nowlin et al. 2000; Lugo-Fernandez 2007). The incoming water of the Loop Current through the Yucatan Channel is typically warmer and saltier than the GOM waters, which in combination with its highly inertial circulation pattern generates energetic conditions that drive circulation patterns throughout the entire GOM (Lugo-Fernandez 2007; Jochens and DiMarco 2008; Lugo-Fernandez and Green 2011).

The Loop Current is not a stagnant circulation, as it alters its orientation angle and periodically extends northwesterly into the GOM with filaments being observed to intrude onto the continental slope near the Mississippi River Delta (Figure 4.3.2-1) (Muller-Karger et al. 2001; Oey et al. 2005). As the Loop Current extends north to approximately 27°N, an instability causes the formation of an anticyclonic eddy (Loop Current Eddy) to separate off from the Loop Current (Hamilton et al. 2000; Vukovich 2007). The physical mechanisms that trigger these Loop Current Eddy separations and their frequency of occurrence are not fully understood (Chang and Oey 2010; Sturges et al. 2010), but the period between Loop Current Eddy separations ranges from 0.5 to 18.5 months (e.g., Vukovich 2007). A linear relationship that exists between the period between Loop Current Eddy separations and the retreat latitude of the Loop Current following separation results from a balance in vorticity between water entering and water exiting the GOM that is displaced by the intrusion of the Loop Current moving toward the northern slope region (Lugo-Fernandez and Leben 2010). Loop Current Eddies typically have a diameter of 300 to 400 km (186 to 248 mi), current speeds between 1.5 to 2 m/s (4.9 to 6.6 ft/s), and speeds up to 0.1 m/s (0.3 ft/s) at a 500-m (1,640-ft) depth (Brooks 1984; Cooper et al. 1990). Loop Current Eddies migrate to the west and southwest under forces induced by the Earth's curvature and rotation with translation speeds ranging from 2 to 5 km/day (1.2 to 3.1 mi/day) (Brooks 1984; Oey et al. 2005).

Loop Current Eddies typically affect deepwater regions (depths greater than 400 m [1,312 ft]) of the GOM and have the potential to disrupt exploration, drilling, and production activities (Crout 2009). Currents associated with Loop Current Eddies have the ability to cause vortex-induced vibrations that can damage platforms and drilling equipment (Kaiser and Pulsipher 2007). It has been estimated that a sustained current of 2 m/s (6.6 ft/s) can use up the fatigue life of certain mooring system components in 1 week (DiMarco et al. 2004).

4.2.3.1.3 Deepwater Currents and Subsurface Jets. Oil and gas exploration and production activities are expanding more and more to deepwater regions of the GOM, which is what motivates the current research emphasis in deepwater currents (McKone et al. 2007; Lugo-Fernandez and Green 2011). Energetic waves and high-speed jets can affect the transport of pollutants such as drilling fluids and oil, as well as physical structures relating to oil and gas operations (DiMarco et al. 2004). For example, the Deep Water Horizon oil spill of 2010 demonstrated the need to understand how deepwater currents affect underwater oil spill plumes (e.g., Adcroft et al. 2010).

Deepwater currents (depths greater than 1,000 m [3,281 ft]) along the northern GOM are typically characterized as meandering waves (referred to as topographic Rossby waves [TRWs]) that are vertically coherent with some degree of bottom intensification, have periods greater than 10 days, are largely decoupled from surface circulations, and have a propagation velocity on the order of 9 km/day (5.6 mi/day) (Hamilton 1990, 2009; Sturges et al. 2004). The energy source of these deepwater currents is not fully realized, but recent studies suggest that the Loop Current generates deepwater eddies near the Campeche Terrace that excite wave propagation westward along the continental slope of the northern GOM (Oey 2008). Additionally, high-energy waves (with periods of less than 10 days) have been observed locally along the Sigsbee Escarpment with maximum speeds of 0.9 m/s (3 ft/s) at depths below 1,500 m (4,921 ft) (Donohue et al. 2008). The analysis by Hamilton (2009) suggests that highly energetic TRWs along the Sigsbee Escarpment generate a mean deepwater flow to the west along the steep escarpment, which acts as the main deepwater transport pathway from the western to the eastern GOM, and that in the western GOM, TRWs are less energetic but interact in a similar fashion with the continental slope to form a generalized mean deepwater flow to the south along the base of the continental slope off Mexico (the generalized deepwater flow path is shown in Figure 4.2.3-1).

Subsurface jets are characterized as currents with no surface expression, having durations on the order of hours to days, speeds in excess 0.4 m/s (1.3 ft/s), and observed currents up to 2 m/s (6.6 ft/s) (DiMarco et al. 2004). Subsurface jets occur at shallow depths (150–600 m [492–1,968 ft]) and in deep waters, and they are typically produced by the downward propagation of inertia in the wake of a storm passage or the interactions of eddy circulations and the topography of the continental slope (DiMarco et al. 2004; Fan et al. 2007). Deepwater jets are difficult to measure because of their limited spatial and temporal extents, but observations from moored instruments in the northwestern GOM show deepwater jets having maximum currents speeds between 0.5 and 0.8 m/s (1.5 and 2.6 ft/s) with durations on the order of 1 to 8 days (Hamilton and Badan 2009).

4.2.3.2 Alaska Region

Sea ice, ocean currents, tides, waves, and storm surges affect offshore oil and gas operations on the Alaska continental shelf and facilities located near the coastline. Typical currents and waves do not threaten the physical integrity of production equipment; however, cold air temperatures and the spray from waves can freeze on structures, causing structural damage as well as affecting the buoyancy of supply and drilling vessels to the extent of capsizing ships (Jones and Andreas 2009). Tides are considered minor along the coastal regions of the Arctic Ocean (NRC 2003a; Weingartner 2003), but tidal ranges in Cook Inlet are considered among the largest in the world (Archer and Hubbard 2003). Impacts of storm surges vary by season from coastal flooding during summer and fall events to ice gouging and damage associated with ice ride-up (wind-driven surge of ice onto shore) during winter and spring storm events (Lynch et al. 2008). While all these oceanographic factors influence oil and gas operations, the primary design consideration for platforms, vessels, pipelines, and other structures is the presence of sea ice and its interactions with currents, tides, and the bathymetry of the Alaska continental shelf (Weeks and Weller 1984; NRC 2003a).

The climate of the Arctic region is complex because of its multiple interactions with oceanic and terrestrial systems, and effects associated with global climate change have resulted in significant changes to the Arctic's atmospheric and oceanographic conditions over the past couple of decades (e.g., Morison et al. 2000; Arctic Council and IASC 2005). Air temperatures in the regions north of 60°N have warmed at a faster rate than that of the overall northern hemisphere over the past century (Arctic Council and IASC 2005). During the 1990s, several studies revealed a warming trend in the layer of Arctic Ocean water with origins from the Atlantic Ocean (Carmack et al. 1995; Grotefendt et al. 1998; Gunn and Muench 2001), as well as an overall increase in Arctic Ocean sea surface temperatures and lower surface-layer salinities along regions of the Beaufort Sea and the Chukchi Sea (Morison et al. 2000; Comiso 2003; Comiso et al. 2003).

The warming of air and water temperatures in Arctic regions generates variability in key factors and processes controlling oceanographic conditions, which include precipitation and snow patterns, freshwater and sediment inputs to oceans, thermohaline circulation patterns (controlled by temperature and salinity gradients), and the aerial coverage and composition of sea ice (Morison et al. 2000; Arctic Council and IASC 2005; Bonsal and Kochtubajda 2009). Changes in oceanic conditions have also corresponded with sea level rise in the Arctic Ocean (Proshutinsky et al. 2001). Predicting oceanic responses to climate change is difficult because of complex interactions (often nonlinear) among factors such as water and air temperatures, sea ice, sea level rise, and thermohaline circulation patterns (e.g., Wang et al. 2003).

Alaskan coastal waters are largely covered by sea ice with some open-water areas for three-quarters of the year, from October until June, with the minimum sea ice extent occurring in September as sea ice begins to form and the maximum extent in March (Weeks and Weller 1984). Sea ice properties vary according to its age and the physical conditions under which it forms, melts, refreezes, and reforms (Gow and Tucker 1991). A general classification of sea ice includes ice formed along shores known as landfast ice and ice formed at sea called drift ice, which can conglomerate to form pack ice or ice floes (Mulherin et al. 2001). Landfast ice gradually advances seaward in the fall, rapidly retreats in the spring, and can break up and reform several times in between. Ice floes move according to wind and currents and can collide and pile on top of one another to form pressure ridges, as well as converge to form well-defined ice-free openings, or polynyas (Mahoney et al. 2007). Another important distinction in sea ice is the difference between newly formed first-year sea ice and multi-year sea ice, which by definition is summer minimum sea ice extent (Lemke et al. 2007).

The spatial and temporal variability in sea ice extent and thickness are controlled by local climate and oceanic factors, with many studies indicating a decreasing trend in Arctic sea ice over recent decades (e.g., Johannesen et al. 1995; Parkinson 2000; Comiso 2002). Sea ice extent, as observed mainly by remote sensing methods, has decreased at a rate of approximately 3% per decade starting in the 1970s (Johannesen et al. 1995; Parkinson et al. 1999). However, multi-year sea ice has decreased at a rate of nearly 9 to 12% per decade since the 1980s (Comiso 2002; Perovich et al. 2010). Since 2000, the extent of summer sea ice was at record lows in 2002 (Serreze et al. 2003), 2004 (Stroeve et al. 2005), 2007 (Perovich et al. 2008), and 2010 (Richter-Menge and Jeffries 2011). Sea ice thickness has also decreased during recent decades, with average sea ice draft (the depth of ice below sea level) values decreasing by as much as 1.3 m (4 ft) (Rothrock et al. 1999) and sea ice volumes decreasing at a rate of 4% per decade since 1948 (Rothrock and Zhang 2005). These recent trends in declining sea ice are a result of anthropogenic influences and natural climate variability, and recent climate simulations suggest that natural climate variability has the potential to cause a stabilization to a slight recovery of sea ice trends over short times scales on the order of a decade or less in the beginning part of the twenty-first century (Kay et al. 2011).

The interactions of sea ice with currents and waves have the potential to create hazardous conditions and damage physical structures though ice gouging, ice ride-up, and scouring, and to block vessel traffic (Weeks and Weller 1984). Landfast ice is typically not a concern as it exerts nominal internal stresses to structures, but ice floes formed during breakup conditions near shore or out in open pack ice areas have velocities on the order of 1 m/s (3 ft/s) (Stringer and Sackinger 1976). Ice gouging is caused by grounded ice keels within ice floes moving in response to wind and currents that typically occur in regions parallel to shorelines (Shapiro and Barnes 1991). Ice gouging is of particular concern for pipelines, as seabed gouging depths can often exceed 3 m (10 ft), affecting coastal regions with up to 50 m (164 ft) of water depth (Weeks and Weller 1984). Ice ride-up occurs as repeated ice floes converge on shore, pile on top of each other, and pile shoreward under continued momentum. Ice ride-up events frequently occur during the spring and fall and can affect structures that are on the order of 50 m (164 ft) inland (Kovacs and Sodhi 1980). In spring, river floodwaters can inundate coastal areas covered by sea ice and potentially break through the ice, generating jet flows and scour craters in the sediments below (process referred to as strudel scour), which can damage pipelines and support structures. Strudel scour craters can be more than 4 m (13 ft) deep and 15 m (49 ft) across and can last up to 2–3 years before being refilled (Reimnitz and Kempema 1982). Strudel scour occurs most commonly near river deltas extending outward to water depths of 6 m (20 ft) (Hearon et al. 2009).

Sea ice also affects oil spill cleanup and weathering processes, as well as acting as a transport mechanism for spilled oil (Stringer 1980). Oil transport and reaction processes are significantly altered for waters that contain more than 30% aerial coverage of sea ice in comparison to open ocean waters (NRC 2003b). The presence of ice and lower water temperatures typically result in lower rates of oil weathering processes such as evaporation, emulsification, and oxidation (Thomas 1983); lower rates of dispersion because of the increased viscosity of oil at lower temperatures (Payne et al. 1991) and the presence of sea ice also has the potential to confine oil spills (Weeks and Weller 1984). Conversely, enhanced transport of oil by sea ice conditions can occur along open water channels or polynyas or by oil incorporation into moving ice floes (Payne et al. 1987). Empirical relationships describing the fate and transport of spilled oil-sea ice interactions are presented in Buist et al. (2008). Ultimately, the fate of oil in the presence of sea ice largely depends on the season (summer ice free, winter ice cover, and fall ice formation), as well as the age and morphology of the sea ice, because these factors determine the ability of the oil to reach reactive areas for oil weathering processes to occur as well as the weathering reaction rates (Payne et al. 1991; NRC 2003b).

4.2.3.2.1 Arctic Ocean: Beaufort Sea and Chukchi Sea. The Beaufort Sea and Chukchi Sea are semi-enclosed seas connected to the Arctic Ocean located along the northern coast of Alaska. The Chukchi Sea is a shallow, continental shelf sea with depths typically less than 50 m (164 ft) that receives Pacific Ocean water through the Bering Strait (Woodgate et al. 2005). The Beaufort Sea consists of a narrow (approximately 100 km [62 mi] wide) continental shelf before a shelfbreak that occurs near the 200-m (656-ft) water depth contour followed by a portion of the Canadian Basin of the Arctic Ocean (Weingartner 2003). The continental shelf region of the Beaufort and Chukchi Seas contains small shoals and barrier islands that affect shelf circulation patterns and are typically associated with the location of ice ridges (NRC 2003a).

The general, depth-averaged circulation patterns in the Beaufort and Chukchi Seas are shown in Figure 4.2.3-3. Circulation in the Canadian Basin of the Arctic Ocean is dominated by the Beaufort Gyre, which is typically a clockwise (anticyclonic) circulation forced by prevailing atmospheric high pressure over the Arctic, but can reverse to a counterclockwise (cyclonic) circulation during summer months or prolonged periods of atmospheric low pressure (Proshutinsky et al. 2003; Asplin et al. 2009). The sea level slope between the Pacific Ocean and the Arctic Ocean drives water through the Bering Strait into the Chukchi Sea, which separates into three principal branches of northward flow among Herald Shoal, Hanna Shoal, and the Alaskan coast (Weingartner et al. 2005; Woodgate et al. 2005; Weingartner et al. 2010). Currently, it is not fully understood how Pacific Ocean waters moving across the Chukchi Sea interact with circulation patterns off the shelfbreak of the Beaufort Sea, but evidence suggests the presence of narrow currents near the Beaufort shelfbreak with prevailing eastward flow and seasonal variability in surface and subsurface intensified currents (Pickart 2004;

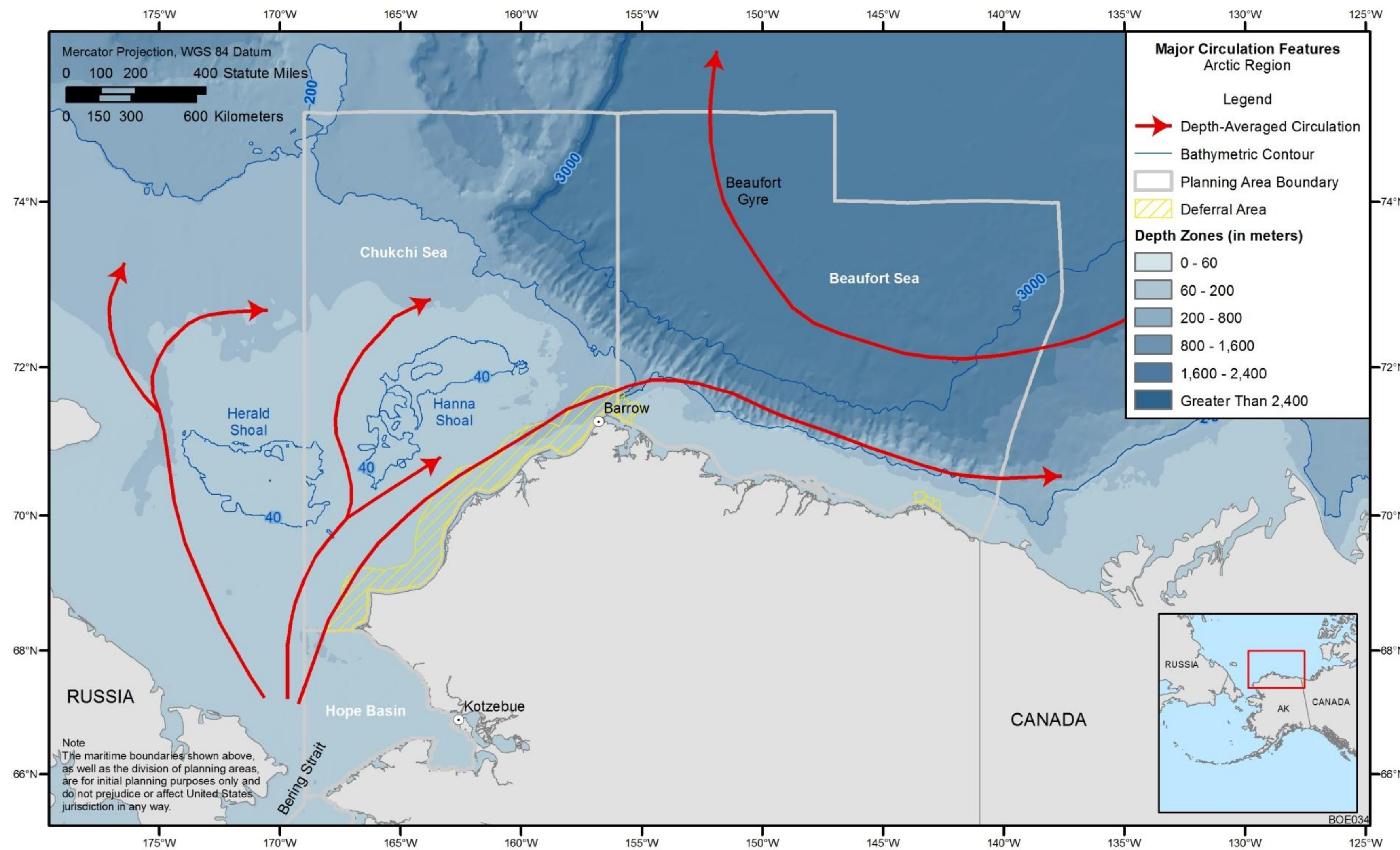

FIGURE 4.2.3-3 Generalized, Depth-Averaged Circulation Patterns in the Chukchi Sea and Beaufort Sea

Spall et al. 2008; Nikolopoulos et al. 2009; Okkonen et al. 2009; Pickart et al. 2010; Weingartner et al. 2010). The currents along the shelfbreak of the Beaufort Sea are highly unstable and prone to eddy circulations resulting from seasonal patterns of sea ice, wind direction, and storm events. For example, westerly winds along the Beaufort Sea shelf can accelerate the shelfbreak currents, resulting in downwelling conditions, while easterly winds can slow the shelfbreak currents, producing downwelling conditions (Weingartner et al. 2010). During the summer open-water season, current speeds along continental shelf areas often exceed 0.2 m/s (0.7 ft/s) with maximum speeds as high as 1 m/s (3 ft/s) in certain regions of constricted flow such as the Bering Strait and Barrow Canyon; during ice-covered seasons, current speeds are generally less than 0.1 m/s (0.3 ft/s) (Weingartner et al. 1998, 2009; Weingartner and Okkonen 2001).

The coasts of the Beaufort Sea and Chukchi Sea consist of river deltas, barrier islands, exposed bluffs, and large inlets; inland is characterized by low-relief lands underlain by permafrost (Jorgenson and Brown 2005). The combination of wind-driven waves, river erosion, and sea ice scour with highly erodible coastal lands creates the potential for high erosion rates along the Beaufort Sea and Chukchi Sea coasts (Kowalik 1984; Mars and Houseknecht 2007). From 1950 to 1980, the coastal erosion rates averaged 0.6 m/yr (2 ft/yr), and over the period from 1980 to 2000 this rate has increased to 1.2 m/yr (3.9 ft/yr) (Ping et al. 2011).

Present and future offshore oil and gas operations in the Beaufort and Chukchi Seas need to take into account climate change impacts on circulation and sea ice patterns. The complex circulation patterns on the Arctic continental shelf are affected by water temperature and density gradients and freshwater inputs of varying temperature from rivers as well as increased sea ice and glacier melting over recent years (Yamamoto-Kawai et al. 2009). Furthermore, reductions in sea ice have been more apparent in nearshore areas associated with landfast ice (typically extending out between 5 and 50 km [3 and 31 mi] from shore) in comparison to offshore regions (Mahoney et al. 2007; Fissel et al. 2009). A recent study has also shown that remote-sensing of sea ice extent may not always distinguish between first-year and multi-year sea ice, which is an important distinction in sea ice quality for supporting exploration activities, biotic habitats, and waterway access (Barber et al. 2009). The summer open ice season that determines when ships can enter the coastal regions along the north Alaskan coast has trended toward an earlier opening date in the spring and a later closing date in the fall (Fissel et al. 2009; Markus et al. 2009). While decreased sea ice has the potential to support more shipping activity in the Arctic, it is likely that hazardous ice floes will persist (Stewart et al. 2007), and decreases in landfast ice could result in increased impacts on coastlines through wave damage and ice ride-up (Arctic Council and IASC 2005).

4.2.3.2.2 Cook Inlet and Shelikof Strait. Cook Inlet and Shelikof Strait are located on the continental shelf of the Gulf of Alaska, which is a semi-enclosed basin of the Pacific Ocean surrounded by the steep terrain of the Alaskan coast. The continental shelf region is characterized as having a complex bathymetry of channels, island chains, and embayments. Cook Inlet is a large embayment with a length of 330 km (205 mi) along a northeast to southwest axis that is approximately 37 km (23 mi) wide in the northeast near Anchorage and 83 km (52 mi) wide at its mouth (Gatto 1976). The upper and lower portions of Cook Inlet are formed by the coastline constriction that occurs near the West Forelands to the north of Kalgin Island. The Shelikof Strait, located southwest of Cook Inlet between the Alaskan coast and the Kodiak Islands, forms a fairly uniform channel that is approximately 270 km (168 mi) in length and 45 km (28 mi) wide (Muench and Schumacher 1980). Figure 4.2.3-4 shows the location of Cook Inlet and Shelikof Strait along with major circulation patterns.

The circulation along the continental shelf of the Gulf of Alaska is dominated by the Alaskan Coastal Current, which is driven by winds and freshwater runoff of the numerous rivers and glaciers along the Alaskan coast (Stabeno et al. 2004). Alaskan Coastal Current waters enter Cook Inlet through the Kennedy and Stevenson Entrances and flow northward along the eastern side of the inlet as the result of Coriolis forces (induced by the rotation of the Earth) and then cross over to the western side of the inlet because of the shoreline geometry near the Forelands (Rappeport 1982). Observed circulation patterns suggest a net outflow of surface flows out of the inlet, which implies that there is a net inflow of deepwater flows into the inlet (Potter and Weingartner 2010). Cook Inlet is estuarine in character because of the mixing of marine waters from the Alaskan Coastal Current and freshwater inflows from several rivers, resulting in complex density-driven circulation patterns (Rappeport 1982; Mulherin et al. 2001). The Matanuska River, Knik River, and Susitna River combined contribute more than 70% of the freshwater inputs to Cook Inlet in the northern basin, as well as act as a significant source of suspended sediments that can reach concentrations greater than 1,700 mg/L (Gatto 1976). Riverine inputs of freshwater and sediments to the northern portion of Cook Inlet vary seasonally, and their resulting influences on temperatures and salinity generate seasonal variability in circulation patterns in Cook Inlet (Okkonen et al. 2009).

The circulation patterns in Cook Inlet are significantly influenced by the strong semidiurnal tide pattern with corresponding tidal amplitudes that range between 4.2 and 5 m (14 and 16.4 ft) in the lower portion and up to 9.0 m (29.5 ft) in the upper portion of Cook Inlet near Anchorage (Rappeport 1982; Archer and Hubbard 2003). Tidal currents travel at speeds ranging between 1 and 4 m/s (3 and 13 ft/s) (Whitney 2000; Oey et al. 2007). Average water depths in Cook Inlet vary from 18.3 m (60 ft) in the upper portion to 36.6 m (120 ft) near its mouth, with several deep channels along its longitudinal axis that contain sand dunes with heights on the order of 2 m (7 ft) (Haley et al. 2000). The interaction of density-driven circulation and tidal currents results in rip currents that form persistently along the deep channels (Haley et al. 2000; Whitney 2000), which can often be observed by turbidity color changes, as well as the accumulation of surface debris and foam along rip current edges (Rappeport 1982). The ebbing flow out of Cook Inlet combines with Alaskan Coastal Current waters and enters the Shelikof Strait, where water depths are on the order of 200 m (656 ft) and average current speeds range between 0.2 m/s (0.7 ft/s) in the winter and 0.1 m/s (0.3 ft/s) in the summer (Muench and Schumacher 1980). The southwest flow out of the Shelikof Strait merges with the Alaskan Stream (the western boundary current of the Gulf of Alaska) approximately 200 km (124 mi) southwest of Kodiak Island (Stabeno et al. 2004; Rovegno et al. 2009).

Significant wave heights (average wave height of the upper-third-largest waves) are typically 0.6 m (2 ft) in the lower portion of Cook Inlet and the Shelikof Strait, but maximum wave heights of 5.5 m (18 ft) have been recorded during storm events (Rappeport 1982). Tsunamis can occur in response to volcanic activity of Mount St. Augustine on Augustine Island

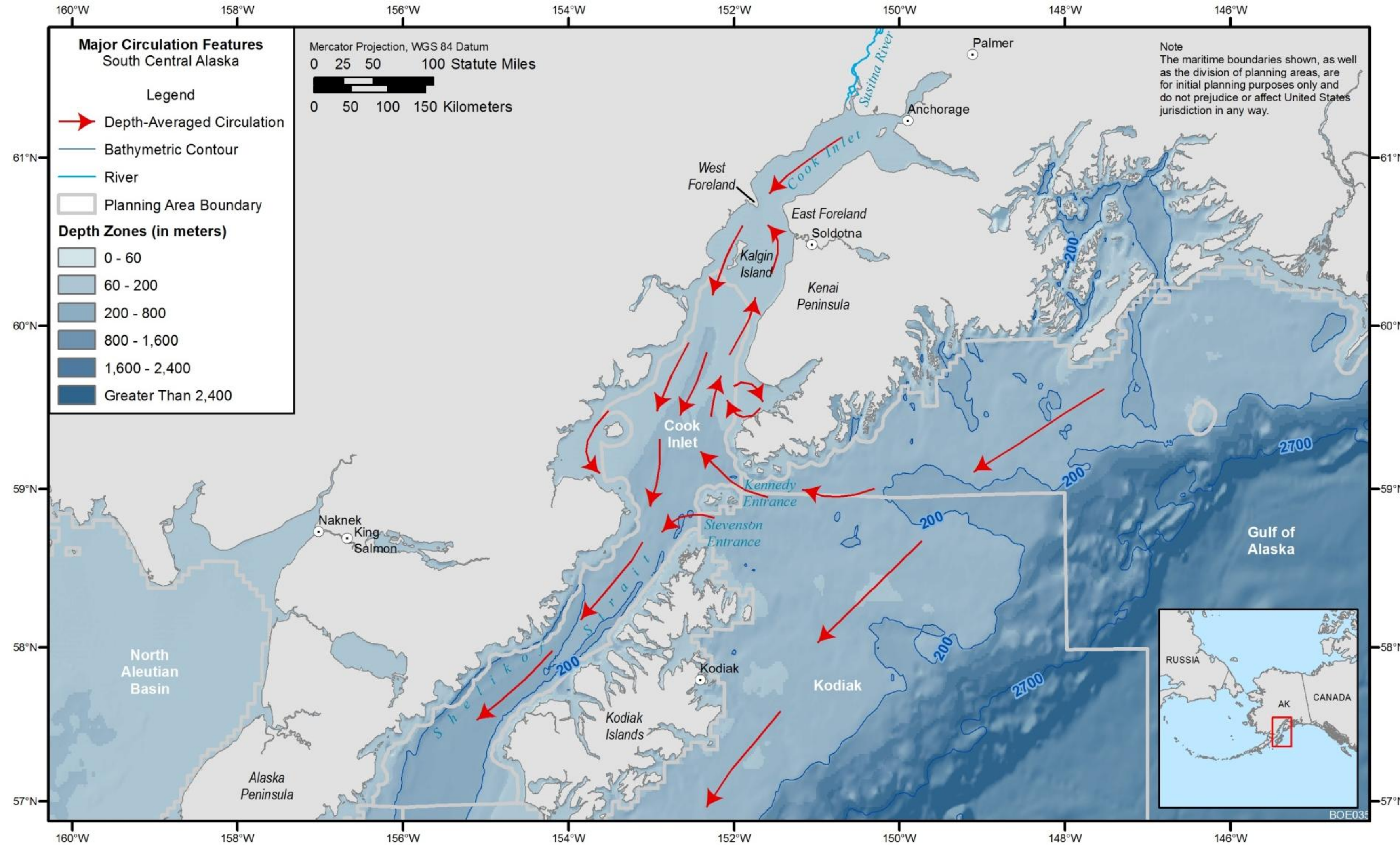

FIGURE 4.2.3-4 Generalized, Depth-Averaged Circulation Patterns in Cook Inlet and the Shelikof Strait

in the southwestern portion of lower Cook Inlet. Modeling results of the 1883 tsunami suggested wave heights of amplitude 1.2 to 1.8 m (3.9 to 5.9 ft) (Kienle et al. 1986). However, more recent modeling results suggest that the timing of a tsunami with the tidal phase can result in a fivefold amplification of wave heights near the shores of Anchor Point (Kowalik and Proshutinsky 2010).

Ice floes moving with tidal currents are the largest threat to navigation and marine structures in Cook Inlet. According to Mulherin et al. (2001), three types of sea ice form in Cook Inlet: pack ice, landfast ice, and stamukhi ice (forms by stacking of low-tide formed ice sheets on the sediment surface). The sea ice forms in the upper portion of Cook Inlet in the fall, while the lower portion is typically ice free until December. Stamukhi ice stacks can reach 7.5 to 12.2 m (24.6 to 40 ft) in thickness and typically become ice floes that move away from the shore because of buoyancy forces. In the upper Cook Inlet basin, ice floes are typically on the order of 320 m (1,050 ft) in width and up to 6 m (20 ft) in thickness on their edges (elevated by pressure ridges from collisions with other ice floes), and move with tidal currents on the order of 4 m/s (13 ft/s) (Gatto 1976). During the fall-winter ice-covered season, the ice pack can cover between 10 and 80% of Cook Inlet, which becomes completely ice free each spring (Muench and Schumacher 1980; Mulherin et al. 2001). In the upper Cook Inlet, there is a greater than 75% probability of sea ice coverage over the entire area by early January (Mulherin 2001). The highest concentration of sea ice in the lower Cook Inlet occurs along the western shores, and the eastern portion often remains ice free (Figure 4.2.3-5).

4.3 ASSESSMENT OF ISSUES OF PROGRAMMATIC CONCERN

4.3.1 Multiple Use Issues and Marine Spatial Planning

The activities that may occur and the facilities that may be installed on the OCS as a result of the Program are described in Section 4.4.1, which presents a scenario for the projected amounts of oil and gas exploration and development activities and the number of facilities and pipelines that are estimated to take place or be installed during the program, if Alternative 1, the Proposed Action, is implemented. Comparisons with other alternatives are provided later in the document, but the analyses presented in Sections 4.3 and 4.4 would apply, as appropriate, across all the alternatives. Much of the rest of this chapter is concerned with assessing potential impacts from these activities and facilities on the environmental resources that are analyzed in the PEIS. In some areas, these oil and gas facilities and activities also create a potential for space use conflicts with other activities and facility sitings not related to oil and gas development. This section discusses the other major activities and facilities on the OCS that could occur and coexist with oil and gas construction and activities during the program and, as a result, create potential space use conflicts. These conflicts could include situations in which the presence of oil and gas infrastructure and associated support, exploration, and production activities preclude, or are precluded by, other uses of the OCS; or situations in which oil and gas facilities and activities in combination with other types of activities and infrastructure could threaten the ecological sustainability of the area. Typically, the BOEM has managed OCS space and multiple use issues through coordination with other State and Federal agencies that manage and regulate activities on or near the OCS, and has developed regulations, lease stipulations, and other mechanisms to

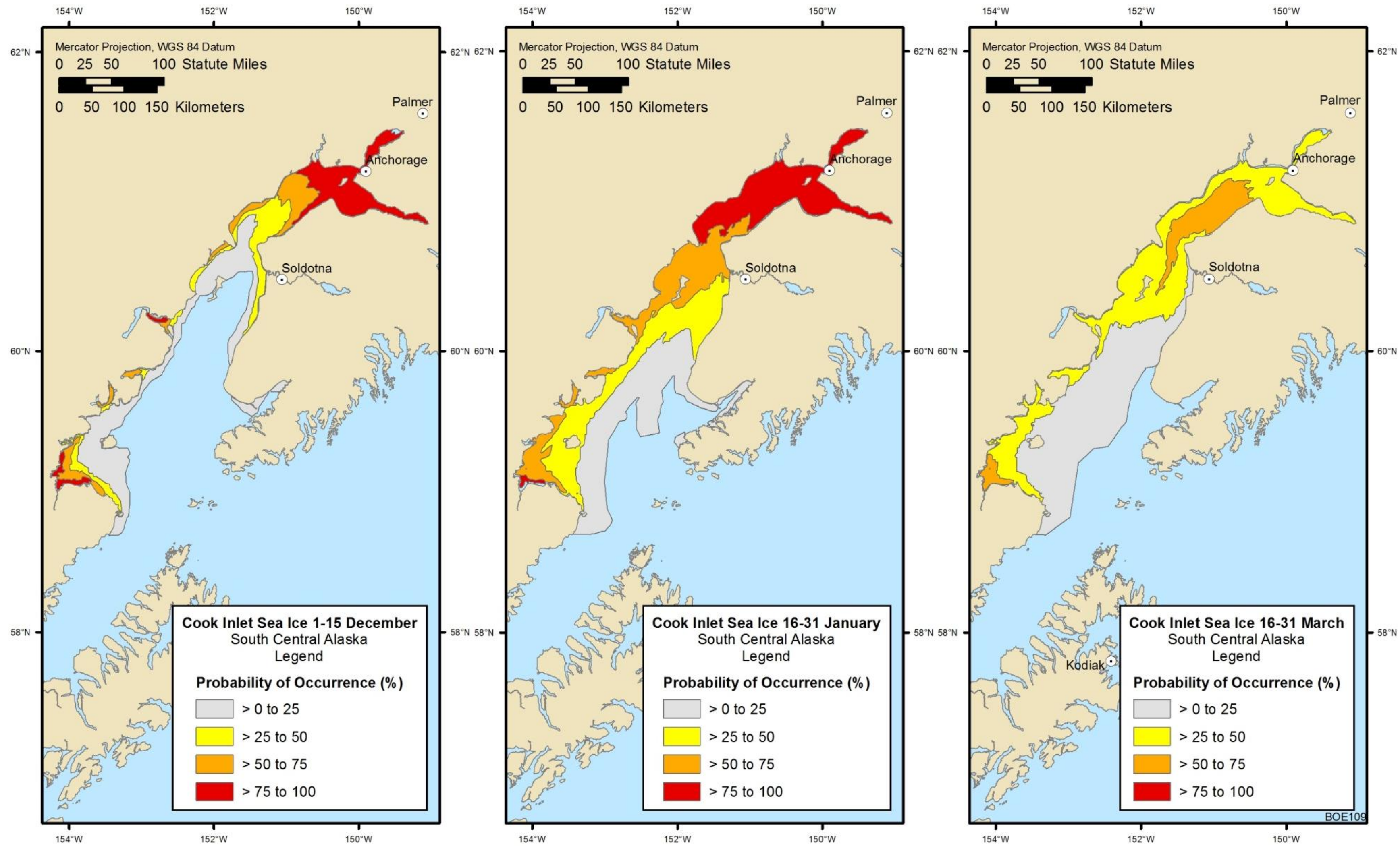

FIGURE 4.2.3-5 Probability of Sea Ice Occurrence in Cook Inlet From Early December to Late March (Mulherin et al. 2001)

restrict oil and gas activities to avoid conflict with other activities taking place in the same area. In recent years, Coastal and Marine Spatial Planning (CMSP) has emerged as a new paradigm and planning strategy for coordinating all marine and coastal activities within an ecosystem-based framework.

4.3.1.1 Multiple Use Issues

4.3.1.1.1 Department of Defense Use Areas. Military Use Areas, established off all U.S. coastlines, are required by the U.S. Air Force (USAF), Navy, Marine Corps, and Special Operations Forces for conducting various testing and training missions. Military activities can be quite varied, but they normally consist of air-to-air, air-to-surface, and surface-to-surface naval fleet training; submarine and antisubmarine training; and Air Force exercises. Offshore military areas (including military dumping areas) are present in some OCS planning areas. Section 3.9.1.2.3 of this draft PEIS discusses offshore military use areas in the OCS planning areas being considered for the proposed action.

Aircraft operated by all U.S. Department of Defense (USDOD) units train within a number of special use airspace (SUA) locations that overlie the military operating areas, as designated by the Federal Aviation Administration (U.S. Fleet Forces 2010). SUAs are the most relevant to the oil and gas leasing program because they are largely located offshore, extending from 5.6 km (3 NM or 3.5 mi) outward from the coast over international waters and in international airspace.

There are 21 U.S. military bases along the coasts of the planning areas being considered for oil and gas leasing in the proposed action: 18 bases along the GOM coast and 3 in the vicinity of the Cook Inlet Planning Area. In addition, there are four active USAF radar sites located on the coast bordering the Beaufort and Chukchi Sea Planning Areas. They are all Long-Range Radar Sites, and each site has restricted areas within certain facilities. Access to each is only for personnel on official business and with approval of the commander of the USAF's 611th Air Support Group. While there are a number of military use restriction areas (danger zones or restricted areas) in the GOM (see Figure 3.9.1-2), there are no such restrictions in the waters of the Cook Inlet Planning Area or the Beaufort and Chukchi Sea Planning Areas (National Marine Protected Areas Center 2008). In the Cook Inlet Planning Area, the closest danger zone is Blying Sound, which is managed by the U.S. Navy and located to the east of Cook Inlet near Prince William Sound. The Blying Sound Danger Zone is rarely activated, and there are no use restrictions for most of the year.

Danger zones are defined as water areas used for a variety of hazardous operations (National Marine Protected Areas Center 2008; U.S. Fleet Forces 2010). Danger zones may be closed to the public on a full-time or intermittent basis. Restricted areas are water areas defined as such for the purpose of prohibiting or limiting public access. Restricted areas generally provide security for Federal Government property and/or protect the public from the risks of damage or injury that could arise from the Federal Government's use of that area.

There are more than 40 military warning areas in the northern GOM area, designated by the USAF for the conduct of various testing and training missions, and by the U.S. Navy for various naval training and testing operations. Most of these areas overlie waters that are less than 800 m (2,600 ft) in depth (Figure 3.9.1-2).

Although offshore oil and gas activities have the potential to affect military activities, the USDOD and U.S. Department of the Interior (USDOI) have cooperated on these issues for many years and have developed mitigation measures that minimize the potential for conflicts. For example, stipulations are applied to oil and gas leases in critical military use areas. Whenever possible, close coordination between oil and gas operators and the military authorities for specific operational areas is encouraged and, in some cases, is required under these lease stipulations. In some instances where the military requires unimpeded access to specific areas on the OCS, specific lease blocks have been deleted from one or more proposed lease sales.

The USDOI will continue to coordinate with the USDOD regarding future lease offerings, new areas of industry interest, and current or proposed areas of military operations. As part of this coordination, applicable stipulations would continue to be routinely evaluated and modified, as necessary, to minimize or eliminate conflicts. An example of this process was the inclusion of three previously deferred blocks (Mustang Island Blocks 793, 799 and 816) in the Western GOM Planning Area in OCS Lease Sales 192 and 196, subject to a recently revised Lease Stipulation of Operations in the Naval Mine Warfare Area.

Offshore oil and gas development under the proposed action within the Alaska Region would not interfere with standard or routine military practices. Additional vessel traffic resulting from industry development and exploration would simply increase existing traffic and not affect military activities. BOEM works in cooperation with the USCG regarding industry exploration and development in waters off the coast of Alaska.

4.3.1.1.2 Liquefied Natural Gas Facilities. Natural gas is liquefied to concentrate a much greater volume of product in a given space to facilitate storage and/or transportation. Use of liquefied natural gas (LNG) reduces the volume it occupies by a factor of more than 600, making the transportation of gas in tankers economical. Environmental effects specific to LNG transportation and facilities are associated with explosions and fires and with the cryogenic and cooling effects of either an accidental release of LNG or the release of cooled water during the vaporization process. In the GOM, most, if not all, LNG facilities are expected to use an open-loop vaporization process that uses a throughput of approximately 130 to 250 million gallons per day of seawater to raise the temperature of the LNG from –260°F to 40°F. This process produces a discharge of seawater that has been cooled by as much as 20°F. These discharges are expected to occur in water depths ranging from 18 to 55 m (60 to 280 ft). This large volume of cool, dense water could create an impact on the surrounding environment, rendering the area uninhabitable by local species of invertebrates and fish, especially in the GOM. The magnitude of this impact is still unknown since there is only one facility (the Gulf Gateway facility) currently operating. The potential cumulative effect of multiple facilities also needs consideration. In addition to the thermal discharge, biocides are added to prevent fouling of the flow through the system.

These facilities operate by offloading vaporized LNG from tankers into the existing offshore natural gas pipeline system. Although BOEM does not permit or regulate these facilities, their increased presence and use on the OCS will create space use issues and will add to the existing mix of potential offshore cumulative impacts. Currently, only one LNG facility has been constructed and is operating on the GOM OCS. The Gulf Gateway Energy Bridge, which was brought into service in March 2005, is located in 85.3 m (280 ft) of water in West Cameron, South Addition Block 603, approximately 116 mi (187 km) offshore of the Texas–Louisiana border. The Gulf Gateway Energy Bridge is capable of delivering natural gas at a base load rate of 500 Bcf per day.

Other LNG facilities on the OCS are currently in some stage of the permitting process. The Bienville Offshore Energy Terminal is a planned LNG facility located 63 mi (101 km) south of Mobile Point, Alabama. The initial application for the facility was withdrawn on October 9, 2008, and a revised application, submitted on June 30, 2009, featured a redesigned terminal using “closed-loop” ambient air technology for LNG vaporization. The application was approved in 2010. In Louisiana, the Main Pass Energy Hub is a converted sulfur and brine mining facility. This LNG facility is expected to begin operations sometime in 2011 or 2012.

4.3.1.1.3 Alternate Energy Development. In April 2009, the President and the Secretary of the Interior announced the final regulations for the OCS Renewable Energy Program, which was authorized by the Energy Policy Act of 2005. The final regulations (74 CFR Part 81: 19638–19871) govern management of the BOEM Renewable Energy Program by establishing a program to grant leases, easements, and right-of-ways (ROWs) for renewable energy development activities on the OCS. Renewable energy from the OCS may come from technologies and projects that harness offshore wind energy, ocean wave (hydrokinetic) energy, or ocean current (hydrokinetic) energy.

Multiple Federal agencies have responsibilities for the regulation and oversight of renewable energy development on the OCS. BOEM issues leases and grants for both OCS wind and hydrokinetic projects and permits the construction and operation of wind facilities. The Federal Energy Regulatory Commission will permit the construction and operation of hydrokinetic facilities on BOEM-issued wave and current energy leases. BOEM also has the authority to issue ROWs for offshore transmission lines that would link OCS renewable energy projects in order to facilitate efficient interconnection of the OCS projects to the onshore electric grid.

As required by the Energy Policy Act, BOEM will issue leases on a competitive basis unless it determines that no competitive interest exists. After a lease is acquired, the developer must submit and receive approval of appropriate plans (for wind energy projects) or license applications (for hydrokinetic projects). At the end of the lease term, the developer must decommission the facilities in compliance with BOEM regulations.

There are currently no commercial hydrokinetic or wind energy projects on the OCS in the planning areas under consideration for the Program. BOEM, in coordination with relevant States, has identified Wind Energy Areas (WEAs) offshore of the mid-Atlantic coast. Although

OCS oil and gas leasing and development activities could interfere with future OCS wind energy renewable energy projects (and vice-versa), BOEM offshore oil and gas and offshore renewable energy programs will be coordinated to ensure that leasing and development activities under both programs are carried out with as little conflict between the two programs as possible. The identification of any future WEAs in areas with high or expected levels of oil and gas development (such as the GOM) will also be closely coordinated between the two programs. No such WEAs, however, have been identified in any of OCS planning areas being considered for oil and gas leasing under the proposed action, nor are any wind or kinetic energy developments anticipated there during the program.

4.3.1.2 Coastal and Marine Spatial Planning

On July 19, 2010, the President signed Executive Order (EO) 13547, *Stewardship of the Ocean, Our Coasts, and the Great Lakes*, establishing a national policy for the stewardship of these resources. This national policy identifies Coastal and Marine Planning (CSMP)[15] as one of the nine objectives. Furthermore, it outlines a framework for effective CMSP to address conservation, economic activity, user conflict, and sustainable use of the ocean, coasts, and Great Lakes.

Despite the existence of numerous articles on CMSP (e.g., see papers in *Marine Policy*, Vol. 32, 2008) and the incorporation of marine spatial planning principles by various nations into their resource management practices (e.g., EO 13547;), a standard, universally accepted definition of MSP currently does not exist. Most existing definitions are phrased in broad terms and objectives, such as the United Nations Educational, Scientific and Cultural Organization (UNESCO) definition, "[MSP] … is a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that have been specified through a political process" (UNESCO-IOC 2010). E.O. 13547 also provides a working definition of CMSP as a "comprehensive, adaptive, integrated, ecosystem-based, and transparent spatial planning process, based on sound science, for analyzing current and anticipated uses of ocean, coastal, and Great Lakes areas. Coastal and marine spatial planning identifies areas most suitable for various types or classes of activities in order to reduce conflicts among uses, reduce environmental impacts, facilitate compatible uses, and preserve critical ecosystem services to meet economic, environmental, security, and social objectives. In practical terms, coastal and marine spatial planning provides a public policy process for society to better determine how the ocean, our coasts, and Great Lakes are sustainably used and protected — now and for future generations."

Although NEPA is not usually seen as a spatial planning exercise, the PEIS for the Program and subsequent NEPA evaluations effectively are, at least in part, just that. The draft PEIS identifies broad areas of the OCS where oil and gas leasing may occur and identifies in a spatial and temporal context the potential for impacts on natural and social resources and systems that could occur with subsequent oil and gas leasing in those areas. The subsequent lease sale

[15] CMSP is also referred as regional ocean planning.

and post-lease NEPA analyses identify the specific areas and time frames where and when mitigating measures need to be applied to address potentially unacceptable impacts on natural resources and socioeconomic resources and systems. One outcome of this NEPA process, therefore, is the identification of areas on the OCS where BOEM regulates and manages oil and gas operations to meet economic and social objectives in a manner compatible with environmental sustainability objectives.

Table 4.3.1-1 describes ways in which the objectives and methods of CMSP are compatible with or differ from those of the Five-Year Programmatic EIS. While there are fundamental similarities and overlaps between the objectives and approaches of CMSP and the 2012-2017 PEIS, a major distinction between the two planning approaches is that the PEIS perspective focuses on the single use of the OCS for hydrocarbon exploration, extraction, and transportation, whereas CMSP is a multi-sector approach to planning which, through the development of a regional plan, aims to facilitate compatible uses and preserve ecosystem services to meet our nation's economic, environmental, security, and social goals.

The National Ocean Policy framework document divides U.S. waters (mean high water mark to 200 NM) into nine regions based primarily on Large Marine Ecosystem (LME) boundaries. It is anticipated that the plans will serve as an overlay for decisions made under existing regulatory mandates. In effect, regional CMS plans once approved by the National Ocean Council (NOC) will assist the BOEM programmatic EIS process in making informed decisions. It is important to note that CMSP is intended to be implemented within the framework of existing laws and authorities, and not to supersede them.

BOEM is the Federal Regional Planning Body (RPB) co-lead for CMSP implementation in the Mid-Atlantic region and, in one year, will take over Federal co-lead responsibility for the Alaska region. Additionally, BOEM will participate on RPBs in the Northeast, Mid-Atlantic and West Coast as the DOI lead. In the Gulf of Mexico region, BOEM representatives will assist US Fish and Wildlife Service (US FWS), the DOI regional lead, with various Federal working group activities.

BOEM's function as a Federal co-lead involves coordinating overall Regional Planning Body (RPB) responsibility on behalf of the Federal partners and providing administrative, personal and financial support as needed to move the CMSP initiative forward. Also as part of the planning process, BOEM facilitates data and information availability, provides research on potential environmental impacts of new technologies, and identifies conflict resolution and avoidance strategies. BOEM is revamping its information systems such as ESPIS (Environmental Studies Program Information System) to enhance the availability of its scientific and spatial data. The update will also make available some of the important spatial datasets through the Multipurpose Marine Cadaster (MMC). Relevant scientific data will also be linked through the newly formed ocean.data.gov portal. This project will ensure that BOEM science and data are available to planners and stakeholders as they engage in regional CMSP initiatives and that regional data portals have access to the ESPIS & MMC data sets. BOEM also plans to continue funding ocean planning focused studies in coordination with other Federal agencies.

TABLE 4.3.1-1 Comparison of the Objectives and Methods of CMSP with Those of the 2012-2017 OCS Oil and Gas Leasing Program PEIS[a]

Coastal and Marine Spatial Planning	Programmatic EIS
Envisioned as a tool to make ecosystem-based management of marine resources possible.	Uses a broad scale appropriate for an ecoregional approach for evaluating potential impacts.
Large Marine Ecosystems (LMEs) used to define spatial boundaries.	Large Marine Ecosystems (LMEs) used to define spatial boundaries.
Based on hierarchal scale-based approach addressing different issues and at different scales at each level of analysis, and in which each level provides context for the next lower level.	The NEPA concept of tiering is based on a hierarchal scale-based approach in which the programmatic EIS provides the general context for the more detailed analyses in the lease sale EIS.
Used to develop areas identifying ecologically sensitive regions as well as areas suitable for specific human uses.	Used as the first step in a planning process to develop areas where oil and gas operations will be regulated to be consistent, in combination with other uses of the area, with current environmental sustainability objectives.
Used to plan for existing and proposed offshore uses, while reconciling economic, social, and environmental demands on an area.	Programmatic cumulative analysis evaluates all differing economic, social, and environmental demands on an area to inform the decision on program timing, size, and locations.
Based on multiple sector planning approach.	Focused on the effects of a single sector on other sectors.

[a] Highlighted text shows areas of particular similarity.

4.3.2 Programmatic Deferrals and Mitigations

4.3.2.1 Introduction

BOEM received comments on the Draft PEIS requesting that more focused leasing, various temporal and spatial deferrals, and other mitigation measures be evaluated and possibly adopted for the program in the Final PEIS. Focused leasing, deferral, and mitigation concerns first arose in scoping comments and were echoed in BOEM's discussions with PEIS cooperating agencies, which included the State of Alaska, the North Slope Borough in Alaska, and NOAA. Related comments suggested BOEM delay leasing until there is more complete information on the Arctic ecosystem (including the effects of climate change), on the effectiveness of oil-spill response and containment in the Arctic, on drilling safety, and on the effects of the Deepwater Horizon (DWH) event on GOM baseline environmental conditions. These comments are considered related to deferral and mitigation comments because they argue that leasing should be constrained during the 2012-2017 Program.

A 5-year program PEIS does not typically analyze specific deferrals and mitigations as alternatives. A deferral decision requires a balancing of many important considerations, including oil and gas resource potential and environmental, sociocultural, and socioeconomic impacts. Chapters 1 (Section 1.3 and Section 1.4.2) and 2 (Section 2.9) of this PEIS explain how more detailed analyses during subsequent program stages evaluate the need for additional mitigation, including deferrals and exclusions, in different Program areas. The PEIS contributes to subsequent decisions through tiering, a concept introduced to NEPA by the Council on Environmental Quality (CEQ) to facilitate the process of conducting a sequence of interrelated impact assessments with each analysis focused on the actual issues ripe for decision at that level of environmental review. Tiering allows an agency to address a broad general program, such as the 2012-2017 OCS Oil and Gas Program, in an initial EIS, and then analyze narrower lease sale and project-specific proposals under the initial program in subsequent, more focused NEPA analyses. CEQ guidance has encouraged agencies to use a PEIS and tiering in these situations such as in the NEPA Task Force report, Modernizing NEPA (CEQ 2003), which highlighted the PEIS and tiering as important instruments for streamlining and modernization.

BOEM recognizes that a useful approach for addressing the issues raised in deferral- and mitigation-related comments is to strengthen the Program's tiering process so that it is more effective and transparent, rather than attempting to develop specific mitigations and spatial/temporal deferrals at the preliminary planning stage of the Program, when information needed for an informed decision may not be available, consultations and coordination may not have occurred, and the analytic granularity is generally too coarse for site-specific or resource-specific decisions.

This section has been included in the Final PEIS to describe and facilitate an ongoing evaluation of mitigation strategies throughout the different stages of the leasing process, with the goal of ensuring that these strategies are analyzed and, where appropriate, ready for implementation at the appropriate stage in the process. Since the process for developing and implementing mitigation strategies could require research and coordination and consultation over an extended time, the 5-year PEIS serves its planning and tiering functions best by establishing a process that will be used during the Program to evaluate, track, and provide for stakeholder input into the development of mitigation strategies. Toward these objectives, the section evaluates mitigation identified through the programmatic public input process in the following ways:

Identification of mitigation categories: Individual mitigation suggestions for the GOM and Arctic Program areas are grouped into categories according to common objectives. Specific mitigation strategies for the Cook Inlet Planning Area are not discussed because no deferral or mitigation issues were identified through the public input process.

Programmatic assessment of mitigation strategies: The term 'mitigation strategy' is used in this section because the final application of mitigation for the issues identified through public and stakeholder input could include multiple measures that together would be the most effective strategy for protecting the resource. The implementation of effective mitigation strategies requires the availability or development of a knowledge base sufficient to consider several factors, including the spatial and temporal aspects of activities and impacts, the specific resources to be targeted by the mitigation, and the nature of the impacts to be mitigated. This section evaluates these factors as they apply to the identified mitigation categories to provide a framework for further evaluation and development of mitigation strategies during Program implementation.

Mitigation tracking process for the 2012-2017 OCS Program: The process that BOEM will follow to track mitigation development is described in Section 4.3.2.4.

4.3.2.2 Program Decision Points

Table 4.3.2-1 shows major Program decision points at which actions can be taken to identify and mitigate potential OCS-related environmental impacts. At the programmatic stage, BOEM balances its OCSLA mandate to foster expeditious development of OCS mineral and energy resources and to protect marine and coastal environments through prudent size, timing, and location decisions. These decisions are made within the constraints of finite agency resources to do the necessary studies, analyses, coordination, consultations, and planning to support potential leasing and development in all Program areas. Mitigations are usually developed and applied to specific leases or areas at the lease sale decision point in order to reduce the potential for significant environmental impacts. At the project decision point, which includes exploration, development, production, pipeline, and facility decommissioning activities, additional site-specific mitigations, regulations, and other requirements and conditions, including those related to monitoring and enforcement, are attached to specific projects as conditions of plan approval.

4.3.2.3 Identification and Assessment of Mitigation Strategies

4.3.2.3.1 Gulf of Mexico Program Areas. Table 4.3.2-2 lists the temporal and spatial deferrals suggested for the 2012-2017 Program in the GOM. These deferrals and mitigations address concerns about the effects of DWH on GOM environmental baseline conditions and its resilience to additional impacts, and the risk of occurrence of and impacts from future CDEs in the GOM. Accordingly, the table identifies the CDE component that the mitigation addresses (for more information about the components that contribute to the risk for a CDE, see Section 4.3.3, Risk of Low-probability Catastrophic Discharge Event).

Drilling/Containment Issues. The first two deferrals listed in Table 4.3.2-2 are based on concerns that OCS drilling safety and oil-spill containment capabilities are inadequate at this time, and that leasing should not occur or be restricted during the 2012-2017 Program. The first deferral would exclude deepwater areas from the Program, based on a presumed higher level of drilling risk there. BOEM’s formal definition of deepwater is the area of the GOM greater than 305 m (1,000 ft) water depth. The second deferral would not allow leasing until drilling safety had improved to some benchmark.

Reducing drilling risk and increasing the containment and response capabilities at the accident site are the most effective ways to protect against the potential occurrence of a CDE

TABLE 4.3.2-1 OCS Program Environmental Decision Points

Program Stage	Decisions
Programmatic	What planning areas will be included in the Program? How many lease sales will be scheduled? When should sales be scheduled?
Lease Sale	What mitigations and deferrals need to be developed and applied to leases to reduce potential environmental impacts?
Project (Plan)	What specific mitigations, regulations, and other requirements and conditions apply to the activity? What mitigation enforcement and monitoring requirements apply to the activity?

TABLE 4.3.2-2 Gulf of Mexico Deferrals and Mitigations

Deferral	CDE Component	Concern
Exclude deep water	Drilling/Containment[a]	Deep water drilling is inherently riskier.
Delay leasing until drilling safety is improved	Drilling/Containment[a]	Regulatory and technological changes to improve safety have not been sufficient.
Do not allow drilling in areas with strong ocean currents such as the Loop Current	Fates[b]	Major ocean currents could entrain and transport oil to areas in Florida and into the Atlantic Ocean.
Gulf of Mexico baseline	Effects[b]	State of recovery or resilience of post-DWH GOM environmental baseline is not known.
Identify and protect sensitive ecosystems	Effects[b]	More ecologic areas need to be identified and protected.

[a] See Section 4.3.3.2.1 for more information on risk factors affecting drilling safety and physical containment at the well site.

[b] See Section 4.3.3.2.3 for more information on the fates and effects of discharged hydrocarbons.

because they reduce the likelihood that a drilling accident would occur, and, should it occur, reduce the amount of discharged hydrocarbons expected to be released into marine and coastal environments. Mitigating the effects of an accidental discharge becomes more difficult and problematic after oil enters open marine and coastal areas. Public and stakeholder concerns about drilling safety and related containment issues are shared by BOEM and BSEE which made improvements in drilling safety the top priority in the regulatory changes that occurred immediately after the DWH event. Section 4.3.3 includes a discussion of regulatory measures that have been promulgated since the DWH, event additional regulations BSEE plans to promulgate in 2012, and other government and industry activities and accomplishments related to improving safety.

BOEM and BSEE do not consider broad exclusions or deferrals in the GOM to be the appropriate strategy at this time for mitigating drilling risk within the context of OSCLA's mandate to foster expeditious development of the OCS while protecting marine and coastal environments. A trend has been established of ongoing drilling safety and containment improvements through regulatory changes and new technologies. This trend is expected to continue under the close scrutiny and evaluation of government, industry, and other concerned stakeholders. While broad statistics can be used to describe the overall likelihood of occurrence of different sizes of accidental oil discharges on the OCS, drilling risk must be assessed ultimately on a well-by-well basis because the factors that affect actual risk at a well site vary from area to area and from well to well (see Section 4.3.3). BOEM and BSEE are engaged in developing a better understanding of the distribution of drilling risk on the GOM OCS and of the factors that affect drilling risk in different areas, including Arctic Program areas. This information will become part of the knowledge base that supports a drilling safety and oil spill risk mitigation strategy. These mitigations could include targeted deferrals but also could be based on enhanced regulations, inspections, improved technologies, and more governmental involvement at higher risk well sites.

Fate and Transport of Oil Issues The fate of oil refers to the movement of oil away from its discharge source and the changes to its chemical and physical properties and composition that occur over time. During the DWH event, there was concern that the Loop Current in the GOM would extend into the area of the northern GOM where the spill was occurring and entrain and rapidly transport large amounts of oil as far away as south Florida and into the Atlantic Ocean. Although the Loop Current did not entrain and transport a large amount of oil during the DWH event, concern remains that entrainment could have been more substantial under different oceanographic conditions and that entrainment and transport could be problematic in the event of future large oil spills. The evaluation of a Loop Current mitigation strategy is organized into discussions of the risk of the Loop Current's intersecting an OCS area experiencing a catastrophic discharge, the risk of oil being entrained into the Loop Current, and the risk that entrained oil would contact and affect distant environmental resources at risk.

Risk of strong current intersecting an oil discharge area: The spatial variability of water movement associated with the Loop Current in the GOM is shown in Figure 4.3.2-1. This figure shows that a relatively small amount of oil and gas leasing and exploration has occurred within the area of the Central and Eastern GOM that is affected by the presence of the Loop Current from 5% to 20% of the time.

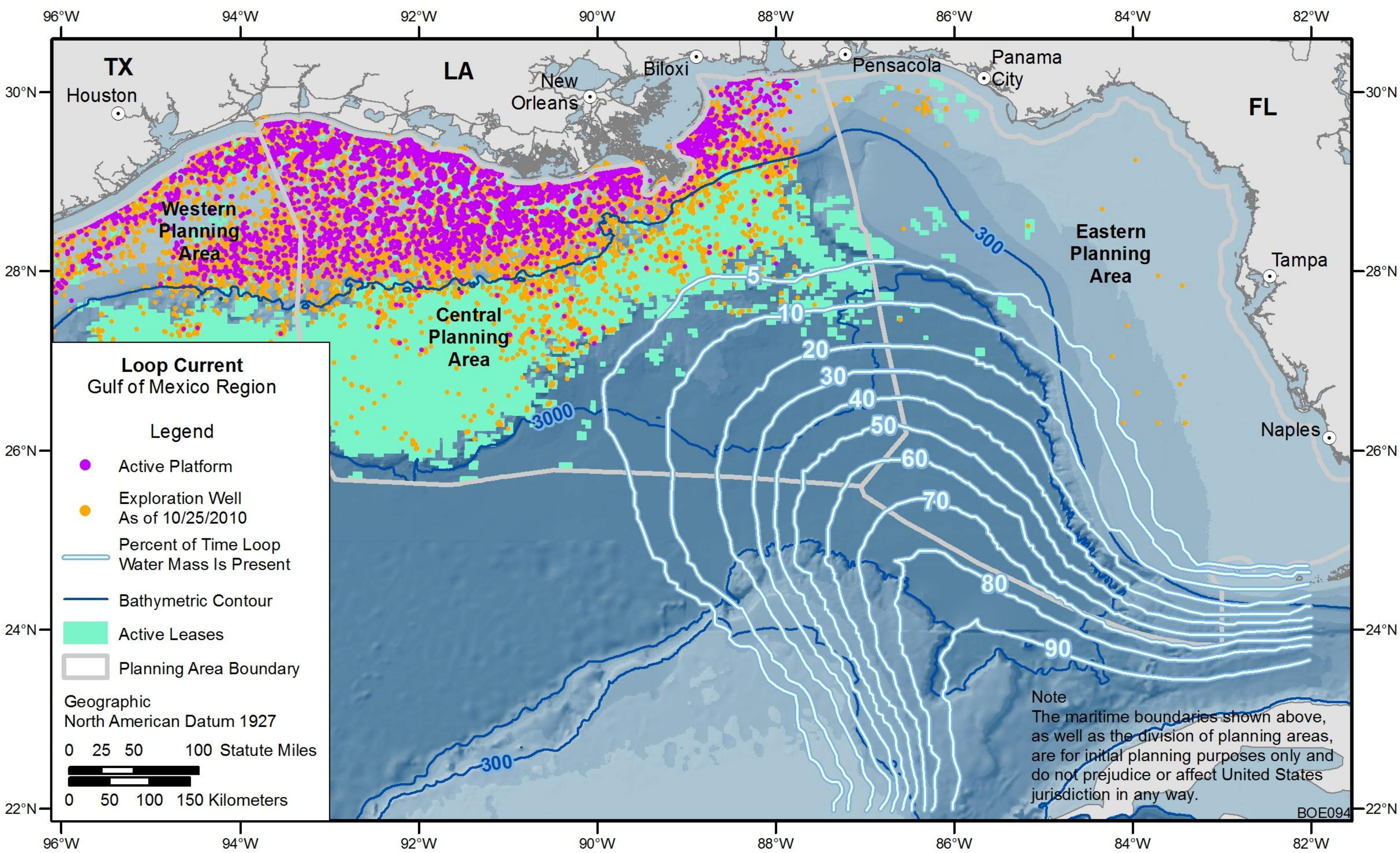

FIGURE 4.3.2-1 Spatial Variability of the Loop Current in Relation to Oil and Gas Activity (Loop Current information based on Vukovich 2007.)

Risk of oil entrainment into a strong current: The mitigation is based on the concern that the entrainment process could incorporate a large amount of oil into a strong current that passes through the discharge area and transport it rapidly toward southern Florida and into the Atlantic Ocean. Liu et al. (2011) attribute the Loop Current's not entraining a large quantity of oil during the DWH event to its location south of the discharge area much of time. The authors believe that entrainment would have been a more significant factor under different oceanographic conditions. Hamilton et al. (2011), on the other hand, conclude that the Loop Current presents a material boundary that would impede the entrainment of oil into the current. BOEM and BSEE recognize the need for improved understanding of the oil-current-current-eddy entrainment process. A new BOEM study entitled *Remote Sensing Assessment of Surface Oil Transport and Fate during Spills in the Gulf of Mexico*, which is anticipated to be conducted from 2012 to 2015, includes a specific task to identify the mixing processes that influence surface oil transport, including an analysis of material boundaries such as the Loop Current that serve as barriers to transport. Another issue being investigated is how winds could contribute to potential transport and mixing across the material boundary.

Risk of entrained oil contacting and impacting distant resources at risk: This mitigation is intended to provide broad protection for ecosystem resources located in the Eastern GOM, southern Florida, and the Atlantic from the effects of very large oil spills that could occur in the Central or Eastern GOM planning areas. These ecosystem resources are located in areas that, prior to the DWH event, might have been considered outside the area that would likely be affected by GOM OCS activities. The specific ecosystem resources and areas of concern have not been fully identified in these areas, nor has the potential for impacts under different Loop Current and CDE scenarios been assessed to determine the actual amount of environmental risk from the unmitigated effects of current transported oil.

It is worth noting that BSEE currently requires operators to monitor ocean currents on Mobile Offshore Drilling Units operating in water deeper than 400 m (1,312 ft) (NTL No. 2009-G02, available at http://www.bsee.gov/Regulations-and-Guidance/Notices-Letters-and-Information-to-Lessees-and-Operators.aspx). Monitoring is performed to evaluate the effects of currents on structural integrity and to ensure the sharing of ocean current data to develop a better understanding of ocean currents and bathymetry and to track the Loop Current and associated eddy currents. Operators and regulators are aware of the prevailing currents and their anticipated change in position over time, which allows for intervention in drilling and positioning of spill response and containment technology when warranted by the strength of currents and other risk factors.

Summary: An ocean current mitigation strategy requires further consideration. Its development would require more knowledge of several cascading risk factors, including the following:

- Risk of discharge event occurrence,
- Risk of strong current intersecting a discharge area,
- Risk of oil entrainment into a strong current,

- Risk of entrained oil contacting distant at-risk resources, and

- Risk of impact from contact with distant at-risk resources.

Effects of Oil Issues. This mitigation would address comments that the state of recovery of the GOM environmental baseline after the DWH event has not yet been determined and that BOEM should delay leasing until missing information is known, or at least for several years (see Section 2.9.3). The basis for the deferral is the concern that additional leasing could contribute to an incremental increase in the chance of another CDE or that routine cumulative actions could have devastating environmental effects on an ecosystem still recovering from a previous event. A related concern was to identify and protect important habitat areas that had been impacted by the DWH event and to make areas or habitats off limits to leasing. Others made more general comments that other sensitive habitat areas of the GOM should be protected as well.

The GOM contains habitat for many threatened, endangered, and sensitive species that are stressed by oil and gas, commercial fisheries, and other human activities, including the recent catastrophic spill. Similarly, climate change may impose additional stress on an ecosystem whose resilient capacity is not well studied. The underlying mitigation concept is not different from existing BOEM requirements that have been in place and continually improved since 1973 for the avoidance and protection of biologically sensitive features and areas on the shelf and slope, such as topographic features, pinnacles, live bottoms, and other potentially sensitive biological features (e.g., NTL No. 2009-G39 at http://www.gomr.boemre.gov/homepg/regulate/regs/ntls/2009NTLs/09-G39.pdf, and NTL No. 2009-G40 at http://www.gomr.boemre.gov/homepg/regulate/regs/ntls/2009NTLs/09-G40.pdf). Rather, a more deliberate strategy would be implemented for future OCS activities.

BOEM anticipates that a large number of new impact assessments and scientific information will become available during the Program to clarify the nature and pathways of potential exposure and contribution to short-term effects. Examples include the Natural Resource Damage Assessment (NRDA), BOEM, and other GOM restoration studies. The BOEM Environmental Studies Program is also fully engaged in studies that are evaluating the effects of the DWH event. While new information may not provide definitive data about chronic or persistent effects, it may indicate that new mitigation strategies are neeeded. BOEM and other State and Federal resource management agencies have monitoring programs in place that will be indespensible in tracking ecosystem changes relative to baseline conditions. BOEM plans to integrate that information as it becomes available, and adapt mitigation or leasing strategies as warranted.

4.3.2.3.2 Arctic Program Areas. Table 4.3.2-3 lists specific Arctic mitigation and deferral suggestions received through the PEIS public input process. They are organized into spatial and temporal deferrals, and by the region to which the mitigations apply: the entire Arctic Program area, the Chukchi Sea Planning Area, or the Beaufort Sea Planning Area. There is considerable overlap among the individual suggestions so some are contained within or have elements in common with others.

TABLE 4.3.2-3 Programmatic Arctic Deferral and Mitigation Suggestions

Location	Mitigation	Mitigation Concerns[a]
Arctic Wide		
Spatial	Exclude ecologically and culturally important areas	SU/ER
	Exclude important subsistence and biological areas	SU/ER
	Create buffers around sensitive areas and resources	ER
	Protect areas upstream and downstream of important ecological areas	ER
	Exclude areas that will protect both bowhead whales and subsistence communities	SU/ER
Temporal	Seasonal restrictions in subsistence areas	SU
	Restrictions during migratory, breeding, and birthing periods	ER
	Delay leasing until adequate spill control and response available	SPILL
	Delay leasing until ecological baseline data is developed	AE
Chukchi Sea		
Spatial	Hannah Shoal	ER
	Herald Shoal	ER
	Point Barrow	SU
	Chukchi ice lead system	SU/ER
	80–97 km (50–60 mi) coastal buffer	SU/ER
	Barrow Canyon	ER
	Buffers around boulder areas such as Kasegaluk Lagoon, Peard Bay, near Skull Cliffs, 25 km (16 mi) southwest of Wainwright	ER
Temporal	During Bowhead whale migration	SU/ER
Beaufort Sea		
Spatial	Within 24–97 km (15–60 mi) of the coast	SU/ER
	32 km (20 mi) to the east of Cross Island	SU
	Cross Island	SU
	All Beaufort Sea areas essential to the success of subsistence whaling	SU/ER
	Boulder Patch	SU/ER
	Camden Bay	ER
	Along coast of the Arctic Refuge and Teshekpuk Lake	ER
	Barrow Canyon	ER
Temporal	During bowhead migration and Nuiqsut whaling	SU
	In Camden Bay during Nuiqsut and Kaktovik bowhead hunts	SU

[a] SU = subsistence use; ER = ecosystem resources; AE = Arctic ecosystem; SPILL = Oil spill.

The table also lists the mitigation issue category that each suggestion has been grouped into. Mitigation categories were developed to organize the numerous mitigation concerns listed above into major themes that will be followed and tracked during the Program. Two broad categories were identified: Subsistence and Oil Spills.

4.3.2.3.3 Subsistence. Many of the requests for Arctic deferrals and mitigations came from Arctic subsistence communities. Some mitigation was intended to protect subsistence use in areas where potential space use conflicts with OCS activities may occur. BOEM has studied subsistence-use densities and identified areas of high use (Downs and Calloway 2008; SRBA 2010). BOEM has also considered specific subsistence-use deferrals in previous Arctic lease sale-stage EISs (Figure 4.3.2-2). In the 2007-2012 Program, BOEM implemented specific subsistence-use spatial deferrals at the programmatic stage. These same deferrals have been included in the proposed action.

Other comments were intended to protect the Arctic ecosystem and its biotic resources. Governmental and non-governmental entities also proposed mitigations to protect Arctic ecologic resources unrelated to their use in subsistence. While the full range of public and stakeholder concerns about mitigations for the Arctic ecosystem and its biologic communities and habitats is broader than specific concerns related to subsistence, subsistence is used as an overall descriptor for this category because of the direct dependence of the traditional subsistence lifestyle on the Arctic ecosystem. In this sense, subsistence mitigation concerns incorporate broader concerns about the potential effects of OCS development on Arctic ecological conditions.

Subsistence mitigation concerns identified in Table 4.3.2-3 have been organized into three categories: Subsistence Use (SU), Ecosystem Resources (ER), and the Arctic Ecosystem (AE). These three categories capture most of the Arctic mitigation and deferral comments listed in Table 4.3.2-3. Principal benefits, relative to the proposed action, would include reduced effects on ecosystems and their biota, as well as reduced effects on time and space conflicts with subsistence practices. Potential adverse impacts may include cascading socioeconomic effects, such as decreased employment opportunities and labor income, related to potentially reduced oil and gas production.

Subsistence Use — Mitigations addressing subsistence use are intended to maintain access to subsistence use areas by either deferring these areas from leasing or restricting industry activity seasonally.

Ecosystem Resources — Mitigation of potential impacts to ecosystem resources are intended to protect the Arctic marine and coastal biota and habitats, many of which are used for subsistence. Subsistence use and ecosystem resource mitigations are closely related as shown in Table 4.3.2-3, which lists numerous mitigations that address both categories. Governmental and non-governmental entities also requested mitigation of potential impacts on Arctic ecosystem resources unrelated to concerns over subsistence use.

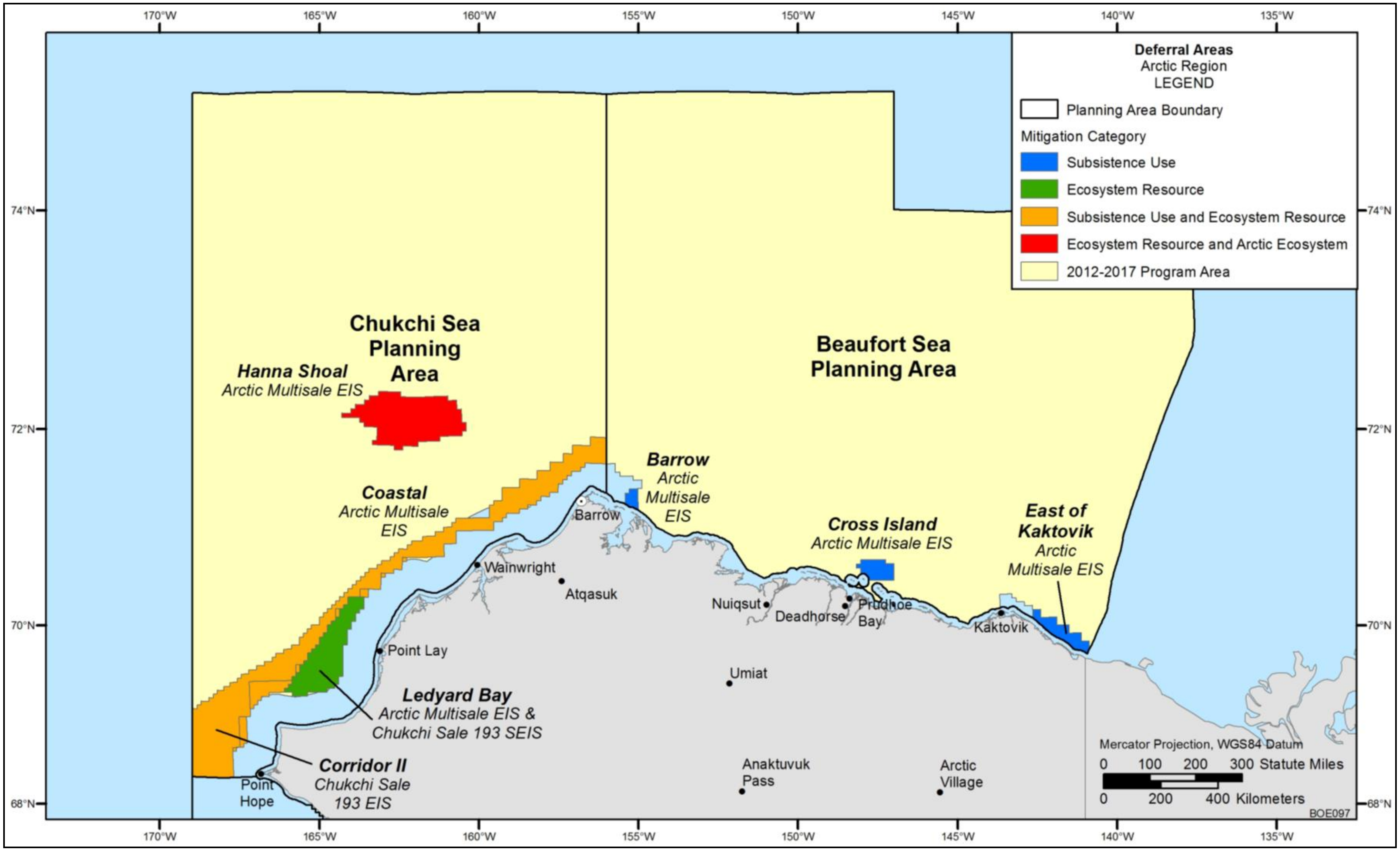

FIGURE 4.3.2-2 Arctic Deferrals Considered as Lease Sale EIS Alternatives, 2007–2012

Arctic Ecosystem — Concerns were raised that the fundamental processes affecting the productivity and sustainability of Arctic ecosystems have not been adequately studied. The comments argue that without further development of foundational knowledge it will be difficult to assess ecosystem responses and resiliency to perturbations from OCS related impacts, and to develop effective mitigation for specific resources in specific areas. A related concern was that the effects of climate change on atmospheric and ocean warming, the sea-ice biome, species migrations, and ocean acidification would result in dynamic conditions that the Arctic ecosystem would be adjusting to during the life of the 2012-2017 Program. Furthermore, new economic uses, such as commercial fishing, marine shipping, and tourism, are anticipated in a warmer and more ice-free Arctic region (Arctic Council 2009). These uses would introduce the potential for additional environmental stresses, and would make conflict resolution among subsistence use and other stakeholder interests more complex.

The nested and cascading relationships among subsistence use, ecosystem resources, and Arctic ecosystem concerns suggest that the process for developing Arctic mitigation strategies would benefit from being done in an integrated way. Considering a subsistence-use mitigation strategy as an example, lease block deferrals, such as those shown in Figure 4.3.2-3 and listed in Table 4.3.2-3, can be effectively applied as subsistence-use mitigation measures, but may not be sufficient by themselves as an effective subsistence-use mitigation strategy within the context of the issues raised in the previous paragraphs. For example, specific spatial and temporal deferrals to protect subsistence use may require re-evaluation and reconfiguration periodically as a result of anticipated climate change effects on species distributions, sea-ice biomes, and the position and configuration of the shoreline, as well as in response to the introduction of new economic uses of the Arctic. A subsistence-use mitigation strategy would need to be adaptable under these dynamic conditions, and include not only specific deferral measures but also a process to facilitate the re-evaluation, reconfiguring, and development of deferral areas and other mitigations over time as needed.

A comprehensive framework would be needed to evaluate subsistence-use mitigation strategies within a dynamic Arctic ecosystem subject to multiple human uses. Developing these strategies will be based on knowledge of:

- The Arctic ecosystem;
- The effects of climate change on the Arctic ecosystem and its components;
- Arctic ecologic community dynamics, including subsistence resources, and their anticipated responses to climate change effects; and
- Human uses of a warmer Arctic, including tourism, commercial fishing, marine shipping, and associated potential environmental stresses.

While studies and investigations are not mitigations per se, they are essential for developing the knowledge base needed to support the implementation of effective mitigation strategies. BOEM has made the acquisition of information and knowledge of the Arctic ecosystem and the biological communities and human uses it supports a high priority for its

Environmental Studies Progam. The Synthesis Of Arctic Research (SOAR) study, which began in 2011, brings together a multidisciplinary group of scientists and Arctic residents to explore and integrate information from completed and ongoing marine research in the Arctic to increase scientific understanding of the relationships among oceanographic conditions, benthic organisms, lower trophic prey species (forage fish and zooplankton), seabirds, and marine mammal distribution and behavior. BOEM is also funding a Hanna Shoal Ecosystem Study. This multiyear study will investigate the importance of Hanna Shoal in the northeast Chukchi Sea as a biological oasis bordering the boundary between Chukchi and Arctic Ocean waters.

In addition, BOEM is collaborating with Federal partners in government-wide research programs such as the Arctic Science Engineering Education for Sustainability (ARCSEES) program, North Pacific Research Board, Interagency Arctic Research Policy Committee, and National Academy of Sciences Polar Research Board research initiatives, as well as the National Research Council "Responding to Oil Spills in the Arctic Environment" review.

4.3.2.3.4 Oil Spill. Concerns about a perceived lack of industry and government ability to handle a large oil spill under Arctic conditions were expressed in comments related to subsistence use, ecosystem resources, and the Arctic ecosystem. A mitigation strategy was suggested to defer Arctic leasing until industry has proven ability to respond to a large Arctic oil spill event effectively. BOEM does not consider a broad deferral of Arctic leasing the appropriate strategy for mitigating oil spill risks within the context of fulfilling its OSCLA balancing mandate. BOEM and BSEE are commited to improving oil spill prevention and containment/response capabilities in advance of future potential Arctic drilling activities. These activities would not likely occur until sometime near or after 2020, based on the scheduling of the first Arctic sale under the new Program in 2015 and an assumed 5-year lag after the sale before exploration drilling begins. Section 4.3.3 evaluates catastrophic discharge event risk factors in the Arctic and discusses regulatory improvements and technologic advances that have been accomplished to date and are planned for the future. These efforts are expected to result in more robust and proven strategies and technologies for managing Arctic oil spill risks that will be available at the exploration well decision point. Concerns about Arctic oil spill risks will be followed through Program decision points.

4.3.2.4 Measures to Enhance Transparency and Effectiveness in Tiering Process

BOEM realizes that each region is different in terms of mineral resources and dependent economies, the relative state of infrastructure and support industries, the sensitivity of ecosystems, environmental resources and communities; and that a leasing strategy needs to be sensitive to those differences, but also must be consistent with OCSLA principles. BOEM envisions a phased OCSLA process that minimizes multiple-use and environmental conflicts to the extent possible during Program implementation, that makes lease sale decisions in the context of the best available information, and that discloses clear reasons for those decisions, even in the face of uncertainty. This vision is consistent with the National Ocean Policy Implementation Plan and related Coastal and Marine Spatial Planning initiatives, all of which provide a complementary framework for space-use conflict considerations.

BOEM is committing to several process enhancements to ensure transparency during the phased OCSLA and tiered NEPA processes of this Program. Although specific approaches to implementation may be tailored to the different needs of the Regions and their stakeholders, BOEM is determined to improve the effectiveness of the tiering process through the following:

Alternative and Mitigation Tracking Table. BOEM is establishing an alternative and mitigation tracking table to provide increased visibility into the consideration of recommendations for deferrals, mitigations, and alternatives at different stages of the leasing process. Beginning with the 5-year PEIS, the table tracks the lineage and treatment of suggestions for spatial exclusions, temporal deferrals, and/or mitigation from the 5-year Program, to the lease sale phase, and on to the plan phase. This table will allow commenters to see how and at what stage of the process their concerns are being considered. BOEM will maintain a table that will be updated as deferral requests are considered at the sale and plan stages and new requests are made. A link to the table will be provided in sale documents and in the annual report, discussed below.

Strengthening the Pre-Lease Sale Process. BOEM is taking a number of steps to enhance opportunities for members of the public to comment and provide new information in the pre-leasesale planning process. Historically, the Call for Information (the Call), which is the first step in the Pre-Lease Sale Process, has generally asked for industry to nominate specific blocks or descriptions of areas within the Program area for which they have the most interest while the Notice of Intent (NOI) requests comments on issues that should be addressed and alternatives that should be considered in the NEPA documents that will be prepared for the action.

Annual Progress Report. BOEM will publish an annual progress report on the approved Program that includes an opportunity for stakeholders and the public to comment on the Program's implementation. Under Section 18(e) of the OSCLA, the Secretary must review an approved Program each year. Historically, this has been an internal review process that reported to the Secretary any information or events that might result in a revision to the Program. If the revision is considered significant under the Act, the Program can only be revised and reapproved by following the same Section 18 steps used to originally develop the Program. However, once the Section 18 process has been initiated for the next 5-year Program, the annual review is subsumed in that process, as the same substantive and procedural requirements are being addressed.

The findings of this progress report may lead the Secretary to revise the Program by reducing the size of, delaying, or canceling scheduled lease sales. If the desired revisions are considered significant, such as including new areas for consideration or more sales in areas already included, the entire Section 18 process must be followed, in essence resulting in the preparation of a new Program.

Systematic Planning. BOEM is committed to engaging in systematic planning opportunities that foster improved governmental coordination, communication, and information exchange. As the only agency authorized to grant renewable energy, marine mineral, and oil and gas leases on the OCS, BOEM has been assigned as the Federal co-lead, along with the U.S. Coast Guard for systematic regional planning efforts in the Mid-Atlantic. Additionally, BOEM will participate on Regional Planning Bodies (RPB) in the Northeast, Mid-Atlantic and West Coast as the USDOI lead. In the GOM region, BOEM representatives will assist the U.S. Fish and Wildlife Service, the USDOI regional lead, with various working group activities. This will facilitate data and information availability, provide research of new technologies, and identify conflict resolution and avoidance strategies. BOEM anticipates that its CMSP engagement will enhance regulatory efficiency through improved coordination and collaboration, and, in the long term, enhance the stewardship of ocean and coastal resources.

These strategies will allow BOEM to not only address the activities that take place under the 2012-2017 Program, but also lay the groundwork for decisions that will be faced in subsequent 5-year periods. It includes efforts to gather information while enhancing opportunities for stakeholders and other interested parties to participate and be engaged in the decision-making process. The initiation of studies and long-term planning now will facilitate future decisions by ensuring the best information is available when making leasing decisions on the approved program and before the development of future OCS programs.

4.3.3 Risk of a Low-Probability, Catastrophic Discharge Event

4.3.3.1 Introduction

The risk of potentially severe consequences of oil spills, especially the risk and consequence of low-probability, large volume spills, is an issue of programmatic concern. Although unexpected and accidental, large spills may result from OCS exploration, development and production operations involving facilities, tankers, pipelines, and/or support vessels. Large accidental platform and pipeline spills (≥1,000 bbl) are addressed in Section 4.4. Incidents with the greatest potential for catastrophic consequences are losses of well control with uncontrolled releases of large volumes of oil, where primary and secondary barriers fail, the well does not bridge (bridging occurs when the wellbore collapses and seals the flow path), and the flow is of long duration (Holand 1997). The term “catastrophic discharge event” is used in this section to describe an event that results in a very large discharge into the environment that may cause long-term and widespread effects on marine and coastal environments.

In general, historical data show that loss of well control events resulting in oil spills are infrequent and that those resulting in large accidental oil spills are even rarer events (Anderson and Labelle 2000; Anderson et al. 2012; Bercha Group, Inc. 2006; Bercha Group, Inc. 2008a,b; Bercha Group, Inc. 2011; Izon et al. 2007). The Norwegian SINTEF Offshore Blowout Database, which tracks worldwide offshore oil and gas blowouts, where risk-comparable drilling operations are analyzed, supports the same conclusion (IAOGP 2010; DNV 2010c; DNV 2011a). Blowout frequency analyses of the SINTEF database suggest that the highest risk operations are associated with exploration drilling in high–pressure, high-temperature conditions (DNV 2010c; DNV 2011a). New drilling regulations and recent advances in containment technology may further reduce the frequency and size of oil spills from OCS operations (DNV 2010c; DNV 2011a). However, as the 2010 DWH event illustrated, there is a risk for very large spills to occur and result in unacceptable impacts, some of which have the potential to be catastrophic.

A fundamental challenge is to accurately describe this risk, especially since there have been relatively few large oil spills that can serve as benchmarks (Scarlett et al. 2011). Prior to the DWH event, the three largest blowout spills on the OCS were 80,000 bbl, 65,000 bbl, and 53,000 bbl, and all occurred before 1971 (Anderson et al. 2012). From 1964 to 2010 there were 283 well control incidents, 61 of which resulted in crude or condensate spills (drilling mud or gas releases not included) (Table 4.3.3-1). Excluding the DWH event, less than 2,000 bbl of crude or condensate were spilled from fewer than 50 well control incidents after 1971. During the 1971–2010 period, more than 41,800 wells were drilled on the OCS and almost 16 Bbbl of oil produced. The National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling has recently argued for a more rigorous and transparent oil-spill risk assessment and planning process to support government and industry decision-making (National Commission 2011). At the present time, there is a not an ideal, standardized approach to characterizing the risk of spill occurrence and consequence across all relevant space and time scales germane to the 5-year Program, consistent with inherent uncertainties associated with different regional factors and different exploration or production operations (Pritchard and Lacy 2011). Figure 4.3.3-1 provides a quantitative, however nonetheless aggregated, characterization of the frequency of loss of well control resulting in oil spills.

Historically, BOEM has also characterized oil-spill risk using the Oil Spill Risk Analysis (OSRA) model to identify the risk of oil released from numerous locations on the OCS occurring and contacting environmental, social and economic resources. BOEM performs OSRA modeling in the evaluation of individual lease sales and certain exploration/development plans. BOEM or BSEE also considers risk during the review of an operator's Exploration Plan, Development and Production Plan (or Development Operations Coordination Document), and/or Application for Permit to Drill (APD). The same OSRA runs often form the basis for spill risk and resource contact analysis in industry-submitted oil-spill response plans. The APD describes the drilling procedures and technology that are planned to be used to drill a specific well under the specific geologic, geophysical, and environmental conditions that exist at the site. BSEE evaluates the APD to determine whether the operator's drilling plan is appropriate for the drilling risk of the site, including use of a new well-containment screening tool developed in collaboration with industry (see Section 4.3.3.3.4).

TABLE 4.3.3-1 Loss of Well Control during OCS Operations (1964–2010)

Region	Exploration Wells	Development Wells	Loss of Well Control Events	Loss of Well Control with Oil Pollution Events
Alaska	84	6	0	0
Atlantic	51	0	0	0
Gulf of Mexico	16,889	29,733	278	59
Pacific	324	1372	5	2
Total	17,348	31,111	283	61

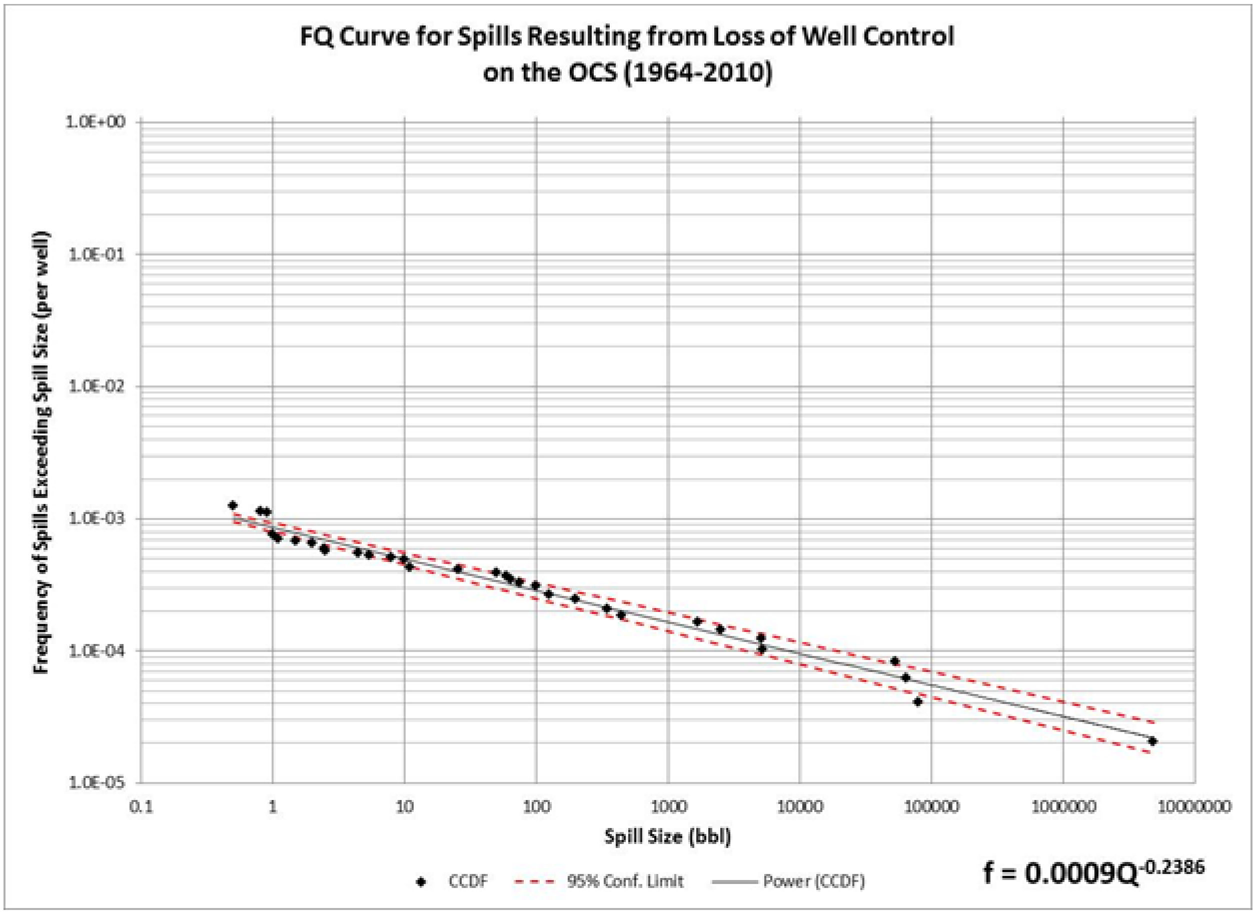

FIGURE 4.3.3-1 Estimated Frequency of OCS Crude and Condensate Spills Both Resulting from Loss of Well Control per Well Drilled and Exceeding a Specified Spill Size (See figure notes 1–13.)

FIGURE 4.3.3-1 Notes

1. The figure shows the frequency of loss of well control (LWC) per well exponentially decreases as spill size increases. See note 9 for more detail about the formula.

2. The BSEE database on LWC includes incidents from 1956 to present day. Most records in the BSEE database can be viewed at http://www.bsee.gov/Inspection-and-Enforcement/Accidents-and-Incidents/Listing-and-Status-of-Accident-Investigations.aspx. The BSEE database also contains a few additional observations besides those available online. As can be expected, the quality of information improves as a function of time. Only the period 1964–2010 is considered herein because of improved quality of information. BOEM undertook a substantial effort to quality control data, when possible identifying and confirming for each incident the relevant API well number, bottom OCS lease number, platform and/or rig, etc. This allowed BOEM to check the timing of a particular LWC incident relative to well operations documented in shared BSEE/BOEM information management systems. BOEM successfully validated more than 90% of all records to well type and operational phase in advance of completing this analysis.

FIGURE 4.3.3-1 Notes (Cont.)

3. The sample size of OCS LWC incidents is small, even when including all OCS Regions. No LWC incidents have occurred or have been reported in the Alaska or Atlantic OCS regions. To obtain a sufficiently large sample size to estimate both historical frequency of LWC and the relative frequency of different sized oil spills (resulting from LWC), 283 incidents between 1964 and 2010 are considered. LWC incidents occurred during exploration drilling/coring (75/2), development drilling/coring (82/1), completion (21), workover (55), production and shut-in (37; a number during hurricanes), and temporary and permanent abandonment (10) operations. Most historical LWC incidents resulted in the surface release or diversion of natural gas; in fact, the database only includes 61 instances of crude or condensate surface releases since 1964. Moreover, the typical crude or condensate spill size is relatively small; the median spill size, including the DWH event, between 1964 and 2010 was 2 bbl.

4. The MMS changed the definition of and reporting requirements for LWC in 2006; prior to that, there was a reporting requirement for blowouts. This resulted in a detectable difference in LWC frequency after 2006 (see trend discussion below in note 7). It is possible that certain incidents that occurred before 2006 were not historically considered LWC incidents that would be considered such following the 2006 change. The BSEE database also contains records for the Gulf of Mexico OCS that SINTEF's worldwide blowout and well release database does not and vice versa. For example, there is a difference of twelve records in the 1983–2007 period. These differences can be attributed in part to the fact that BSEE and SINTEF use overlapping, but different definitions of LWC.

5. This analysis essentially assumes that wells spudded or drilled is an unbiased exposure variable (in aggregate) to estimate the frequency of LWC from all OCS operations. It is relatively simple to understand and collate and can be readily compared to BOEM's scenario of OCS exploration and development for the 5-year Program. However, BOEM recognizes that number of wells spudded or drilled likely underestimates all exposure over the varied exploration, development, and production operations during which LWC may occur. While the number of wells spudded or drilled works well for drilling-related incidents, the number of well completions, number of well workovers, number of active producing wells or well producing years, and number of temporary and permanent abandonment operations are expected to be comparatively better exposure variables for LWC incidents occurring during those operations. Not including that additional exposure (either in terms of an activity level or time exposure) results in a relatively conservative treatment of frequency estimation. For example, more than 42,000 downhole completion intervals were completed on wells in the Gulf of Mexico OCS alone during the same time frame, not accounting for injection intervals. Completion may involve a distinct re-entry into the borehole. While BOEM/BSEE has compiled the data for most of these other exposure variables for the historical period (1964–2010), the spill size data for such operational categories cannot be statistically analyzed (using this methodology) due to the small number of crude/condensate spills from LWC in each category.

6. The exposure variable, OCS wells spudded or drilled, includes original boreholes, sidetrack boreholes, and bypass boreholes for both exploration and development wells. No boreholes associated with both surface and bottom state leases are included in the exposure data. Similarly, no relief, stratigraphic test, COST, or other wells are included in exposure data.

FIGURE 4.3.3-1 Notes (Cont.)

Approximately 48,450 exploration and development boreholes were spudded or drilled in the Alaska, Atlantic, Pacific, and Gulf of Mexico OCS Regions from 1964 through 2010 (36% exploration/64% development). Many wells in the Pacific and Gulf of Mexico OCS actually have numerous boreholes, especially when including bypasses and sidetracks. Approximately 25% of boreholes in the Gulf of Mexico and Pacific OCS Regions are bypasses and/or sidetracks. Note that less than 5,000 boreholes have been spudded or drilled in water depths greater than 200 m in the Gulf of Mexico and Pacific OCS Regions. Injection wells are included in the count of development boreholes. In the Gulf of Mexico OCS, boreholes originally spudded as exploration boreholes are often later completed and eventually produced. In this analysis, if LWC occurred during completion, workover or production operations, such incidents were considered development related.

7. There is no statistically significant trend in the frequency of LWC or LWC with spills (when standardized by wells spudded per year) except after the LWC rule changes introduced in 2006. Incident reporting associated with non-drilling operations increased by a factor of ~2 compared to the historical reporting rate. This suggests that it is likely that equivalent events were unreported prior to 2006. Because of the overall lack of definitive trend, the period from 1964 through 2010 was used in aggregate, despite rather substantial changes in regulation, technology, and industry operations/practices. This allows for the inclusion of some relatively large (≥ 1,000 bbl) oil spills before 1971 when major regulations changes were introduced; otherwise, after 1971, the spill next largest to the DWH event is 450 bbl.

8. LWC frequencies can be standardized by operational phase and well type as is available for the SINTEF database (see DNV 2011a). The LWC frequency across exploration, development and production operations is not the same and treating them in aggregate introduces some error/uncertainty because of the lack of treatment of specific exposure. In aggregate, the OCS LWC frequency is 0.006 incidents per well spudded or drilled when accounting for all LWC incidents regardless of operational phase and oil spill occurrence. The OCS LWC frequency for exploration drilling is 0.0044 incidents per well spudded or drilled, whereas the OCS LWC frequency for development drilling is 0.0027 incidents per well spudded or drilled. While it has been suggested that there is greater incidence of kick (a precursor to LWC) in deepwater (defined here as >200 m) (see note 11 below), the frequency for LWC in deepwater is less than shallow water. Of the 283 OCS LWC incidents considered, 21 instances of LWC occurred in >200 m (13 LWC incidents from drilling; 7 of these 13 incidents were exploratory). In fact, only 5 crude/condensate spills (2 during exploration drilling; 2 during exploration well abandonment; 1 during a development well workover) have resulted from LWC incidents in > 200 m. Over the same time period, the total vertical depth and average water depth of boreholes notably increased, especially since the early 1990s as industry moved into relatively deeper water and/or targeted relatively deep gas plays on the shallow Gulf of Mexico shelf. That trend is coincident with a decrease in the number of boreholes being spudded and drilled per year. Similarly, the number of boreholes relative to each well also increased over the time period considered. Despite these notable trends, the actual frequency of LWC in deepwater is less than in shallow water. Although frequency of LWC for wells characterized by HP/HT downhole conditions was not calculated, it is expected to show a comparatively greater incidence (DNV 2011a).

FIGURE 4.3.3-1 Notes (Cont.)

9. The power law fitting ($f = \alpha Q^{\beta}$) follows the methodology presented in DNV (2011b). In this equation, f corresponds to the frequency of crude/condensate spills per well exceeding spill size Q (bbl). Alpha (α) describes the relative frequency of spill occurrence, whereas beta (β) defines the power relation between spill size and frequency. For scaling purposes, alpha can be compared to the frequency for all LWC discussed above in note 8. The complementary cumulative density function (CCDF), or sample complementary cumulative frequency distribution, shows the number of spill events per exposure that are greater than or equal to a given spill size. The cumulative density function (CDF) is first estimated by ranking the OCS LWC spill observations by size and counting the observations equal to or less than that spill size. The CCDF essentially reverses the observation count for the CDF. The uncertainty in both the CDF and CCDF must be acknowledged, given the limited sample size and relatively few observations in the extreme value tail. In fact, there are no observations between 80,000 bbl and 4,900,000 bbl, and approximately 96% of the cumulative spill volume following LWC is accounted for in a single incident (i.e., DWH event). The power law is fitted to the CCDF using least squares regression. The fit is statistically significant at the 99% level ($r^2 = 0.98$). Confidence intervals at the 95% level were calculated and are displayed above.

10. The power law parameters and confidence limits only offer an approximation of the exceedance frequency of spill sizes related to LWC. The distribution of spill sizes resulting from LWC (n=61) could not be definitively shown to follow a power law distribution, so estimates using least squares regression of the power law parameters may be biased (see Clauset et al. 2009). Dozens of other non-normal, extreme value probability distributions (e.g., log normal, exponential, general extreme value, etc.) were also tested against data observations using maximum likelihood estimators, and no distribution could confidently be fitted to the limited LWC spill data observations.

11. Using this method, there is insufficient LWC spill occurrence data to confidently differentiate by well type or operational phase, water depth, downhole parameters, etc., although these variables may contribute to well complexity and LWC risk. For example, Pritchard and Lacy (2011) report that wellbore instability (kick/loss of circulation) occurs as much as 10% of total deepwater time, and, moreover, that kick incidence (fluid influx from formation into the wellbore) is greater in deepwater wells than other “normal” wells. Holand and Skalle (2001) also suggested an increased kick frequency with borehole depth and water depth. The Mechanical Risk Index (MRI) has been suggested as a complementary analytical tool to better characterize well complexity and well control risk, as well as evaluate non-productive time and drilling cost (Pritchard and Lacy 2011; Skogdalen and Vinnem 2012). The MRI, described in detail in Kaiser (2007), accounts for the following principal factors: total measured depth, vertical depth, horizontal displacement, water depth, number of casing strings, and mud weight at total depth. The Macondo well has been classified as a particularly complex well according to the MRI criteria. It is important to note that drilling complexity and difficulty does not necessarily equate to frequency of LWC, despite the apparent relationship between kick frequency and certain borehole parameters (Holand and Skalle 2001). Although certain parameters may contribute to additional risk, the OCS data suggests, primary and redundant secondary barriers, newer technology, and better trained personnel (all common to deepwater wells given the investment requirements) may in part contribute to lower LWC frequency.

FIGURE 4.3.3-1 Notes (Cont.)

12. Alternative methods could be used to estimate the likelihood of occurrence of a catastrophic spill from LWC based on an event tree, fault tree, bow tie or modeled approach (DNV 2010a; DNV 2010c). For example, a different means to calculate the expected frequency of LWC could follow this example event tree: frequency of LWC for a specific operational phase, factor adjustment for different incident rates by water depth, factor adjustment for not being a shallow gas blowout, factor adjustment for surface flow as compared to underground flow, factor adjustment for whether the surface release is gas or crude/condensate, factor adjustment for BOP reliability or other barriers, etc. This could then be coupled with stochastic spill size distribution modeling based on historical spill size observations, predictions of worst-case discharge, and/or historical/predicted discharge durations. The DNV 2010a analysis provides a recent example in part for exploration drilling in the Canadian Beaufort Sea; following such methods, DNV calculated that the likelihood of uncontrolled flow of oil after considering certain technological barriers was 1 per 100,000 exploration wells drilled. That assessment did not address the reduced expected frequency related to varying spill sizes from an uncontrolled surface flow.

13. This analysis does not account for new risk-reducing measures (including those required by new BSEE regulations), which are likely to reduce the likelihood of a blowout (DNV 2010b, c) or control its potential size (e.g., capping, containment and well control technologies). This analysis of historical OCS LWC and crude and condensate spill observations again represents a conservative approach to frame the risk.

Industry often prepares sophisticated, well-specific risk assessments for exploration or development wells. The hazards-based or well-specific approach can use event-tree, fault-tree, and “safety case” analytical methods (Cooke et al. 2011; DNV 2010b). Well-specific quantitative risk analysis (QRA) is frequently performed by operators (e.g., Mechanical Risk Integrity, BlowFAM, BowTieXP), where complexity or risk is quantified and compared to acceptance criteria and thresholds. Such quantitative risk analysis considers formation/well characteristics, technology and procedures, and human error/management (which is frequently a root cause of many well control incidents). The recently promulgated Safety and Environmental Management System (SEMS) rule, building on API Recommended Practices (RPs) 14C, 14J, and 75, now requires all OCS operators to identify, address, and manage safety and environmental hazards during design, construction, start-up, operation, and maintenance activities.

To support the planning decision involved in establishing a 5-yr schedule of lease sales, detailed analyses of highly variable, region-specific and/or well-specific risk is neither feasible nor appropriate. At this decision juncture, the critical realization is that the risk of a spill with catastrophic consequences, albeit small, is not zero. Different OCS regions and operations may have different risk profiles (Scarlett et al. 2011). This section assesses the importance of different catastrophic discharge event risk factors in different program areas. This discussion is presented to bring into focus critical risk factors, acting individually or in combination, that may occur in program areas so that additional consideration is given to these issues during decision-making on the Program.

Following the DWH event, the National Oil Spill Commission, the National Academy of Engineering/Natural Research Council, and the Department of the Interior Inspector General, among others, offered numerous recommendations about possible regulatory and technology changes, industry practices, and risk assessment approaches that could potentially contribute to safety improvements and oil-spill risk reduction (National Commission 2011; NAE and NRC 2011; DOI IG 2010). In Section 4.3.3.3.4 of the PEIS, recently implemented and ongoing regulatory and industry reforms are organized around prevention, containment, and response themes and summarized accordingly. In addition, the PEIS highlights promising study, research, and collaboration addressing improvements along the same central themes. BOEM believes, in totality, the wide-ranging reform measures and promising research will contribute to further risk reduction, safety improvements, and incident preparedness and response capability over the 40- to 50-year life of this 5-year Program.

4.3.3.2 Risk Factors Influencing Occurrence, Size, Containment, Response, and Fate/Consequence of a Catastrophic Discharge

Risk is the combination of the probability of an event and the magnitude of the consequences of that event. While BOEM primarily analyzes spills in context of accidental small spills (<1000 bbl) and large spills (≥1,000 bbl), this programmatic discussion on risk focuses on low-probability, very large volume, long-duration OCS spills with the potential for catastrophic effects (40 CFR 1502.22) (see Table 4.3.3-2). Such a catastrophic discharge event may result in "large-scale damage involving destruction of species, ecosystems, infrastructure, or property with long-term effects, and/or major loss of human life" (Eccleston 2010). Such a spill would be defined by the National Oil and Hazardous Substances Pollution Contingency Plan as a "spill of national significance" or "a spill which due to its severity, size, location, actual or potential impact on the public health and welfare or the environment, or the necessary response effort, is so complex that it requires extraordinary coordination of Federal, State, local, and responsible party resources to contain and cleanup the discharge" (40 CFR Part 300, Appendix E). Note that some spills potentially classified as spills of national significance would not necessarily be catastrophic discharge events. For a spill to be considered a catastrophic discharge event, its potential discharge volume must be such that catastrophic effects could occur. As previously discussed, long duration uncontrolled flows from a well control incident provide the greatest volumes of potential flow and are the spill sources considered in this section. A scenario of maximum spill volume and duration is presented in Table 4.3.4-3, describing catastrophic discharge characteristics in different program areas. The discharge rate, volume, extent, and duration varies with geologic formation, well design, and engineering characteristics, spill response capabilities, and time to containment. The potential volume of oil that could enter the environment fundamentally depends on the success of intervention, containment, response efforts at the incident site, and the length of time needed to stop the flow from the well by drilling a relief well. The effect of discharged oil not recovered is influenced by various weathering processes and response measures, such as use of dispersants and burning. The potential adverse effects also vary with time of year and location of release relative to winds, currents, land, and sensitive resources, specifics of the well (i.e., flow rates, hydrocarbon characteristics, and infrastructure damage), and response capability (i.e., speed and effectiveness). A catastrophic discharge event does not inherently equate to a spill with

TABLE 4.3.3-2 Risk Factors That Affect a Catastrophic Discharge Event

Risk Factors	Factors That Affect Occurrence	Factors That Contribute to Catastrophic Consequences
Geology	Drilling location, drill depth; mature vs. frontier areas Formation and reservoir pressure; reservoir volume Seabed complexity Shelf hazards	Larger reservoir volume Higher reservoir pressures and temperatures Uncertainty associated with drilling in frontier areas
Water Depth	Increased water depth increases complexity of operation	Shallow water depth increases probability of contact with humans, sensitive species and sensitive environments
Well Design and Integrity	Drill string length Mud program Cementing and casing design Well integrity New technologies (e.g., associated with expansion) Secondary barrier systems (e.g., BOPs, Backup control systems, ROVs) Human error Scale of operations and expansion	Exploratory drilling and improper well construction Prevention system failure Source of blowout: wells and platforms (as opposed to pipelines) Human error, often involving lack of understanding of new technologies
Loss of well control prevention and intervention	Improperly maintained or operated equipment Mechanical failure Equipment failure	Mechanical failure Equipment failure
Scale and expansion	Complexity of operations both physical and operational Human error Coordination and management	Human error Coordination and management
Human error	Lack of training and preparedness Extreme working environments	Lack of training Failure to take precautionary measures
Containment Capability	N/A	Subsea vs. surface containment
Response Capability	N/A	Distance from shore (duration) Response capability in remote areas Capping at the well; drilling relief well chemical and mechanical response
Geography	Region-specific meteorology: temperature, extreme weather, prevalence of ice	Distance to shore: proximity to coastline increases probability of catastrophe Hurricanes associated with high-volume spills

TABLE 4.3.3-2 (Cont.)

Risk Factors	Factors That Affect Occurrence	Factors That Contribute to Catastrophic Consequences
Oil types, weathering and fate	Temperature of oil: higher oil temperatures and lower water temperatures (e.g., Arctic) increase likelihood of breakage Tidal patterns Currents and hurricanes	Oil weathering and evaporation Mechanical recovery, dispersal, or burning Transport/ice Oil persistence Ambient temperatures affect rate of oil flow from blowout location

catastrophic effect. Instead, impacts depend critically on the spill size, oil type, environmental conditions, resources present and exposed, toxicity and other impact mechanisms, and population/ecosystem resilience and recovery following direct exposure.

Industrial Economics, Inc., and Environmental Research Consulting, under contract to BOEM, identified a suite of factors that may contribute to loss of well control and affect the size and duration of catastrophic discharge event, differences in efficacy of containment and response, and differences in fate. They include the following:

- Geologic formation and hazards;
- Water depth and hazards;
- Geographic location (including water depth);
- Well design and integrity;
- Loss of well control prevention and intervention;
- Scale and expansion;
- Human error;
- Containment capability;
- Response capability;
- Oil types and weathering/fate; and
- Specific regional geographic considerations, including oceanography and meteorology.

Many of these factors apply to drilling, abandonment, containment, response, and effects of the event and contribute to the overall catastrophic discharge risk associated with an OCS area, or even a particular well. The interplay of these factors is relevant to evaluating the risk of a catastrophic discharge event and ensuing consequences (Table 4.3.3-2). As BP concluded in its report on the DWH event, a complex series of connected mechanical failures, human judgments, engineering design mistakes, and operational, implementation, and team interactions often contribute to incidents (BP 2010). Many of the risk factors are interrelated, and some factors both increase and decrease cumulative risk depending upon whether one is evaluating the risk of occurrence or the consequence of that occurrence. Moreover, some risk factors may contribute to more or less risk depending on the specific situation.

4.3.3.2.1 Loss of Well Control Occurrence.

Geologic Conditions. Depending on the region, the geology of the OCS varies greatly in character and oil and gas exploration potential. Risk assessments of mature areas (areas where prior drilling operations have occurred) benefit from previous geological exploration and well development. For example, from 1964 to 2010, there have been more than 46,500 exploration and development boreholes spudded or drilled on the GOM OCS. In comparison, frontier areas, such as the Arctic, are relatively underexplored and do not have long registries of geological data or previous attempts at well drilling; in the Arctic, only 84 exploration wells, 14 COST wells, and 6 development wells have been drilled since 1975. This lack of detailed geologic characterization adds additional risk to frontier operations. Though improvements in seismic technology allow three-dimensional modeling of sub-seafloor geology, frontier areas inherently are characterized by greater risk (USGS 2011d; National Commission 2011). Geologic data in deepwater and ultra-deepwater frontiers in the GOM is growing, as is the industry's understanding of the geological variability and risks, especially as operators continue to develop leases tied to these oil-rich areas.

Because of variations in shallow and deep geologic framework, exploration and drilling often encounter numerous challenges including shallow hazards, such as seafloor instability, shallow water flow, permafrost, and gas hydrate, shallow gas and sour gas zones, as well as relatively deeper hazards, such as salt bodies and tar zones (Close et al. 2008; Nuka and Pearson 2010; Shaughnessy et al. 2007). In deepwater reservoirs in the GOM, narrow margins in pore pressure and fracture gradient, over-pressurized and low pressure zones, and reservoir compartmentalization (including low flow assurance) can represent key engineering challenges because of often greater drill depths (Cunha et al. 2009; IHS/GPT 2011). Such geological differences across the different regions represent key concerns for the potential influence geology exerts on wellbore integrity, a key element in drilling and developing wells. Section 4.2 includes a more detailed discussion of the geologic hazards that represent important safety and operation considerations.

Most of the larger reservoirs being targeted on the shallow GOM shelf produce natural gas. There are comparatively fewer plays capable of very large oil discharges as compared to deep water. In shallower wells, the relatively lower formation pressure typically results in a higher margin of safety, although encountering shallow gas represents a substantial hazard. The pressure margin allows operators to change the weight of the drilling mud by several pounds per gallon to balance formation or reservoir pressures. In additional, a large number of shallow-water wells actually require positive external stimulation to produce and facilitate flow of the product from the drilling site.

In general, geologic pressure (pore pressure) and temperature increase with depth. Offshore oil reservoirs can be highly pressurized and compressed under thousands of feet of unconsolidated sediment, salt bodies, and sedimentary rock. The true vertical depth of some reservoirs may exceed 9,144 m (30,000 ft). Deep wells are known to have pressure ratings exceeding 20,000 pounds per square inch (psi) (USDOI 2010; Midé 2010). As pressure and pressure gradients increase, drilling operations become more challenging and necessitate careful balancing of pressures to prevent either the collapse of the well (from excessive pore pressures) or fracturing of the rock and loss of circulation (from excessive drilling pressure). Deeper reservoirs also tend to feature larger volumes of oil. In the event of a well blowout, wells tapped into larger reservoirs can potentially release more oil into the environment and at greater discharge rates since flow rates depend in part on temperature and pressure. Uncontrolled flow rate, or "open flow potential," can be over 100,000 bbl per day. While ultra-deep wells frequently encounter very high formation or reservoir pressures, some wells, such as the Perdido field, have low reservoir pressures and require pumping to facilitate production.

Water Depth: Rig and Well Complexity. Water depth alone is not a strong predictor of well control incidents, but it has been related to the complexity of technology and operations, as well as the frequency of safety incidents (Jablonowski 2007; Malloy 2008; Muehlenbachs et al. 2011). True vertical depth of the well, which includes water depth and well depth, may be a better exposure variable for blowout risk because it encompasses risk factors associated with downhole conditions (Holand 2006). Exploration wells are most often drilled in open water where no platform exists. Jackups, submersibles, semisubmersibles, and drillships, collectively referred to as mobile offshore drilling units (MODUs), are commonplace in exploration drilling, whereas modular rigs installed on platforms are more commonly used in production wells. Drilling of a production well often involves interaction with a production platform and the existing wells on the platform. Water and well depth not only drives the drilling technology, but also influences well design and construction practices, as well as safety measures used to mitigate risk of well control incidents. As oil prices remain relatively high, exploration and production firms venture into deeper waters where larger reservoirs of oil are known to exist. While contingent on a number of factors, deepwater and ultra-deepwater oil operations may have higher safety incidence rates owing to rig technology (Jablonowski 2007), although there have been and continue to be a greater number of loss of well control events in shallow water (Shultz 1999; Izon et al. 2007).

Although definitions of exact depth ranges vary, shallow water depths are generally defined as less than 200 m (656 ft). Shallow water exploration and development rigs involve comparatively simple operations and well construction, allow direct access to well control prevention mechanisms, are less susceptible to deepwater currents (although waves and strong coastal currents are in play), and do not face as frequent complications with pressure and temperature variations often found with deepwater and ultra-deepwater wells. In addition, shallow water depths allow surface blowout preventer (BOP) placement where preventative maintenance and service can be done directly by rig operators, although surface BOPs have fewer redundancies (see discussion below). At the same time, GOM infrastructure in shallow water tends to be older and may be more prone to mechanical failure. Depending on water depth, OCS exploration wells in the Arctic may be drilled from an artificial island; large, usually bottom-anchored drilling structures; or a drill ship.

The greater complexity of wells and specialized equipment used on deepwater and ultra-deepwater rigs may present more opportunity for mechanical breakdown and accidents (Jablonowski 2007). Well complexity increases the number of routine operations and incidence of unusual operations, such as stuck pipe and complex casing and cementing programs (Jablonowski 2007). Complexity also increases the number of individual tasks that need to be performed on a well, complicating procedures and communication.

Deepwater depths are roughly defined as seabed depths that exceed 200 m (656 ft) but are less than 1,500 m (4,921 ft). Because of the extreme depths of deepwater drilling, these operators can no longer utilize traditional fixed platforms directly on the seabed, and different technologies and procedures are required. Deepwater drilling rigs are multi-point moored to the sea floor or dynamically positioned. More complex operations such as mooring, station keeping, riser management, and deepwater well control may complicate operations and increase the number of procedures prone to errors and equipment prone to failure. The newest platforms incorporate advanced technology about which few data on long-term success or incidents have been gathered (USGS 2011d). Deepwater wells require subsea BOP placement at depths unreachable for human service; ROVs, which are designed for such conditions and have relatively higher rates of reliability compared to surface BOPs, become necessary for intervention operations (Midé 2010). Maintenance, repair, and assurance of proper functioning of such technology are more difficult at greater depths.

Ultra-deepwater is a relatively new class of wells defined as exceeding wellhead depths of 1,500 m (4,921 ft). Similar to deepwater platforms, ultra-deepwater rigs are floating semi-submersibles and dynamic positioned drill ships. Ultra-deepwater wells require intricate and complex platforms, structures, and equipment to operate. High hydrostatic pressures and low ambient temperatures in such deep waters necessitate heavier and more specialized equipment and redundant systems because of intervention difficulties. The extended depth demands larger platforms and operating rigs to handle the added drilling materials, as well as storage capacity.

Well Design and Integrity. Well construction is a process with numerous stages preceding well abandonment or production. Construction of an offshore well involves different types of setting agents, pipe, casing, cements, wellhead technology, rigs and platforms, drilling muds (synthetic or water based), and cleaning/preparation agents. These differ by environment, with deepwater wells requiring distinctly different construction and technologies to withstand conditions at extreme hydrostatic pressures and lower temperatures compared to shallow-water wells.

Since the process of sub-seabed drilling cannot be directly observed, drilling operators in an offshore environment are reliant on secondary indicators to ensure proper construction of the well. Geophysical imaging, pressure readings, and reclaimed fluid testing are some of the secondary indicators used in drilling at depth. Though these tests lend accuracy in mapping pressure zones, impediments such as pockets of gas, shallow water flows, faults, salt deposits, or rubble zones are not always forecast.

The primary function of a well system is to reliably contain, control, and transport hydrocarbons to the surface. In general, risks are determined by well bore parameters and an operator's familiarity with the well bore. Drilling engineers must constantly monitor pore pressures, fracture gradients, fluid circulation, and abnormal pressure zones to avoid loss of well control. When drilling into frontier or new reservoirs, limited knowledge of wellbore parameters can increase risk of accidents. The number of barriers is often scaled with the likely consequence of failure; multiple barriers are often used to achieve adequate reliability and avoid leaks (SINTEF 2011). Complex hole sizing, drilling string, wellhead technology, and mud programs, as well as casing and cementing designs are required to reach target depths in deep water and ultra-deep water. Mud, casing, and cementing programs must be designed, refined, and implemented as well bore parameters and formation characteristics are being monitored.

Drilling mud/completion fluid pressure is the primary well control barrier for drilling and well intervention operations (PCCI 1999). When this fluid hydrostatic pressure drops below that of the formation, a kick occurs, which means that formation fluid enters the wellbore (Holand and Skalle 2001). Casing and cementing programs, diverters, BOPs, and wellheads can provide backup (secondary or redundant) barriers to prevent a blowout when a kick occurs. Casing and cement, as well as drilling or completion fluids, are used to ensure the fluids in a formation do not enter the wellbore during drilling and completion operations. For production operations, a packer/tubing string and tree may provide the primary well control barrier. The production casing and wellhead system provide a backup barrier in case of a packer or tubing string leak.

In 2008, BOEMRE published guidelines on the various steps towards managed pressure drilling, a process that avoids the continuous flow of formation fluids, to facilitate better planning of drilling operations (Eschenbach and Harper 2011). Further drilling safety procedures and practice requirements have been developed by BOEMRE (or BSEE) since the 2010 DWH event, including the new Drilling Safety Rule and SEMS Rule. Under these and other rules, drilling practices must properly address and manage known and possible risks with adequate mitigation and safety technology (USDOI 2010; USGS 2011d).

Well integrity issues arise with the cement used in construction. Fluids used to clean and prepare the well for cement are either water-, synthetic-, or oil-based, which can contaminate cement. At sub-seabed depths of 5,486 m (18,000 ft) or more, heavy cleaning fluids run the risk of not filling their intended purpose and contaminating subsequent cementing jobs. Cementing problems were associated with 18 of 39 blowouts between 1972 and 1999 in the GOM (Izon et al. 2007). However, the majority of these cement-related blowouts were of short duration, primarily released natural gas, and involved shallow strings in a well-surface casing. Mechanical indicators such as negative pressure testing and pressure and heat gauges to test cement integrity have also come under scrutiny for lack of accuracy; the pressure gauges used for negative pressure testing for Macondo were accurate to ± 400 psi, an arguably imprecise measure (IAOPG 2011). It is presumed both cementing issues and mechanical failure may have been a factor in the Macondo well blowout (National Commission 2011).

When considering the risk of loss of well control, it can be important to distinguish among the different types of wells, including exploration, development, and production wells. Exploration wells are generally drilled in open water from a mobile offshore drilling unit, jack-up rig, or gravel island, whereas production and development wells are often drilled from an existing platform. In general, exploration may involve greater uncertainty due to the availability of geologic data, nature of drilling technology, and unique barrier factors, such as BOP placement (Eschenbach and Harper 2011). Despite the increased risk of drilling wells on undeveloped frontiers, procedures followed in drilling exploratory wells may be more conservative (i.e., safer) to account for this increased level of uncertainty (Eschenbach and Harper 2011).

In the GOM from 1980 through 2004, there were a relatively higher number of well releases during development drilling and well workover operations as compared to exploration drilling. This contrasts with worldwide trends where more well releases tend to occur during exploratory drilling (Holand 2006). Holand (2006) attributes this to the fact that more development wells are actually drilled. Hurricanes or ship collisions caused approximately 50% of the historical production blowouts (Holand 2006). Since 2004, the loss of petroleum during hurricanes was minimized by shutting in OCS wells. No blowouts occurred during 6 hurricanes in the Gulf of Mexico (Anderson et al. 2012). Simultaneous operations of drilling and production also increase the risk of incidents when drilling production wells. Another root cause of sustained blowouts during completion and workover is the positive potential for pressurized hydrocarbons and limited bridging tendency with flow through perforations or gravel pack (Flak 1997).

In general, the riskier wells include wildcat wells (first well into formation), offset wells (wells drilled near another well that encountered drilling trouble zones or past well control problems), and extended or ultra-deep drilling (SPE Advisory Summit 2011). Deepwater and ultra-deepwater wells require complex infrastructure, planning, and execution to construct; therefore, facilities and volume of production tend to get larger with distance from shore and water depth (Shultz 1999). The complex nature of the formations, combined with the drilling depths in high-pressure/high-temperature conditions required to reach the target zones, presents a challenge to drilling engineers (Close et al. 2008). This challenge is highlighted in the greater number of casing strings required to drill to target depth, which in turn creates the challenge in achieving good cement isolation in a tight tolerance annuli (Close et al. 2008; Chatar et al. 2010). Despite such challenges, over 2,300 deepwater development boreholes and approximately 2,600 deepwater exploration boreholes have been drilled (if deepwater is considered >500 ft). Of these, the Macondo well is the only exploration well to involve a blowout and large oil spill. No spills have occurred for deepwater development wells.

Loss of Well Control Prevention and Intervention. A blowout occurs when there is failure to control a kick and regain pressure control, and can be defined as an uncontrolled flow of formation fluids. Oskarsen (2004) classifies offshore operations blowouts in three groups:

- Surface blowouts characterized by fluid flow from a permeable formation to the rig floor;

- Subsurface blowouts characterized by fluid flow at the well at the mudline, where the exit conditions are controlled by the seawater; and

- Underground blowouts characterized by fluid flow from one formation zone to another, typically by using the wellbore as a flow path.

Loss of well control, under BSEE regulations, can also include flow through a diverter and uncontrolled flow resulting from a failure of surface equipment or procedures (30 CFR 250.188). Potential scenarios for each blowout type are described in Oskarsen (2004). Blowout frequencies by different phases of exploration and production operations and relative water depths are available in Holand (2006). Although high hydrostatic pressures at depth will aid in choking any flow from potential blowout points (PCCI 1999), two independent barriers are typically used for well control. The primary barrier is usually the hydrostatic pressure exerted by the well mud/synthetic fluid column (either static or dynamic). The secondary barriers typically include the pressure control equipment such as the BOP, the diverter system, the wellhead (innermost casing hanger seal), and the choke/kill line valves. These barriers are routinely used during drilling, completion and workover operations. If the well is flowing (i.e., producing oil and/or gas), the primary barrier is that closest to the reservoir (PCCI 1999). BSEE regulations now require at least two independent tested barriers, including one mechanical barrier, across each flow path during well completion activities (30 CFR 250.420(a)(6)).

Individual BOP systems are used during drilling operations to prevent unrestrained release of crude oil from reservoirs. BOPs are composed of all systems required to operate them, including flexible joint, annular preventer, ram preventer, connector, choke and kill lines, choke manifold and auxiliary equipment (MMS 1996c). The specific type of BOP may influence the loss of well control and well releases. For example, fault tree analysis in the DNV Beaufort Sea Study showed that there is substantial risk reduction with BOPs having two sets of blind shear rams spaced at least 1.2 m (4 ft) apart (DNV 2010a). The study concluded that the reliability of a two blind shear system is 99.32%, compared to 99% for a single blind shear ram (Midé 2010). Despite the seemingly low percentage, an increase of 0.32% in BOP reliability raises the estimated number of wells that can be drilled before an uncontrolled blowout to 6,213 from 4,225 (Midé 2010).

In shallow-water wells, BOPs are placed above the sea on the rig, allowing for periodic repair and maintenance. The operations of surface BOPs are not subject to the same complicating factors associated with subsea BOPs, and they are more accessible for repair and intervention. However, surface BOPs that are placed on floating facilities (as opposed to jack-up rigs) present other risks. The high-pressure riser and casing from the seafloor to the rig can be exposed to dynamic stresses. A failure of a high-pressure riser due to these stresses can lead to uncontrolled flow below the surface BOP system located on the floating facility. Well operations from a floating platform with a surface BOP stack and a high-pressure riser (through the water column) are higher risk operations than drilling from a jack-up rig or a fixed platform. The single high-pressure riser (or in some cases, a dual riser system) used by floating platforms is subject to environmental forces such as current induced vibration that make it more susceptible to stress fatigue. Jack-up rigs and fixed production platforms have more casing strings tied back to the surface of the rig or platform, which provide additional external support for the pressured casing. In addition, because these tied-back casing strings are used in shallower water operations with a shorter water column, they are less exposed to current-induced stress. Numerous studies have examined the reliability of surface and subsurface BOP stacks where redundancies in different designs and maintenance requirements contribute to differences in failure rate (Sattler and Gallander 2010; MCS 2010; Midé 2010; Melendez et al. 2006; West Engineering Services 2004; Holand 1999; Tetrahedron 1996; Holand 1992). Some studies have indicated that subsea stacks are more reliable than surface stacks (Sattler and Gallander 2010).

Deepwater and ultra-deepwater wells have subsea BOPs that are affixed directly to the well on the seafloor. Deepwater and ultra-deepwater seafloor depths exceed depths at which human operators can work, thus requiring submersibles and emergency backup control systems. These systems can demonstrate failures. For example, in the relatively few documented instances when BOP systems have failed, the main control system is responsible for approximately 50% of these failures (Midé 2010). Important technology includes the secondary deadman system, acoustic backup system and ROV. ROV activation of the BOP using the secondary control system has a 75% success rate. DNV (2010a) reported a 25% reliability of current acoustic backup systems.

Overall, more research and development is necessary to increase the success rates of control systems in order to reduce the risk of deepwater drilling operations. Evidence for the initial containment response to the DWH event, as well as a review of industrial and governmental containment response, suggests that mitigation technology has not kept pace with extraction technology that enabled industry to drill in increasingly deeper waters (IPIECA 2008; Cohen et al. 2011). However, industry and regulatory enhancements are underway to improve control systems (USDOI 2010; DNV 2010b) (see Section 4.3.3.3.4 for more details).

Scale and Expansion. Scale and expansion of OCS operations increases the complexity of drilling and production operations. Factors associated with scale include the number of wells, new types of production facilities, new methods of transporting oil, higher levels of production, the addition of simultaneous operations during production, and higher rates of pumping. Expansions in scale of oil production require more well and platform construction, along with higher production volumes. New technologies necessitated by an increased scale of operations may be associated with higher levels of risk, especially when technologies are not fully developed. The number of incidents reported increases with more complex operations, which by their very nature, often entail greater scale, expansion, and complexity (Jablonowski 2007; Pritchard and Lacy 2011; Muehlenbachs et al. 2011). Large-scale oil production involves the use of subsea well complexes and large central processing and storage facilities, about which little data on long-term success and incidents have been gathered. The OCS operations in the GOM are moving farther offshore and incorporate more complex drilling and production operations. For example, the Shell Perdido Project is simultaneously connected to 22 different wellhead sites (Shell 2011b). A production facility of this scale, in addition to being in ultra-deep water, typifies the trend in scale and expansion (Shell 2011a). Increased production from comparatively fewer surface facilities may concentrate the safety risks during drilling and production, but it also provides for the opportunity to better track indicators and manage and regulate the factors that contribute to safety incidents.

More complex facilities and operations require equally complex management structures. Operations of greater scale entail a complex set of relations between different operators, contractors, and management groups. While the probability of release on more complex facilities has not been actively studied, it is noted that the Macondo well suffered from insufficient correction of known concerns prior to blowout because of management and communication issues between operators and contractors (Winter 2010; JITF 2010).

Human Error. Human error, or combinations of human and mechanical failure, are the root cause of many OCS accidents and spills (Jablonowski 2007; Muehlenbachs et al. 2011). Low-probability, high-impact failures such as the Macondo well blowout indicated more stringent requirements were necessary to address human error (Winter 2010; USDOI 2010). In the case of the Macondo well, operators misread pressure readings, authorized high-risk activities, disregarded warning signs, and overlooked the checks and balances that exist in regulatory assignments, while mechanical BOP failure compounded the severity of the release (Winter 2010; National Commission 2011). The new SEMS rule recognizes this gap and establishes a mandatory program to ensure OCS operators identify, address, and manage safety and environmental hazards and impacts during design, construction, start-up, operation, inspection, and maintenance activities. This systemic approach to managing risk and ensuring safety and environmental protection should provide more focus on the risk of system failures as well as on the human factors that could contribute to an incident (SPE Advisory Summit 2011) (see Section 4.3.3.3.4 for more detail).

Level of training and safety culture are important factors in determining the number of safety and well control incidents (Jablonowski 2007; Vinnem et al. 2010). A well-trained crew that has participated in numerous practice exercises will decrease the probability of a spill caused by human error. Lack of proper training has been a significant issue in the last decade, probably because of a lack of incidents (Etkin 2011). Previously, standard industry practice often permitted operation of technical equipment with on-the-job training or one-week training courses. The MMS published final regulations for Well Control and Production Safety Training (30 CFR 250, Subpart O) in 1997 (amended on August 14, 2000), and revised them in 2000 to provide for training system audits, interviews, and tests to measure training results. Recently, the advent of new regulations (the SEMS rule) and requirements for personnel on platforms and working on drilling operations aims to eliminate the current gaps in industry-required trainings. Individuals working in specific technical jobs are now required to attend annual training and certification, and operators are required to perform job safety and hazards analyses (USDOI 2010; BOEMRE 2010e; IAOGP 2011).

Other factors such as climate and temperature could affect worker performance. For instance, colder temperatures in the Arctic lead to higher probabilities of human error due to the extreme working conditions (Eschenbach and Harper 2011).

4.3.3.2.2 Containment and Response. The effectiveness of containment and spill response dictates the amount of oil released in the environment. Area and operation-specific oil-spill contingency plans, as well as actual containment and response efforts, will be designed around many of the factors that contribute to the risk of spill occurrence and fate of oil in the water. Assuming the correct containment plan is in place, the risk of poor planning and containment execution still exists (USCG 2010).

If the BOP fails, other options are available to control the blowout, including capping/shut-in, capping/diverting, surface stinger, vertical intervention, offset kill, and relief wells (Neal Adams Firefighters, Inc. 1991). Of these methods, a relief well is often considered most important, and may be required immediately (even if it is not the first choice), since it is typically considered the most reliable solution for well control. The amount of time required to drill a relief well may depend upon the complexity of the intervention (e.g., depth of formation), the location of a suitable rig, the operations that may be required to release the rig, and any problems mobilizing personnel/equipment.

Once the oil has reached the sea's surface, the first few hours of a spill are the most critical for response efforts. Boomers and skimmers should be deployed immediately to contain the oil and *in situ* burning and dispersant use should be evaluated to supplement mechanical collection methods. Since *in situ* burning and dispersant use are time sensitive, responders should ensure the necessary supplies for either method (e.g., flame-resistant booms) are available.

If a spill cannot be contained at the site's wellhead (subsea), a response effort may be required to restrict the surface spreading of oil in the water, especially from the shore. The following sections outline the methods of containment, as well as the risks and considerations unique to each. In some circumstances, non-traditional spill response measures may also be proposed to contain or prevent oil from being transported into sensitive ecosystems, such as coastal wetlands. For example, following the DWH event, temporary sand berms were constructed in the GOM along the northern Chandeuler Islands. Although all oil-spill response measures require advance approval of the On-Scene Federal Coordinator in the USCG, some measures may be relatively untested and lead to unintended consequences (Lavoie et al. 2010).

Water Depth, Distance from Shore, and Other Variables. As shown by the DWH event, the loss of well control in deeper depths presents containment obstacles and challenges that would not necessarily be encountered during a loss of well control in shallow waters. Although many of the same techniques used in shallow water were used to attempt to control the Macondo well, the well control efforts were hindered by water depth, which required reliance solely upon the use of ROVs for all well intervention efforts. This is a concern in deep water because the inability to quickly regain control of a well increases the size of a spill, as occurred during the DWH event. Other complications associated with responding to a deepwater blowout include inaccessibility of the well, methane hydrate formation at lower seafloor water temperatures, and the need to work with larger and less-available support equipment due to the greater water pressure. The inverse relationship holds true for emergency response to spills. The closer the well is to shore, the quicker the potential response.

Distance from shore, coupled with response measures, fundamentally drive the size of the impacted area. Oil-spill contact potential, the likelihood of released oils contaminating areas or materials of interest (e.g., beaches, wildlife, sensitive environments), decreases with greater distance from shoreline (IPIECA 2008; JITF 2010). As physical distance from sensitive areas and shores increases, sea waters, currents, waves, and biological processes are able to dilute and digest more of the spilled oil. Volume alone does not determine the impact of the releases. Releases close to shore may have greater effects, especially when concentrated into inlets or smaller areas (IPIECA 2008).

Oil-spill response options in Arctic environments will vary depending on seasonal oceanographic and meteorological conditions (Potter et al. 2012). Oil-spill response strategies and tactics for cold climates must be designed to deal with a mix of open water and ice conditions that could occur throughout any portion of the operating period and extending beyond the operating period to account for response for a spill occurring on the last day of planned operations. Different environmental conditions prevalent in the Arctic and sub-Arctic may in part impede or facilitate different response windows and methods (Bjerkemo 2011; MMS 2009b). Ice can serve as a natural oil boom and dampen surface waves, while cold weather slows the rate of oil evaporation – making it easier to burn (Bjerkemo 2011). Shore ice may also provide a physical barrier, allowing oil to concentrate in greater thickness, limiting shore contact and promoting *in situ* burning (Bjerkemo 2011). However, spill removal companies have testified that icy waters make traditional techniques (booming and skimming) significantly less effective (CRRC 2009). A spill during the fall freeze-up would be the most dangerous time for a spill, and even chemical response methods would be limited (Nuka and Pearson 2010). The Arctic is sparsely populated and infrastructure is not abundant. Thus, the ability to appropriately respond to incidents remains a concern (USGS 2011d). Ice-free seasons are relatively short (around three months a year), and ice state may influence the ability to drill a relief well. The relatively shallow Arctic depths could result in more contact potential in the event of a catastrophic spill. Should spilled oil persist in the water column, there is concern that oil could become trapped in ice. A substantial government and industry-sponsored investment in oil-spill response research in varying ice states using different methods has occurred in the past few decades (Dickins 2011; MMS 2009b). Recent research in the Arctic focuses on high-capacity mechanical recovery systems for varying ice types and states, improving techniques for surface and subsurface dispersant application in coldwater environments and in drift and pack ice, ignition techniques and oil-herder applications to improve the efficacy of *in situ* burning, fate and biodegradation studies of dispersed oil in cold water environments, and detecting and tracking spilled oil under ice and within ice matrix (IAOGP 2012; Dickins 2011; Kanocz and Johnsen 2011; S.L. Ross et al. 2010). In addition to these challenges, government and industry must augment logistical, personnel, and infrastructure capacity to accommodate the level of response expected for a worse-case scenario Arctic oil spill.

Status of Technology to Physically Contain. OCS operators are required to submit documentation that they are able to deploy adequate containment resources to respond to a blowout or other loss of well control (30 CFR 254; Certification NTL). In general, subsea containment at the wellhead is ideal and most effective because it contains the oil at the source. Perhaps the most significant hurdle to the development of containment at the blowout point (subsea) has been cost (BOEMRE 2010f; PCCI 1999). Given the low historical probability of a significant blowout occurrence and limited use of subsea containment equipment, industry development of cost-effective equipment had not historically occurred prior to the DWH event, although that has changed in response to new regulatory requirements.

As mentioned, containing oil at the wellhead is the ultimate goal in the event of a blowout. However, subsea collector technologies have historically presented some operational challenges given design and installation difficulties (PCCI 1999). For subsea oil containment, the technical hurdles to be overcome during a deepwater blowout include the behavior of deepwater currents; the ability to manipulate heavy objects on the seabed; the ability to design subsea collectors that are flexible enough to cap a large range of subsea wellhead assemblies and accommodate a high volume of recovered oil, gas, and water; the ability to approach the blowing well and install containment devices on the seafloor; and the lack of standardization in subsea wellhead design.

ROVs capable of manipulating heavy objects, especially collector technologies, near the seafloor and in turbulent conditions caused by the blowout, are limited. In fact, even relatively minor blowout plumes have rendered many ROVs useless. Aside from the risk of physical damage from plumes, the following risk factors exist related to ROV use:

- Sufficient surface support or subsea lifting devices such as syntactic foam buoys are required to assist the ROV with heavy object lifting;

- Subsea currents can complicate ROV use; and

- Navigation systems and/or sensors can be damaged from the blowout plume.

In comparison, subsea containment in shallow water is less complicated; for example, it is easier to mobilize equipment and avoid hydrate formation at the relatively warmer seafloor temperatures.

The DWH event and implementation of NTL No. 2010-N10 (Certification NTL), however, has created new impetus for industry-driven containment technology. For example, Marine Well Containment Company (MWCC) – a partnership between ExxonMobil, Chevron, ConocoPhillips, and Shell – has announced the release of its seabed containment system (Helman 2011). According to the company, the unit features the ability to do the following:

- Contain 60,000 bbl per day of liquid and 120 million standard ft^3 of gas;

- Inject dispersants; and

- Be placed in water up to 3,048 m (10,000 ft) deep.

This system is intended to address the weakness of the BP containment dome that caused its initial failure during the DWH event (Helman 2011). The system can inject antifreeze-like chemicals to inhibit natural gas hydrate build-up, which created spill containment complications during the DWH event. The MWCC's system is based on design changes made by BP that led to effective capture during response efforts to the DWH event.

Another option for source control and containment is through the use of the equipment stockpiled by Helix Energy Solutions Group, Inc. The Helix initiative involves more than

20 smaller energy companies and supplements the MWCC response effort. Helix has maintained the equipment it found useful in the DWH event response and is offering it to oil and gas producers for use. Together, the ships and related equipment can accommodate up to 55,000 bbl of oil/day, 70,000 bbl of liquid natural gas, and 95 MMcf of natural gas at depths up to 2,438 m (8,000 ft).

Shell is developing equivalent shallow-water containment technology for use in the Arctic. The company is under increasing scrutiny from industry stakeholders to ensure that an event similar to the one that happened in the GOM will not occur in the Arctic. Shell has pre-staged response equipment and vehicles designed for Arctic conditions that can be activated immediately (Dyer 2011). For example, in the 2011 Revised Outer Continental Shelf Chukchi Exploration Plan, Shell's spill response plan includes oil-spill response (OSR) vessel (Nanuq); an ice-capable Oil Spill Response Barge (OSRB) and associated tug (Point Oliktok tug and Endeavor barge); MSV Tor Viking and M/V Fennica vessels for ice management; a secondary relief well rig (Noble Discover); an oil storage tanker with a 500,000 bbl capacity for storage of any recovered liquids (Affinity); associated smaller workboats and aerial support (Shell 2011c). In addition, Shell's plan includes two vessel of opportunity skimming systems (VOSSs) to assist with containment and recovery, along with an Arctic oil storage tanker to provide storage of recovered oil (BOEMRE 2011m; Shell 2011c). Shell has committed to having a pre-fabricated subsea capping system with surface capability to capture and dispose of oil, and has indicated that this system is in final design and construction (Shell 2011c). Similar containment and response capabilities are also planned for exploration drilling activities in the Beaufort Sea, and some response capabilities will serve both locations (Shell 2011d).

Aside from subsea containment, subsea dispersant injection into the well or blowout jet zone is considered to be one of the most promising measures to contain the *effects* of the oil spill. Design concepts to date require advanced planning to incorporate the appropriate equipment for dispersant injection into the drilling infrastructure/equipment (e.g., subsea stack or BOP). The industry is now focused on wellhead-independent injection systems; this method involves applying dispersants into the blowout plume. As noted above, MWCC's system includes a subsea injection capability. However, the environmental tradeoffs of subsea dispersant use (similar to surface dispersant use, discussed in the following section) continue to be debated and have been poorly documented based on limited prior application (USEPA 2011n).

Mechanical Recovery Methods. Mechanical recovery methods include the use of booms, barriers, and skimmers, as well as natural and synthetic sorbent materials (NRC 2003b). Of all response efforts, mechanical methods exhibit the least impact on the environment and are considered to be the first line of defense against surface oil spread (USEPA 2011p).

Booming and skimming are the two most widely used mechanical containment methods. The effectiveness of these two measures will depend on the volume of the oil spill, location of the well, and sea conditions. For example, at remote open-sea well locations, the immediate availability of sufficient oil storage and/or oil-water separators may be limited (BOEMRE 2010f; PCCI 1999). Booms and skimmers become less effective in higher wave swells and wind, and in fast currents. Three main types of skimmers exist, each with characteristics that may make them more effective given certain ocean and spill conditions. Weir and suction skimmers operate best on smooth water with little debris; oleophilic skimmers are the most flexible, can be used on spills of any thickness, and may work most effectively on water that has rough ice debris (e.g., in Alaska) (USEPA 2011q). Although oil recovery efforts must withstand the harsher climate conditions of the Arctic, a research program conducted by SINTEF in 2010 concluded that the mechanical recovery of oil spills is possible despite difficulties associated with ice management and maneuvering vessels and skimmers through ice (Sørstrøm et al. 2010). Varying ice states (i.e., type, thickness, coverage) may require different ice management tactics and/or substantially reduce options for mechanical recovery and recovery rates, or in the case of oil in or under pack or solid ice, mechanical recovery may not be possible during several months of the year (S.L. Ross 2011; Nuka Research and Planning Group 2007b). In any environment, collection rates of 20% are considered exceptional in most cases (USEPA 2011g). In the case of the DWH event, skimmers only accounted for the removal of 3 or 4% of the released oil because of relatively low efficiency (USCG 2010).

The DWH event tested new, "enhanced" booms and skimmers, which may help expand the range and efficiency of recovery in open water and near shore. Advances have been made to create booms that can withstand rough sea conditions and more viscous oil, including in cold-water conditions offshore Norway (McKay 2011). As a result, the effectiveness of recovery both on open water and near shore can be expected to increase, especially given the attention of the USCG to this matter (USCG 2010).

Sorbent materials capture oil through absorption or adsorption and are often used to supplement booming and skimming. Lighter oil products (e.g., gasoline, diesel fuel, benzene) are absorbed more easily, while thicker oil responds better to adsorption (USEPA 2011r). While generally effective, the use of sorbents is less practical with extremely large spills or in windy conditions.

Chemical and Biological Methods. Surface dispersants (chemical-based) can be applied via boats, aircraft, helicopters, or through subsea injection techniques. A two- to three-day window following an event generally exists to use dispersants (BOEMRE 2010f); therefore, pre-approval of dispersal as a contingency method and of specific dispersant use is essential (NRC 2005b). The USEPA maintains a list of chemicals and spill-mitigating devices that may be deployed during an oil spill in coastal waters of the United States; this is a part of the National Contingency Plan (NCP). Actual approval of response measures is required by the USCG and USEPA chairs of the Regional Response Team (RRT). Since the toxicity of dispersants is an important consideration (IPIECA 2008; NRC 2005b), mechanical containment methods are generally the preferred initial response. However, very large spills may require immediate application of dispersants, because mechanical recovery may not be adequate or weather conditions may prevent mechanical recovery and *in situ* burning. Further study is needed to understand the effects of subsea and surface application of dispersants in marine ecosystems, but following the DWH event, subsea injection of dispersants at the source is viewed as an effective method for reducing the amount of oil that reaches the surface. In certain situations, dispersants may provide the only means of removing significant quantities of surface oil quickly. It is essential that the effectiveness of chemical dispersion be monitored continually and the response terminated as soon as the dispersant is no longer working. While modern dispersants and oil/dispersant mixtures exhibit relatively low toxicity to marine organisms, concerns remain about the overall volume used and persistence in the environment (Berninger et al. 2011; Hemmer et al. 2011; Hamdan and Fulmer 2011; Wooten et al. 2012). The Joint Industry Oil Spill Preparedness and Response Task Force (2011) summarizes ongoing research initiatives addressing the effectiveness, fate (e.g., biodegradation, bioaccumulation), and toxicological effects of dispersants in marine environments, including subsea application in deep water. In addition, the Oil Spill Preparedness and Response Joint Industry Task Force is working closely with Federal agencies, such as USCG, USEPA, NOAA and BSEE, to make more informed decisions about dispersant use in the context of trade-offs (e.g., draft National Response Team guidance on dispersant use).

The effectiveness of dispersants (compared to booming and skimming methods) is more dependent on sea conditions. Studies indicate that dispersants are most effective at salinities close to that of normal seawater (NRC 2005b). In addition, dispersants work best in warmer water (USEPA 2011n), although some research suggests dispersants also can be applied in cold waters (S.L. Ross 2007, Potter et al. 2012).

Gelling agents react with oil to form rubber-like solids that can then be removed from the water via nets or skimmers. Gelling agents can be most effective for small to moderate spills in moderately rough seas. The volume of gelling agent required can be as much as three times that of the oil spill; therefore, for larger spills, it is impractical to use this method. Moderately rough seas provide increased mixing effect of the agents with the oil, resulting in greater solidification (USEPA 2011o).

The use of biological agents (i.e., bioremediation) for oil-spill response is an emerging area of research. Bioremediation is the act of adding materials (e.g., microorganisms) to the environment to increase the rate of natural biodegradation. Currently, two technologies – fertilization and seeding – are being used in the United States for oil-spill remediation (USEPA 2011m). Unlike the other methods covered in this section, bioremediation is a longer-term response effort.

***In Situ* Burning.** Burning is an effective method to remove much of the oil once it has reached the water's surface and reduces the need for storage of recovered oil. Weathering properties of the oil will affect whether or not surface burning is a viable option. For burning to work effectively, oil thickness must be at least 1 to 2 mm and water-in-oil emulsion must be 50% or less (NOAA 1997).

The weathering properties of oil in icy waters are also important for recovery efforts. Studies have shown that, in general, oil in icy waters weathers at a slower rate than in open waters. The slower weathering process of oil in the Arctic Ocean increases the opportunity of successful *in situ* burning, which efficiently reduces free floating oil and oil collected in booms (Sørstrøm et al. 2010). *In situ* burning has been successful in cases where oil was trapped in ice (Nuka and Pearson 2010; Ross et al. 2010). Herding agents can also be added to the water surface surrounding an oil slick, causing the slick to contract, thus reducing the slick's area and increasing its thickness, facilitating burning (Buist et al. 2011). However, under certain ice and environmental conditions, the effectiveness of *in situ* burning is limited (S.L. Ross 2011).

A factor that could limit the application of *in situ* burning is the impact on human health due to gas and particulate release from oil burning. Studies estimate that 5 to 15% of the oil is converted to particulates (mostly soot) but that public exposure is not expected unless the smoke plume sinks to ground level. However, *in situ* burning raises general concerns over air quality impacts (NOAA 1997a).

4.3.3.2.3 Fate.

Oil Type. Various oil types have varying characteristics, including pour point, viscosity, weight, and composition. In general, lighter oils tend to be less viscous and can be byproducts of crude oils such as diesel and gasoline. Lighter oils tend to be less toxic, although some from the GOM tend to have higher concentrations of toxic compounds (Etkin 2011). Heavier oils tend to resist weathering and dispersant application, and then may persist in the water column for long periods of time (USGS 2011d; USDOI 2010; Etkin 2011). Similarly, oils that persist in marine and coastal sediments may be physically or biologically remobilized after initial sedimentation or burial, such that longer-term re-exposure is an important consideration (NRC 2003b; Clement et al. 2011).

Evaporation. Evaporation occurs when oil comes in contact with air on the surface of the water. Evaporation rates are a function of numerous dynamics including oil viscosity, ambient temperature, sunlight exposure, and oil type (IPIECA 2008). In general, lighter oils such as diesel or gasoline will dissipate quickly or evaporate from the water, although evaporation is slower in colder temperatures. More viscous or heavy forms of oil will tend to persist longer and resist evaporation (USGS 2011d). Compared to other oil-producing regions, a greater portion of oils extracted from the GOM tend to be lighter crude oils. Because such oils persist for a shorter period of time, they may cause less long-term damage and lower cleanup costs. The viscosity of Arctic oils varies, but due to colder surface temperatures and a generally cooler average climate, these oils are thought to evaporate more slowly, become trapped in ice, or become viscous and suspended in the water column (USGS 2011d).

Weathering. Weathering of oil in the sea results from a number of factors, including exposure to atmosphere, currents, biological organisms, and tidal patterns. In general, lighter oils such as diesel and gasoline weather quickly (Dickins 2011; IPIECA 2008; Etkin 2011). Higher ambient temperatures also accelerate weathering. The warm waters of the GOM are thought to help oil to dissipate, although this may not be the case for all oils, especially those generated in deepwater environments where ambient temperatures can be lower (USDOI 2010; IPIECA 2008; Etkin 2011). In cases where releases become suspended in the water column, long-term persistence may occur and potentially threaten marine life and economic activity tied to the marine environment.

The weathering characteristics of spilled oil influence the range of drift and spreading considered within spill trajectory assessments and dictate the effectiveness of chemical dispersants, *in situ* burning, or mechanical responses. Conditions in the Arctic may lead to longer term oil persistence. Denser, more viscous oils in colder temperatures weather at very slow rates, potentially persisting in sensitive environments for years (USGS 2011d;

Short et al. 2004; Siron et al. 2003; Peterson et al. 2003). Cold water also increases the probability that oil from a spill will solidify in the water, persisting indefinitely and rendering cleanup more difficult. However, weathering in the Arctic will be contingent on the season and weather (Dickins 2011). If oil is exposed to more air and sunlight, evaporation and dispersion due to weathering may also accelerate. Due to the variability in seasons (and in particular the ice pack), it is important to consider the timing of the release in the Arctic to evaluate the potential for long-term damage to the surrounding marine and coastal environments.

Transport. The transport and behavior of oil and gas released into oceans varies greatly depending on the conditions of the area. The magnitude and spread of transport may depend on water depth, ocean currents, meteorological events, and geographic specific factors including the prevalence of ice. Fluids released into deep water, for instance, are subject to high hydrostatic pressure and low ambient temperature, increasing the oil's persistence and its potential to transport to coastlines. A shallow water release from a high-pressure formation with a high velocity may result in a turbulent mixing of the gas, oil, and water, with the mixture quickly transported to the surface by the expanding gas under decreasing hydrostatic pressure (PCCI 1999). Research as part of the DeepSpill Joint Industry Project indicates that above the point of separation, gas bubbles and large oil droplets rise toward the surface while smaller, dispersed oil droplets may be entrained in deepwater currents at the terminus of the jet phase (Johansen et al. 2001; S.L. Ross Environmental 1997). Deepwater spills increase the potential for oil remaining trapped throughout the water column, and this increases the risk of oil transport to other regions and water bodies, although the oil is expected to be highly dispersed.

Meteorological events specific to the GOM may potentially transport spilled oil to shallow and coastal areas, increasing the risk of catastrophic consequences. Major meteorological events specific to the GOM are cold fronts and hurricanes. The wind force and magnitude of the storms in the area have the potential to expand the affected area of an oil spill. Typically occurring between June 1 and November 30, hurricanes also have the potential to destroy production facilities and precipitate releases. Data on platform spills also show that oil spills that result from hurricane damage in the GOM have been larger in volume, accounting for approximately 43% of large (>1,000 bbl) spills (Eschenbach and Harper 2011). During hurricane passages in the GOM, production is shut-in and facilities are evacuated. This reduces the probability of a very large release of oil from facilities.

Strong coastal currents on the Louisiana-Texas shelf, characterized by seasonal reversals, are important to physical transport on the shelf (see Section 4.2). Another major consideration related to physical transport in the GOM is the Loop Current and associated eddies. The current dominates upper ocean circulation in the eastern and central GOM, and transports approximately 30 million m^3 of water per second, with a variance of about 10%. Speeds may exceed 150 cm/s at the surface with velocities as high as 5 cm/s at 1,000-m (3,280-ft) depths. In both shallow and deep water, currents are dominated by cyclonic and anticyclonic eddies that vary in magnitude and frequency, which increases the uncertainty associated with effects on drilling operations (Donohue et al. 2006). The characteristics exhibited by the GOM Loop Current impose uncertainties during drilling operations and in the event of an oil release. The vast amount of water transported throughout the GOM by the Loop Current provides the potential for the current and its associated eddies to transport oil from a spill to the shelf and coastal areas, as well as water bodies outside of the GOM (MMS 2007c). Due to the proximity of the current to the shelf and sensitive coastal areas, there is a general concern regarding the rapid transport of oil in the event of a release. In many cases, the frontal boundary at the edge of the Loop Current may limit the extent of transport (see Section 4.3.2). In addition, highly persistent oil, especially in deepwater locations, may remain in the ocean for an indefinite period of time, increasing the potential for eddies to entrain oil and slope and shelf currents transport to sensitive coastal areas (MMS 2007c).

The Alaska Coastal Current, sensitive to wind forcing, is an important factor in determining surface transport of oil in the Arctic. An equally important transport vehicle and barrier is ice. Offshore of the shore-fast zone, the motion of the ice will be expected to transport the oil that is associated with the ice matrix. Field tests conducted by SINTEF Materials and Chemistry demonstrated that ice can help contain a spill, and act as a natural barrier to the spread of oil (Brandvik et al. 2006). Studies have shown that when ice coverage exceeds 10–20%, the higher ice coverage can trap spilled oil within newly formed ice (Sørstrøm et al. 2010). Ice concentrations of 60% or higher may prevent the spilled oil from spreading (Nuka Research and Planning Group 2010) and potentially affecting sensitive habitats, coastal areas, and adjacent bodies of water. Physically removing ice that encases spilled oil is a potential solution in extreme cold temperatures. During the winter of 1998, 90% of the oil spilled in the St. Lawrence River was recovered by removing 1,369 tons of ice (recovering 10 tons of oil) (S.L. Ross et al. 2010). Ocean currents in the Arctic are influenced by cyclonic and anticyclonic eddies pushing released oil in numerous directions.

4.3.3.3 Regional Risk Profiles

The previous discussion of risk factors has been used to develop generalized regional risk profiles for the areas under consideration for the Program. Figure 4.3.4-1 presents a conceptual framework for considering the sequence of events, circumstances, and factors that define a low-probability discharge event and contribute to the even lower potential for catastrophic consequences. The catastrophic discharge event sequence is divided into two principal phases: risk of occurrence and containment, and risk of fate and consequence. This framework conservatively assumes that a relief well is needed to kill a wild well following a loss of well control incident.

The top part of Figure 4.3.3-2 shows risk factors related to the occurrence of a well incident and the ability to contain and recover oil discharge at the well site up to the time needed to drill a relief well. The ability to mitigate these risks factors directly reduces the duration and volume of the oil spill and likelihood that the spill will be a catastrophic event. Reducing the risk of well control incidents, particularly for frontier exploration wells with the potential to release catastrophic discharge volumes, is of primary importance to avoid any risk of oil in the environment. As detailed in Section 4.3.3.3.4, BOEM and BSEE implemented substantive regulatory improvements following the DWH event to identify and mitigate risk factors that contribute to well integrity and operational safety incidents.

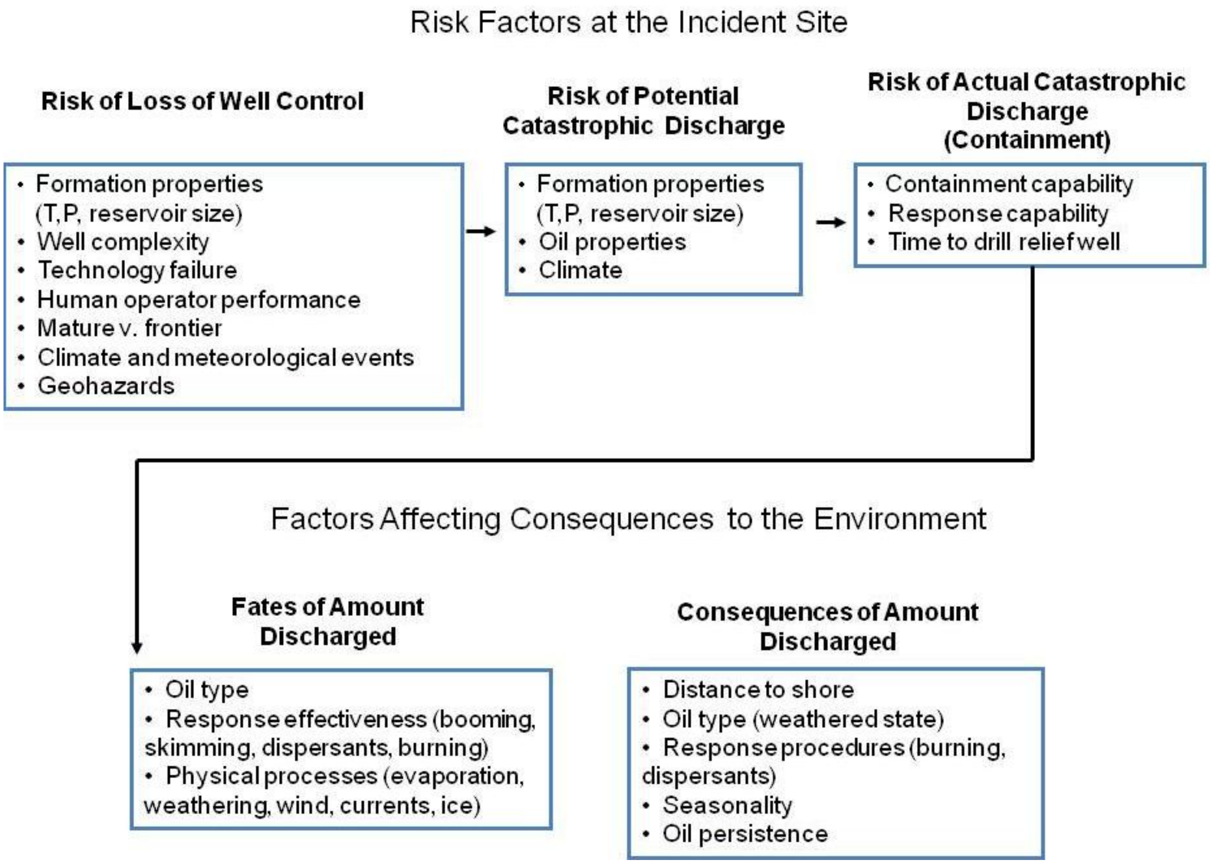

FIGURE 4.3.3-2 Factors Affecting a Catastrophic Discharge Event

If well barriers and intervention fails, containment and response at the well site becomes the next critical line of defense to minimize the volume of oil being released into the ocean. Mitigating the factors that constrain the ability to contain oil at the well site minimizes the degree and duration of exposure that may otherwise occur prior to a relief well being completed weeks to months later (or potentially longer in the Arctic depending on location and ice conditions). New seabed containment systems developed for the GOM have the potential to contain 60,000 bbl of oil per day. This system, if as effective as stated, could contain over 5,000,000 bbl of oil during a 90-day discharge period and significantly reduce the nature of exposure. Equivalent systems and/or capabilities are being developed to enhance containment in the Arctic (Shell 2011c, d). As detailed in the subsequent discussion in Section 4.3.3.3.4, BOEM and BSEE have implemented substantive regulatory improvements following the DWH event to ensure industry has appropriate containment capability.

The lower part of Figure 4.3.3-2 shows factors that affect the fate and, in part, drive the consequences of oil released into and transported through the larger environment. These factors are not absolute risk factors, *per se*, because they do not operate in one direction, either increasing or decreasing risk, across all ecological and human use resources. Usually response actions taken to manage the fates or consequences of a spill involve considerations of tradeoffs among potential impacts. For example, dispersants may be applied at the spill site to protect coastal habitats and resources from contact with a heavy, surface oil slick, but at the risk of exposing resources occupying the marine water column to the effects of dispersants and dispersed oil.

Physical processes such as the Loop Current in the GOM could transport dispersed oil across large areas within and potentially outside the GOM, but whether or not this effect is considered a risk factor depends on whether the ecological or human use concerns focus on the effects of a widespread but dilute oil presence or on the effects of higher oil concentrations on critical resources within a more localized area. Even distance to shore does not operate unambiguously as a risk factor since drilling in deeper waters located farther offshore could increase drilling risk and potential impacts to pelagic marine resources, but at the same time reduce the risk of contact with coastal habitats and resources.

4.3.3.3.1 Catastrophic Discharge Event Scenarios. BOEM has prepared credible scenarios of catastrophic discharge for each planning area that are used in later effects analyses (Table 4.3.3-3). In each planning area, such a scenario is a low-probability, accidental event, and a conservative estimate of likelihood is provided based on historical frequency alone. The scenarios do not account for potential discharge mitigating factors such as new reform measures including enhanced well barriers, well intervention, or containment and response requirements. The scenario, consistent with the requirements of 40 CFR 1502.22, assumes that there is some unintended failure or failures in the spill prevention or containment systems, although the likelihood of that occurrence is assumed to be low and not an expected outcome. Engineering analyses of comparable regulatory reforms suggest that effective or redundant barriers and safety measures can substantially decrease the likelihood of occurrence of loss of well control (DNV 2010c; DNV 2011a). Herein, oil is conservatively assumed to flow from the well until the well is killed using a relief well. The volume presented is a potential volume released. When accounting for containment, subsurface and surface dispersion, evaporation, mechanical recovery, and *in situ* burning, the actual amount released is assumed to be less. The principal factors driving the potential release amount and duration are geologic, well design, and oil type properties (which determine maximum discharge rate) and time frame required for drilling a relief well. The time frame required for drilling a relief well is principally governed by water and reservoir depth, timing of year, and availability of drilling rigs.

Bercha Group, Inc. (2011, 2008a,b) has previously modeled the historical spill size distribution frequency for a spill greater than or equal to 150,000 bbl for GOM and North Sea well drilling as 3.42×10^{-4} per well for exploration drilling, 1.96×10^{-4} per well for development drilling, and 0.29×10^{-4} per well year producing. Modal frequencies are also presented in Bercha Group, Inc. (2011). Bercha Group, Inc., calculated a slightly smaller well incident frequency of 3.94×10^{-4} per well for Arctic spills greater than or equal to 150,000 bbl. This finding suggesting lower risk in the Arctic is also supported by Willemse and van Gelder (2011). The difference relates to the underlying Gulf of Mexico spill and spill cause data analyzed, the methods used to reflect specific effects of the Arctic, and resultant fault tree model simulations applied in context of the Arctic. In the Gulf of Mexico, there is generally speaking a higher incident rate because of more offshore traffic, hurricanes, and more corrosion due to aging facilities and technologies. The Arctic does have unique effects, such as ice gouging, strudel

TABLE 4.3.3-3 Program Area Catastrophic Discharge Scenarios[a]

Program Area	Volume (Mbbl)	Duration (days)	Factors Affecting Duration	Exceedance Frequency (per well) for Spill Volume Range[b]
Gulf of Mexico	0.9–7.2	30–90	Water depth and drill depth determines timing of relief well	$>10^{-4} – <10^{-5}$
Arctic				
Chukchi Sea	1.4–2.2	40–75	Type of drill rig used and rig availability to drill relief well during open water season	$>10^{-4} – <10^{-5}$
Beaufort Sea	1.7–3.9	60–300	Type of drill rig, timing of drilling relative to ice conditions, and rig availability to drill relief well	$>10^{-4} – <10^{-5}$
Cook Inlet	0.075–0.125	50–80	Availability of rig to drill relief well	$>10^{-4} – <10^{-5}$

[a] The GOM OCS Region has estimated the discharge rate and duration for a catastrophic spill event for both shallow and deep water (in part) based on information gathered from shallow water and deepwater well tests and flow rates validated by the Ixtoc (1979) and the DWH (2010) oil spills. The Alaska OCS Region has estimated a very large oil-spill scenario based on a reasonable, maximum flow rate for each OCS planning area, taking into consideration geologic conditions and well log data. The Alaska OCS Region modeled the flow of fluids from a representative reservoir into the well and flow up through the borehole based on formation thickness, porosity, and permeability; oil saturation, viscosity, and gas content; and reservoir pressure and temperature. The number of days until a hypothetical blowout and discharge from a well could be contained was also estimated. Different assumptions about the type of drilling rig, timing of drilling, nature of ice conditions, and relief well operations underlie the CDE scenarios in the Chukchi Sea and Beaufort Sea; therefore, the scenarios are not directly comparable. The time period required to drill a relief well and kill the well in the Chukchi Sea is explained in detail in BOEMRE (2011j). The relief well is drilled and killed within the open water season. Over half of the 75-day estimate includes transport of relief well rig to the site and drilling of the actual relief well. The greater range in spill duration in the Beaufort reflects different assumptions about the drilling rig and timing of drilling relative to seasonal ice conditions. The scenario range incorporates both open- and late open-water season and winter blowout scenarios (the late open-water season may delay the relief well drilling until the following open-water season). These are discharge volumes and do not account for decreases in volume from bridging, containment, or response operations.

[b] See the figure notes for Figure 4.3.3-1 for a detailed discussion of 1) the method used to approximate exceedance frequency and 2) the method's limitations. These conservative estimates are based on historical frequency alone. No new reform and safety measures are considered. Similarly, reliability of primary and secondary barriers is not explicitly considered. The only factor quantitatively considered across the different OCS regions is spill size. Although more precision is possible, further precision has not been reported here as not to overstate the results. The empirical formula is referenced in Figure 4.3.3-1. The difference in likelihood between the smallest and largest spill size, when using the 95% confidence intervals, is only a factor of 5. This is because very large spill events resulting from loss of well control have been, historically speaking, rare.

scour, thaw settlement, and upheaval buckling, which can contribute to the spill frequency, but largely for pipeline spills.

The principal risk factors that would affect drilling operations, containment, and response in Gulf of Mexico and Arctic program areas are summarized below. Cook Inlet is not considered further because of the relatively small size of the estimated catastrophic discharge event there compared to other program areas.

4.3.3.3.2 Gulf of Mexico Risk Profile. Drilling operations in deep water came under close scrutiny following the DWH event in April, 2010. A suspension on approving drilling plans and permits in deep water was imposed by the Secretary in July 2010. The Secretary lifted the suspension in October 2010 based on the implementation of new regulatory reforms to improve OCS drilling safety and a better understanding of the root causes of the DWH event. The safety of drilling in deepwater areas of the GOM remains an issue of concern, as witnessed by comments received during scoping and on the Draft PEIS. As stated earlier, water depth by itself does not impose risk and not all deepwater wells are characterized by the same degree of risk; rather, it is high–pressure, high-temperature conditions, large reservoir volumes, complexity in drilling technology and operations, and the relative inaccessibility of the well site on the seafloor that may impose additional risk from deepwater operations. Figure 4.3.3-3 highlights factors that apply to risks particular to deepwater wells (red text). The figure also highlights risk reduction factors associated with drilling in deep water compared to drilling in shallow water (green text). In recognition of the complexity of operations, industry often employs redundant systems to increase safety margins.

Loss of Well Control.

Geologic Properties. Deepwater geologic formations tend to have higher temperatures and pressures than shallow water formations, although that is not uniformly true and shallow water wells can be drilled under high-pressure, high-temperature conditions. In addition to varying oil properties, the differences in pressure regimes may contribute to relatively greater discharge rates. In addition, deepwater formations tend to hold larger volumes of hydrocarbons so worst-case discharges tend to be greater. The combination of the high temperature and pressure regime and comparatively large reservoir volumes create conditions that favor potentially catastrophic releases. When considering all OCS wells, the average true vertical drill depth for boreholes in shallow water (less than 201 m [660 ft]) is approximately 2,864 m (9,400 ft), compared to 4,115 m (13,500 ft) in waters deeper than 201 m (660 ft). The drill depth required to reach target reservoirs requires more information about shallow and deep geologic hazards to avoid engineering and well integrity challenges. The time required to intervene using a relief well is also greater, because of the relative depth of the intervention zone. Because of the steeper gradient of the continental slope where deepwater wells are often drilled, compared to the gentler slope on the continental shelf, deepwater wells may be more subject to mass movement and other seafloor instabilities that, if unanticipated, may increase the risk of a loss of well control incident. To avoid these complications, BSEE requires well shut-in prior to the passage of hurricanes, which are the most frequent cause of large-scale seafloor movements.

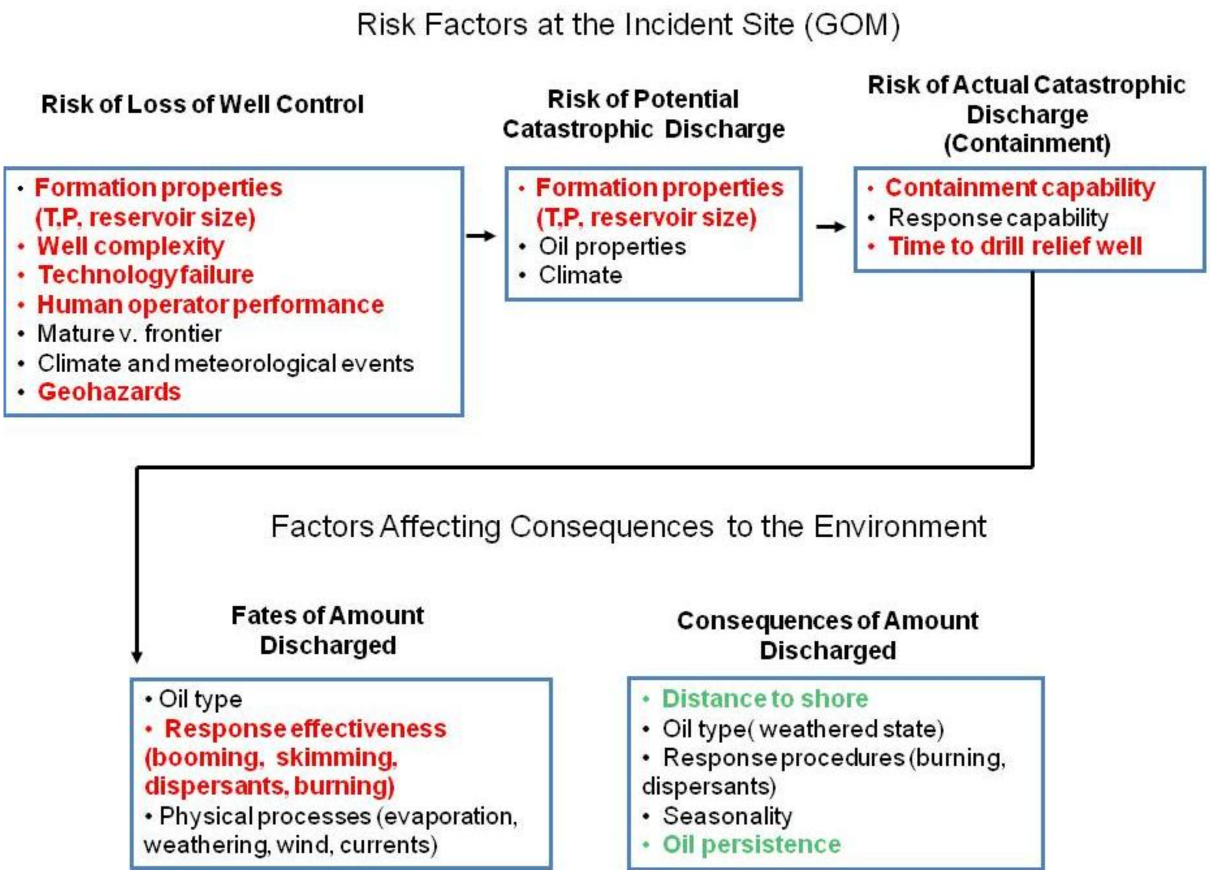

FIGURE 4.3.3-3 Principal Factors Affecting a Catastrophic Discharge Event in the Gulf of Mexico

***Well Complexity, Technology Failure and Human Performance*.** More complex wells and technology are often required in deepwater drilling to address the higher pressures and temperatures and greater drilling depths that will be encountered. This places greater demands on human and technology performance, especially where hydrostatic pressures are substantial greater due to an average 762-m (2,500-ft) greater water depth. Furthermore, the inaccessibility of the seafloor to humans at deepwater well sites means that the subsea BOP systems used at deepwater drill sites are inaccessible to human maintenance, inspection, and intervention in the event they are activated as a result of a loss of well control event. Deepwater drilling sites use ROVs and other indirect methods of intervening in a loss of well control incident at the seafloor. Recognizing this, redundant systems and multiple barriers are often incorporated into well design.

Containment and Response. The drilling of a relief well in deep water will likely take longer than in shallow water because of the greater water depth, greater drill depth, and more complex drilling conditions the relief well would encounter. Table 4.3.3-3 estimates that up to 90 days may be needed after the loss of well control event to drill the relief well and kill the wild well. During that time, the success of containment and response at the well site would be a critical factor governing whether sufficient oil is released into the environment to have catastrophic consequences. Containment and response is expected to be more challenging in areas with deeper water because of the greater distances from land support bases and staging areas. Progress has been made in the GOM to develop effective containment and response technology for deepwater conditions, including deep dispersant application.

Fate and Consequence. Should containment and response at the well site fail to prevent discharge of oil into the ocean environment, response and oil recovery would continue as the oil discharge spreads. Response operations could be more challenging to support in deeper water because of the greater distances from shore bases, as well as the fact that the area of surfaced oil would continue to increase as deepwater currents exported oil to the shelf.

Because deepwater wells are located at greater distances offshore than shallow water wells, high concentrations of oil are less likely to contact important ecological and human use coastal resources. In addition, the risk of persistence of the oil in the environment would likely be less in deepwater events because oil released there would be less likely to contact coastal wetland and estuarine areas where it could become incorporated into wetland soils and persist for long periods of time.

Summary. The principal risk that applies to deepwater drilling in the GOM occurs as a result of drilling and containment/response risks associated with the use of drilling technologies at these depths. As described below, BOEM has been aggressively pursuing regulatory changes to address and mitigate risks associated with these deepwater drilling and containment issues. It is not necessarily true that a deepwater, large volume spill would have more environmental consequences than a smaller spill occurring in shallow water. Deepwater spills may, in part, impose less risk on highly valued coastal areas because of their distance offshore, which allows for more natural weathering and dispersion. In comparison, shallow shelf spills may more rapidly contact low-energy estuarine and wetland areas.

4.3.3.3.3 Arctic Risk Profile. An ongoing concern in the Arctic is the environmental effects of a large oil spill on sensitive marine and coastal habitats that occur there within a land-sea-ice biome that supports a traditional subsistence life style for Alaska native populations and provides important habitats for migratory and local faunal populations. The ability to respond to and contain a very large discharge event under the extreme climatic conditions and seasonal presence of ice is of particular concern. Figure 4.3.3-4 highlights factors that apply to risks particular to operations in the Arctic related to extreme cold and the presence of ice.

Loss of Well Control. While some formation properties of the Arctic OCS are expected to have pressures, temperatures, and volumes sufficient to produce a discharge that could result in catastrophic consequences (Table 4.3.3-2), drilling risks associated with these formation characteristics are not directly related to issues of extreme cold and presence of ice. Instead, the fact that the Arctic OCS is largely a frontier geologic province contributes risk to Arctic drilling operations (USGS 2011d).

Human error while working under extreme weather conditions on the Arctic OCS could increase the risk of loss of well control in certain circumstances where established procedures are not followed. However, when accounting for other Arctic specific variables, the incident rate of

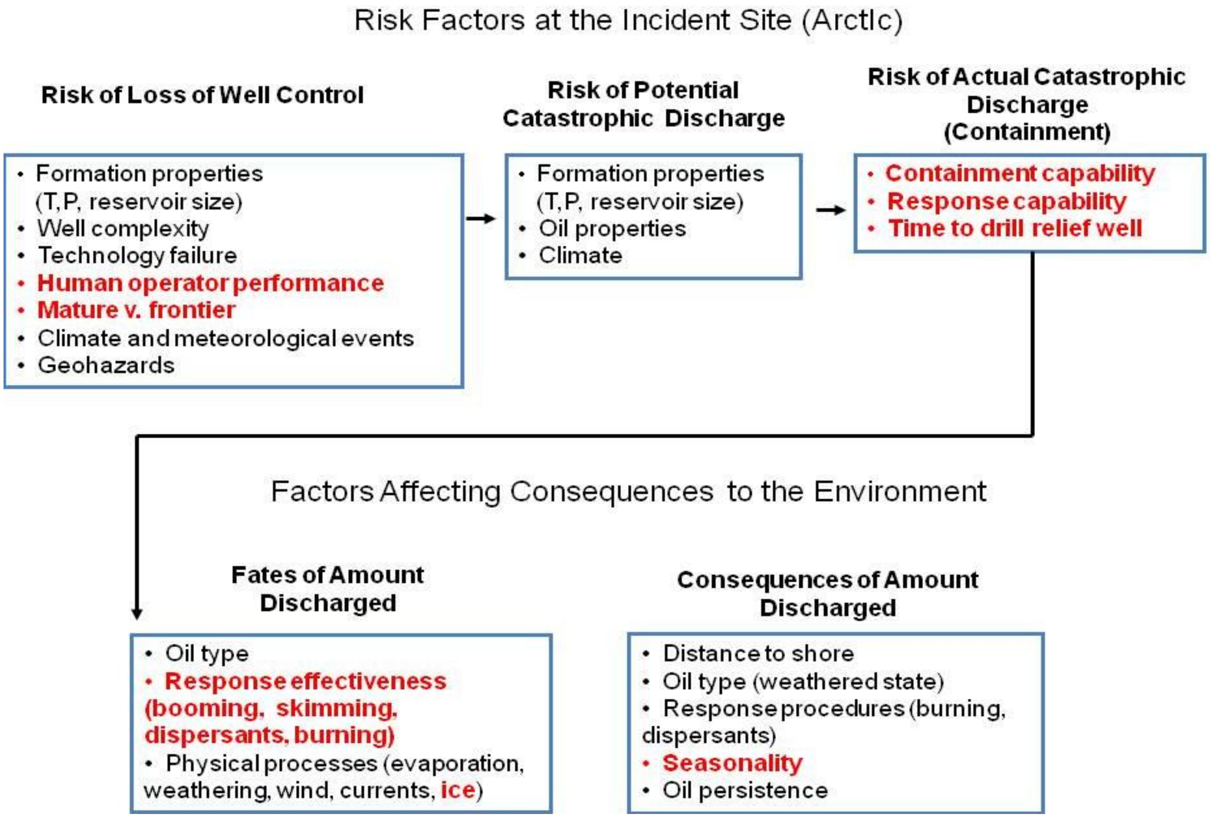

FIGURE 4.3.3-4 Principal Factors Affecting a Catastrophic Discharge Event in the Arctic

loss of well control is expected to be slightly lower than for exploration and development operations in the GOM (Bercha Group, Inc. 2008a, b, 2011).

To address some of the risk inherent in Arctic operations, BSEE regulations include specific requirements for conducting operations in the Arctic, such as locating the BOP in a well cellar (a hole constructed in the sea bed) to position the top of the BOP below the maximum potential ice gouge depth, using special cements in areas where permafrost is present, enclosing or protecting equipment to assure it will function under subfreezing conditions, and developing critical operations and curtailment procedures which detail the criteria and process through which the drilling program would be stopped, the well shut in and secured and the drilling unit moved off location before environmental conditions (such as ice) exceed the operating limits of the drilling vessel.

Containment and Response. Much of risk from a catastrophic event that is particular to the extreme climate of the Arctic is associated with containment and response issues at the well site. The time needed to drill a relief well varies from 40 to 300 days depending on the timing of the event relative to the ice free season, since the well site may become inaccessible when solid or broken ice is present. During that time, the ability to mount effective containment and response efforts under broken or solid ice conditions is a critical factor. Specialized containment structures are being engineered and tested to withstand the ice and weather conditions in the

Arctic drilling season conditions (Shell 2011c, d). Under BSEE regulations and the Certification NTL, OCS operators must have containment equipment staged and ready for deployment to adequately contain oil released from a wild well. However, it is important to acknowledge the rare possibility that primary and secondary barriers and the required containment system may not be fully successful and response gaps may exist during certain ice, weather, daylight and visibility, or temperature conditions such that advance planning is essential and unique seasonal management strategies are required (Nuka Planning and Research Group 2010; S.L. Ross 2011; Wendler and Sharma 2011). For example, different ice regimes (solid ice, open water, fall freeze-up, spring breakup) will limit the safety, effectiveness, or operational feasibility of oil-spill response systems (Nuka Planning and Research Group 2010). Limits may be imposed not only by environmental considerations and technology limitations, such as the need for icebreakers and on-water storage capability, but also by the limited existing infrastructure, such as roads, airfields, and ports, and human capital resources that are found in the North Slope. Equipment and human capital problems may exist for larger response efforts because of the remoteness of the area, time required for mobilization, and difficulties in transporting supplies and workers across the North Slope given the limited infrastructure and severe weather conditions (Wendler and Sharma 2011). Individual operators, in support of exploration and development plans, must mobilize specialized equipment, such as icebreaking support and on-water storage capabilities, that are not otherwise available in the region. Therefore, advance logistical planning and staging of equipment is paramount, as recognized under BSEE oil-spill response plan (OSRP) requirements (30 CFR 254). Required components of the OSRP include introduction and plan contents; emergency-response-action plan; equipment inventory; contractual agreements for spill-response services; worst-case discharge scenario; dispersant-use plan; *in situ* burning plan, and a training and drills plan. Plans are required to be reviewed and updated every 2 years or when a change occurs that significantly reduces response capabilities; a significant change occurs in the worst-case discharge scenario or in the type of oil being handled, stored or transported at the facility; there is a change in the name(s) or capabilities of the oil-spill removal organizations cited in the plan; or there is a significant change to the Area Contingency Plans. OCS operating regulations also require operators to develop a Critical Operations and Curtailment Procedure (COCP) with exploration or development and production plans. The COCP addresses the methods by which an operator will cease, limit, or not initiate specific critical operations because of environmental conditions that may be encountered at the site.

Operator's plans are developed in context of the National Contingency Plan (NCP), the Alaska Federal and State Preparedness Plan for Response to Oil and Hazardous Substance Discharges and Releases (Unified Plan), and in close coordination with Federal and State agencies. In addition to the Unified Plan, Alaska has divided the State into 10 geographic regions and developed subarea contingency-response plans for each area. The North Slope Subarea Contingency Plan addresses specific response issues for the Beaufort and northern Chukchi Seas. These plans include sections that identify spill-sensitive biological and cultural resources and geographic response scenarios, which identify shoreline types in the subarea and lists spill-response tactics that can be used to protect those areas. Subarea contingency plans provide for coordinated and integrated response by departments and agencies of the Federal and State governments to protect human health and the environment and to minimize adverse effects due to oil and hazardous substance discharges. The Alaska Regional Response Team (ARRT) provides the appropriate regional mechanism for planning and preparedness activities before a response action is taken and for coordination and advice during an event. In the event of a spill, the USCG would be in charge of overall command and control activities. These command and control activities, supported by BSEE, USEPA, NOAA, and other Federal and State agencies, would proceed in conformance with federally-mandated contingency plans for the North Slope area that have recently been revised and updated (see Section 4.3.3.3.4). Section 4.3.3.3.4 further highlights major new field testing and technology research, planning exercises, and capacity building efforts that are underway to improve response technology, response capability, and spill preparedness.

Fate and Consequence. Response away from the well site could also be hindered and/or aided by sea state, visibility, and broken and solid ice. In addition, some options available to manage fates of spills have not been previously used in larger-scale operations the Arctic to fully evaluate their effectiveness, such as burning and dispersant use, although state-of-the art research on these response techniques suggest they could decrease the volume of oil in the water (SINTEF 2010).

4.3.3.3.4 Reforms and Research to Reduce Risk. In the aftermath of the DWH event, President Obama directed the Secretary of the Interior to identify new precautions, technologies, and procedures needed to improve the safety of oil and gas development on the OCS. At the same time, the Secretary directed BOEMRE to exercise its authority under the OCSLA to suspend certain drilling activities so that the Bureau could (1) ensure that drilling operations similar to those that led to the DWH event could operate in a safe manner when drilling resumed, (2) ensure extensive spill response resources directed toward the spill would be available for other spill events, and (3) provide adequate time to obtain input for enhancing intervention and containment capability and promulgate regulations that address issues described in the *Increased Safety Measures for Energy Development on the Outer Continental Shelf* report (USDOI 2010a). In addition, incident investigations provided numerous other recommendations detailed in reports including the National Oil Spill Commission (OSC) report (National Commission 2011), the National Academy of Engineering (NAE) and the National Research Council (NRC) report *Macondo Well–Deepwater Horizon Blowout: Lessons for Improving Offshore Drilling Safety* (NAE and NRC 2011), the Deepwater Horizon Joint Investigation Team (JIT) Report consisting of the USCG's *Report of Investigation into the Circumstances Surrounding the Explosion, Fire, Sinking, and Loss of Eleven Crew Members Aboard the Mobile Offshore Drilling Unit Deepwater Horizon in the Gulf of Mexico* (USCG 2011c) and USDOI's *Report Regarding the Causes of the April 20, 2010 Macondo Well Blowout* (USCG and BOEMRE 2011p), the USCG *Incident Specific Preparedness Review BP Deepwater Horizon Oil Spill* (USCG 2011a), and the USDOI OCS Safety Oversight Board *Report to Secretary of the Interior Ken Salazar* (USDOI 2010b).

In response to Administration directives and numerous report recommendations, and in recognition that advances in prevention and safety were critical, the USDOI launched the most aggressive and comprehensive reform program to offshore oil and gas regulation and oversight in U.S. history. BOEM and BSEE overhauled and continue to proactively reform the offshore regulatory process. Similarly, the oil and gas industry has voluntarily responded with rigorous reform measures including new and revised industry standards, recommended practices (RPs), specifications, and guidelines.

In 2010 and 2011, BOEMRE collected a large amount of information through public hearings and other meetings held specifically on the DWH oil spill and through public comments on rulemaking efforts. The information collection, review, and analysis efforts aided in the development of new regulations, Notices to Lessees and Operators (NTLs), and BOEM/BSEE procedures that address drilling safety, oil spill response, and enhanced inspection procedures. New exploration plans, applications for permits to drill, and oil-spill preparedness and response plans are subject to higher engineering and environmental review standards.

BOEM and BSEE recognize that a proactive government and industry are critical to ensure safe and environmentally sound OCS oil and gas operations. This section highlights (1) previously implemented and ongoing reforms in BOEM, BSEE, other Federal agencies, and industry for improving oil-spill prevention, which include well design, workplace safety, corporate accountability, oil-spill containment, and oil-spill response, and (2) promising research in these areas that respond to the various reform recommendations. Table 4.3.3-4 summarizes these efforts. The measures described below contribute to a more robust regulatory system and industry practice to ensure that energy development is conducted safely and in an environmentally responsible manner, while also being more efficient, transparent, and responsive. Enhanced measures, such as improved BOP reliability, improved cementing and other secondary barrier programs, better-defined operational and risk assessment procedures, and integrated treatment of human risk factors, have been show to effectively reduce risk (DNV 2010b).

Recent and Ongoing Regulatory Reform and Government-Sponsored Research. BOEM and BSEE have already instituted regulatory reforms responsive to many of the recommendations expressed in the various reports prepared following the DWH event. To date, regulatory reform has occurred through both prescriptive and performance-based regulation and guidance, as well as OCS safety and environmental protection requirements. The reforms strengthen the requirements for all aspects of OCS operations. The discussion below also addresses ongoing reform and research endeavors to improve workplace safety and strengthen oil-spill prevention planning, containment, and response.

BSEE Regulatory Review. BSEE is currently conducting a comprehensive evaluation of its operations regulations to identify important issues related to regulatory gaps and implementation. This effort addresses specific recommendations from the USDOI OCS Safety Oversight Board, National Commission, and NAE. The review will do the following:

- Address the effectiveness, comprehensiveness, and timeliness of the regulations based on BSEE's authority under the OCSLA.
- Review internal sources of information that could be used to identify regulatory needs.

TABLE 4.3.3-4 Prevention, Containment, and Response Reforms and Research Initiatives

	Current	Ongoing
Prevention	Government • Proposed and final regulations: Drilling Safety Rule, SEMS • NTL/guidance: NTL-2010-N06, blowout prevention (BOP) guidance • Well Containment Screening Tool • Enhanced inspection and enforcement procedures, including strengthened training program • Implementation Teams • JIT, Ocean Energy Safety Advisory Committee (OESC) • Research: BSEE Technical Assessment and Research (TA&R) Program, Operational Safety and Engineering Research (OSER), Ohmsett National Oil Spill Response Test Facility	Government • Clarify existing regulations and develop new proposed and final regulations • Develop NTLs/guidance • Enhanced inspection and enforcement procedures, including strengthened training program • Implementation Teams • OESC • Research: BSEE TA&R OSER, Ohmsett
	Industry • New and revised industry standards, recommended practices, guidelines • Joint Industry Task Forces (JITFs): Procedures and Equipment JITFs, Center for Offshore Safety (COS), International Association of Oil and Gas Producers (OGP) • Joint industry research programs/projects: Blowout Risk Assessment Joint Industry Project (BORA JIP), DeepStar	Industry • Revise industry standards, recommended practices, guidelines • Procedures and Equipment JITFs, COS, OGP • Joint industry research programs/projects: BORA JIP, DeepStar
Containment	Government • • NTL/guidance: NTL-2010-N10 • Well Containment Screening Tool • 12/13/2010 BOEMRE Guidance • Enhanced inspection and enforcement procedures, including strengthened training program • Implementation Teams • JIT, OESC • Research: BSEE TA&R OSER, Ohmsett	Government • Clarify existing regulations and develop new proposed and final regulations • Develop NTLs/guidance • Enhanced inspection and enforcement procedures, including strengthened training program • Implementation Teams • OESC • Research: BSEE TA&R OSER, Ohmsett

TABLE 4.3.3-4 (Cont.)

	Current	Ongoing
	Industry • New and revised industry standards, recommended practices, guidelines • Subsea JITF, COS, OGP Wells Expert Committee (WEC) • Joint industry research programs/projects: OGP Subsea Well Response Project	Industry • Revise industry standards, recommended practices, guidelines • Subsea JITF, COS, OGP WEC • Joint industry research programs/projects: OGP Subsea Well Response Project
Oil Spill Response	Government • NTL/guidance: NTL-2010-N10 • Enhanced inspection and enforcement procedures, including strengthened training program • Implementation Teams • Environmental Response Management Application (ERMA®) • JIT, OESC • Research: BSEE TA&R OSER, BSEE Oil Spill Response Research (OSRR) Program, Ohmsett	Government • Clarify existing regulations and develop new proposed and final regulations • Develop NTLs/guidance • Enhanced inspection and enforcement procedures, including strengthened training program • Implementation Teams • ERMA® • OESC • Research: BSEE TA&R OSER, BSEE OSRR, Ohmsett, National Research Council
	Industry • New and revised industry standards, recommended practices, guidelines • Oil Spill Preparedness and Response JITF, OGP Arctic Oil Spill Response Technology Joint Industry Programme, Oil Spill Removal Organizations (OSROs) • Joint industry research programs/projects	Industry • Revise industry standards, recommended practices, guidelines • Oil Spill Preparedness and Response JITF, OGP Arctic Oil Spill Response Technology Joint Industry Programme, OSROs • Joint industry research programs/projects

- Evaluate the adequacy of BSEE regulations to address current offshore technology.
- Identify items within the regulations that need to be addressed and prioritize those items for future rulemakings.
- Identify areas of BSEE regulations that may be ineffective and identify issues related to implementation.
- Assess the advantages and disadvantages of creating regulations to specifically address deepwater operations.

Improving Prevention.

Workplace Safety Rule (SEMS Final Rule). The National Commission and the NAE recommended a variety of changes to USDOI's regulatory scheme, such as the expanded use of safety management systems. BOEMRE promulgated the performance-based Safety and Environmental Management System (SEMS) rule on October 15, 2010 (75 FR 63610) (30 CFR Part 250, Subpart S), requiring full implementation for all OCS facilities and operators no later than November 15, 2011. The SEMS rule establishes a holistic, performance-based management tool that requires offshore operators to establish and implement programs and systems to identify potential safety and environmental hazards when during exploration, development, and production operations; clear protocols for addressing those hazards; and strong procedures and risk-reduction strategies for all phases of activity, from well design and construction to operation, maintenance, and decommissioning. It also requires operators to have a comprehensive safety and environmental management program designed to reduce human and organizational errors. SEMS applies to all OCS oil and gas operations and facilities under BOEM and BSEE jurisdiction, including drilling, production, construction, well workover, well completion, well servicing, and USDOI pipeline activities. SEMS also applies to all OCS oil and gas operations on new and existing facilities under BOEM and BSEE jurisdiction, including design, construction, startup, operation, inspection, and maintenance. The performance-based SEMS rule helps to define clear roles and responsibilities in which BSEE defines the performance goals, and the operator is responsible to ensure that these goals are met. Empowering industry to develop the framework specific to improving safety and environmental performance of facilities and operations and holding them responsible for meeting that greater standard should significantly reduce the most frequent causes of historic incidents that have occurred during OCS activities. Training and auditing are integral parts of the SEMS rule, which ensures operators are accountable for verifying that contractors and subcontractors have robust policies and procedures in place.

The SEMS rule is based on API RP 75 (API 2004), which was previously a voluntary program to identify, address, and manage safety hazards and environmental impacts in oil and gas operations. The 13 elements of API RP 75 that 30 CFR 250 Subpart S now make mandatory include the following:

- Defining the general provisions for implementation, planning and management review, and approval of the SEMS program;
- Identifying safety and environmental information needed for any facility, including design data, facility process such as flow diagrams, and mechanical components such as piping and instrument diagrams;
- Requiring a facility-level hazard risk assessment;
- Addressing any facility or operational changes, including management changes, shift changes, contractor changes;
- Evaluating operations and written procedures;

- Specifying safe work practices, manuals, standards, and rules of conduct;
- Training, safe work practices, and technical training (including contractors);
- Defining preventive maintenance programs and quality control requirements;
- Requiring a pre-startup review of all systems;
- Responding to and controlling emergencies, evacuation planning, and oil-spills;
- Putting contingency plans in place and validating them with drills;
- Investigating incidents, procedures, corrective action, and follow-up;
- Requiring audits every 4 years, with an initial 2-year reevaluation and then subsequent 3-year audit intervals; and
- Specifying records and documentation that describes all elements of the SEMS program.

Implementation of SEMS requires periodic lessee or independent third-party comprehensive audits of the 13 elements defined in API RP 75 (API 204) and included above. BSEE may participate in lessee or independent third-party audits and may also conduct audits. BSEE-conducted audits may be announced or unannounced. BSEE may also direct an operator to have an independent 3rd party audit. Any deficiencies found in SEMS audits must be addressed in a corrective action plan (CAP) and must be submitted to BSEE within 30 days of submittal of the audit report. If BSEE determines that an operator's SEMS program is not in compliance, BSEE may issue an incident of noncompliance (INC), assess civil penalties, or initiate probationary or disqualification procedures from serving as an OCS operator. The required SEMS plan and audits are designed to improve, enhance, communicate, and document the identification and mitigation of safety and environmental hazards for offshore facilities and activities, resulting in safer and environmentally sound working conditions through teamwork, training, and communication among all parties for all activities on the OCS.

One of the most important elements fostering improved industry-wide risk management is the facility-level hazard analysis. The purpose of the analysis is to identify, evaluate, and reduce the likelihood and/or minimize the consequences of uncontrolled releases of oil and gas and other safety or environmental incidents. API RP 14C, *Recommended Practice for Analysis, Design, Installation, and Testing of Basic Surface Safety Systems for Offshore Production Platforms* (API 2001a), and API RP 14J, *Recommended Practice for Design and Hazards Analysis for Offshore Production Facilities* (API 2001b), identify accepted practices. In addition, the facility-level hazard analysis requires a job hazard analysis (operations/task level) be performed to identify and evaluate hazards of a job/task for the purpose of hazards control or elimination.

Upcoming BSEE Final Rule: Revisions to Safety and Environmental Management Systems (SEMS II). On September 14, 2011, BOEMRE published a Notice of Proposed Rulemaking (76 FR 56683) to require operators to develop and implement additional provisions in their SEMS. The upcoming SEMS II final rule will include refinements to the existing SEMS program. The SEMS II rule will amend the existing regulations to require operators to develop and implement additional provisions involving stop-work authority and ultimate work authority, establish requirements for reporting unsafe working conditions, require employee participation in the development and implementation of their SEMS programs, and establish requirements for reporting unsafe working conditions. In addition, the final rule will require the use of independent third parties to perform the audits of the operators' programs.

Information Requirements for Exploration Plans, Development and Production Plans, and Development Operations Coordination Documents on the OCS (Plans NTL). The National Commission recommended that the USDOI improve its oil-spill risk analysis and response planning process with a focus on the importance of worst-case scenario planning and analysis. Although effective June 18, 2010, prior to the National Commission Report publication in 2011, the Plans NTL (NTL-2010-N06) (BOEMRE 2010j), is consistent with the recommendations and sets new standards regarding the content of information needed in exploration and development plan submittals to describe a blowout and worst-case discharge scenario. This NTL explains the procedures for the lessee or operator to submit supplemental information for new or previously submitted exploration plans (EPs), development and production plans (DPPs), or Development and Coordination Documents (DOCDs). The required supplemental information includes the following: (1) a description of the blowout scenario as required by 30 CFR 250.213(g) and 250.243(h); (2) a description of the assumptions and calculations used in determining the volume of the worst-case discharge required by 30 CFR 250.219(a)(2)(iv) or 30 CFR 250.250(a)(2)(iv); and (3) a description of the measures proposed that would enhance the ability to prevent a blowout, to reduce the likelihood of a blowout, and to conduct effective and early intervention in the event of a blowout, including the arrangements for drilling relief wells and any other measures proposed. The early intervention methods of the third requirement could include the surface and subsea containment resources that BOEMRE announced in NTL2010-N10 (Certification NTL) (BOEMRE 2010k).

Increased Safety Measures for Energy Development on the Outer Continental Shelf (Drilling Safety Rule) (Interim Final Rule). The USDOI Secretary recommended in the May 27, 2010 USDOI Report, *Increased Safety Measures for Energy Development on the Outer Continental Shelf*, the implementation of a number of specific measures to ensure sufficient redundancy in the BOPs, to promote the integrity of the well and enhance well control, and to facilitate a culture of safety through operational and personnel management. In response to these recommendations, BOEMRE published the Interim Final Drilling Safety Rule (75 FR 63346). The subsequent NAE and JIT recommendations were consistent with the Safety Measures report and the Rule. The NAE and JIT recommended improving BOP reliability and performance through such actions as more testing, independent certification, and improvements in ROV interface capabilities. The NAE also recommended significant redesigns of BOP systems. In addition, the NAE and JIT both recommended additional safeguards for well design and construction, including standards for negative pressure testing, third-party review of engineering plans, and better testing of cement jobs. The Drilling Safety Rule (amended 30 CFR Part 250, Subparts A, D, E, F, O, and Q), issued October 14, 2010, addresses well bore integrity and well control equipment and procedures. The rule effectively implements many of the recommendations made in the May 27, 2010, USDOI report *Increased Safety Measures for Energy Development on the Outer Continental Shelf* (USDOI 2010a). BOEMRE amended its drilling regulations related to subsea and surface blowout preventers, well casing and cementing, secondary intervention, unplanned disconnects, recordkeeping, well completion, and well plugging. To ensure compliance with requirements of interim drilling safety regulations, BSEE has implemented the review of BOP system schematic drawings.

Well integrity provides the first line of defense against a blowout by preventing a loss of well control. It includes the appropriate use of drilling fluids and the well bore casing and cementing program. These are used to balance pressure in the borehole against the fluid pressure of the formation, preventing an uncontrolled influx of fluid into the wellbore. Provisions in the rule addressing well bore integrity include the following:

- Making mandatory the API Standard, 65–Part 2 , *Isolating Potential Flow Zones During Well Construction* (an industry standard program) (API 2010);

- Requiring submittal of certification by a professional engineer that the casing and cementing program is appropriate for the purposes for which it is intended under expected wellbore pressure;

- Requiring two independent test barriers across each flow path during well completion activities (certified by a professional engineer);

- Ensuring proper installation, sealing, and locking of the casing or liner;

- Requiring BSEE approval before replacing a heavier drilling fluid with a lighter fluid; and

- Requiring enhanced deepwater well-control training for rig personnel.

Well-control equipment is used to regain control of a well in the event of a loss of well control. Well-control equipment includes the BOP and control systems that activate the BOP, either through a control panel on the drilling rig or through ROVs that directly interface with the BOP to activate appropriate rams. Provisions in the rule that focus on the enhancement of well control equipment include the following:

- Submittal of documentation and schematics for all control systems;

- Requirements for independent third-party verification that the blind-shear rams are capable of cutting any drill pipe in the hole under maximum anticipated surface pressure;

- Requirement for a subsea BOP stack equipped with ROV intervention capability (at a minimum, the ROV must be capable of closing one set of pipe rams, closing one set of blind-shear rams, and unlatching the lower marine riser package);

- Requirement for maintaining a ROV and having a trained ROV crew on each floating drilling rig;

- Requirement for auto shear and deadman systems for dynamically positioned rigs;

- Establishment of minimum requirements for personnel authorized to operate critical BOP equipment;

- Requirement for documentation of subsea BOP inspections and maintenance according to API RP 53, *Recommended Practices for Blowout Prevention Equipment Systems for Drilling Wells* (API in prep. c);

- Requirement for testing all ROV intervention functions on the subsea BOP stack during stump test and testing at least one set of rams in initial seafloor test;

- Requirement for function testing auto shear and deadman systems on the subsea BOP stack during the stump test, and testing the deadman system during the initial test on the seafloor; and

- Requirement for pressure testing if any shear rams are used in an emergency.

A section-by-section summary of major regulatory changes is provided below.

<u>Subsea ROV and Deadman Function Testing — Drilling.</u> Previous regulations at 30 CFR 250.449(b) required a stump test of the subsea BOP system. In a stump test, the subsea BOP system is placed on a simulated wellhead (the stump) on the rig floor. The BOP system is tested on the stump to ensure that the BOP is functioning properly. The new regulatory section at 30 CFR 250.449(j) requires that all ROV intervention functions on the subsea BOP stack must be tested during the stump test and one set of rams must be tested by an ROV on the seafloor. Autoshear and deadman control systems activate during an accidental disconnect or loss of power, respectively. The new regulatory section at 30 CFR 250.449(k) requires that the autoshear and deadman systems be function-tested during the stump test, and the deadman system tested during the initial test on the seafloor. The deadman-switch test on the seafloor verifies that the wellbore closes automatically if both hydraulic pressure and electrical communication with the drilling rig are lost. The initial test on the seafloor is performed as soon as the BOP is attached to the subsea wellhead. These new requirements will help ensure that a well can be secured in an emergency situation and prevent a possible loss of well control. The ROV test requirement will ensure that the dedicated ROV has the capacity to close the BOP functions on the seafloor. The deadman-switch test on the seafloor verifies that the wellbore closes automatically if both hydraulic pressure and electrical communication are lost with the

drilling rig. These regulatory changes will not affect shallow wells or facilities since they do not use subsea BOPs or ROVs.

Subsea ROV and Deadman Function Testing — Workover/Completions. Previous regulations did not require subsea ROV function testing of the BOP during workover or well completion operations. The new regulatory sections 30 CFR 250.516(d)(8) and 250.616(h)(1) extend the requirements added to deepwater drilling operations (discussed in the previous section) to well completion operations and workover operations using a subsea BOP stack.

Negative Pressure Tests. Previous regulation at 30 CFR 250.423 required a positive pressure test for each string of casing, except for the drive or structural casing string. This test confirms that fluid from the casing string is not flowing into the formation. The new regulatory section at 30 CFR 250.423(c) requires that a negative pressure test be conducted for all intermediate and production casing strings. This test will reveal whether gas or fluid from outside the casing is flowing into the well and ensures that the casing and cement provide an effective seal. Maintenance of pressure under both tests ensures proper casing installation and the integrity of the casing and cement.

Installation of Dual Mechanical Barriers. Previous regulations did not require the installation of dual mechanical barriers. The new regulatory section at 30 CFR 250.420(b)(3) requires that the operator install dual mechanical barriers in addition to cement barriers for the final casing string. These barriers prevent hydrocarbon flow in the event of cement failure at the bottom of the well. The operator must document the installation of the dual mechanical barriers and submit this documentation to BSEE within 30 days after installation. These new requirements will ensure that the best casing and cementing design will be used for a specific well.

Professional Engineer Certification for Well Design. Previous regulations at 30 CFR 250.420(a) specified well casing and cementing requirements, but did not require verification by a registered professional engineer. The new regulatory section at 30 CFR 250.420(a)(6) requires that a registered professional engineer certify that the well casing and cementing design is appropriate for the purpose for which it is intended under expected wellbore conditions.

Emergency Test of Activated Shear Rams. Previous regulations did not address BOP inspection following use of the blind-shear ram or casing-shear ram. The new regulatory section at 30 CFR 250.451(i) requires that, if a blind-shear ram or casing-shear ram is activated in a well-control situation where the pipe is sheared, the BOP stack must be retrieved, fully inspected, and tested. This provision will ensure the integrity of the BOP and that the BOP will still function and hold pressure after the event.

Third Party Shearing Verification. Regulation 30 CFR 250.416(e) requires information verifying that BOP blind-shear rams are capable of cutting through any drill pipe in the hole under maximum anticipated conditions. This regulation has been modified to require verification of this capability by an independent third party. The independent third party provides an objective assessment that the blind-shear rams can shear any drill pipe in the hole if the shear rams are functioning properly.

Upcoming BSEE Final Rule: Increased Safety Measures for Energy Development on the Outer Continental Shelf (Drilling Safety Rule). The Drilling Safety Final Rule will address public comments received on the interim final rule and will modify and clarify some provisions of the interim final rule based on public comments, including modifications of the negative pressure test requirements for casing strings, clarifications involving standards that are incorporated by reference, and a revised definition of mechanical barriers. The rule will also incorporate new industry best practices on cementing.

Safety Alert No. 10 for the Macondo Well Blowout. The BSEE National Safety Alert No. 10 was initially published on April 30, 2010, and consequently updated on November 10, 2011, following USCG and BOEMRE JIT Report (USCG and BOEMRE 2011). The updated Safety Alert incorporated the investigative findings related to areas of BSEE responsibility. The Safety Alert reminds lessees and contractors of the new requirements under 30 CFR 250.415(f) effective with the publication of the interim final Drilling Safety Rule (see above) requiring lessees to submit a written description of how they have evaluated the best practices included in API RP 65–Part 2 (API 2010). The written description must identify the mechanical barriers and cementing practices they will use for each casing string. This description must be included as part of the operator's casing and cementing programs, required in 30 CFR 250.411.

The Safety Alert urges lessees and contractors to thoroughly examine the detailed investigation findings, conclusions, and recommendations in the JIT Report, and, based these findings, BSEE recommends that lessees and contractors:

- Minimize the amount of fluid transfers during well operations so that accurate monitoring of flow-in versus flow-out can be achieved (refer to Safety Alert No. 284, Diverter Flow Event).

- Recognize the potential for a well to flow during a negative pressure test. It is recommended that lessees and contractors ensure that their procedures for conducting negative pressure tests outline expected test results including failure indicators. These expected test results should be discussed at a pre-kill meeting prior to conducting the negative pressure test.

- Review their well-control procedures to ensure that the initial response actions default to routing the well flow to the overboard diverter line(s) when appropriate.

- Evaluate and consider relocating the mud-gas separator vent line(s) to prevent directing gas, condensate, and oil back down toward the rig floor.

- Inspect all dynamically positioned Mobile Offshore Drilling Units (MODUs) and determine if all air intakes are located as far as practically possible from the rig floor.

- Evaluate the configuration and operation of subsea BOP stacks to maintain central alignment of the drill pipe and minimize the effects of elastic buckling during emergency activation of blind shear rams (http://www.bsee.gov/Regulations-and-Guidance/Safety-Alerts/National-Safety-Alert-No--10.aspx).

Upcoming BSEE Proposed Rule: Blowout Prevention Systems. This proposed rule will upgrade regulations related to the design, manufacture, and repair of BOPs. BSEE regulations for BOPs currently consist of (1) field pressure and functions tests, (2) generic performance statements related to BOP capabilities, and (3) several generic industry practices related to inspection and maintenance. This rule will incorporate upcoming improved industry standards for BOP design and testing along with supplemental BSEE requirements to increase the regulatory oversight over this critical equipment.

Upcoming BSEE Proposed Rule: Production Safety Systems and Lifecycle Analysis. This proposed rule will amend and update 30 CFR Part 250, Subpart H, Oil and Gas Production Safety Systems, by addressing issues such as production safety systems, subsurface safety devices, and safety device testing.

Forum on Next-Generation Blowout Preventer and Control System Technology, Management, and Regulations. As part of its ongoing efforts to improve the safety of offshore oil and gas operations, BSEE hosted a public Forum on Next-Generation BOP and Control Systems Technology, Management, and Regulations in May 2012. The forum brought experts from government organizations, trade associations, equipment manufacturers, offshore operators, consultants, and training companies from around the country that served on panels to discuss next steps in offshore drilling safety including:

- BOP technology needs identified from DWH event investigations;

- Real time technologies to aid in diagnostics and kick detection;

- Design requirements to ensure the ability of BOPs to cut casing or drill pipe and seal a well effectively;

- Manufacturing, testing, maintenance and certification requirements to ensure operability and reliability of BOP equipment; and

- Training and certification needs for industry personnel operating or maintaining BOPs (http://bsee.gov/BSEE-Newsroom/Press-Releases/2012/press05082012.aspx).

USCG Risk-Based Targeting of Foreign-Flagged Mobile Offshore Drilling Units. The new USCG Office of Vessel Activities Policy Letter 11-06, "Risk-Based Targeting of Foreign Flagged Mobile Offshore Drilling Units (MODUs)," became effective on July 7, 2011 (USCG 2011e)). This policy letter is one of the steps the USCG has taken to improve oversight of foreign-flagged MODUs in response to the DWH event. The new policy details the inspection procedures that utilize the newly developed MODU Safety and Environmental Protection Compliance Targeting Matrix. This matrix enables the USCG to prioritize inspections of foreign-flagged MODUs that may require increased oversight through a systematic determination of probable risk based on vessel characteristics, accident and violation history, past discrepancies, flag state performance, and classification society performance.

Improving Containment. The National Commission highlighted the need for stronger requirements for well-containment capabilities, as well as the need for improved industry resources. Although BOEMRE issued the Certification NTL (NTL-2010-N10) (BOEMRE 2010k) prior to the National Commission Report, its development and implementation is consistent with the Report recommendations. BSEE also developed an evaluation tool, the Well Containment Screening Tool (WCST), to apply during permit and plan approval to demonstrate whether a well's design and equipment are adequate for well containment.

Statement of Compliance with Applicable Regulations and Evaluation of Information Demonstrating Adequate Spill Response and Well Containment Resources (Certification NTL). The Certification NTL (NTL-2010-N10) (BOEMRE 2010k), effective on November 8, 2010, requires lessees and operators using subsea or surface BOPs on floating facilities (i.e., deepwater facilities) to provide a statement verifying compliance with new well containment and oil-spill response requirements prior to being granted a permit to drill/modify. Specifically, the statement, signed by an authorized company official, indicates that authorized activities will be in compliance with all applicable regulations, including the requirements of the Drilling Safety Rule.

The NTL also informs lessees and operators that BSEE will be evaluating whether or not each operator has submitted adequate information demonstrating that it has access to and can deploy surface and subsea containment resources to promptly respond to a blowout or other loss of well control. Although the NTL does not provide that operators submit revised OSRPs that include this containment information, operators were notified of BSEE's intention to evaluate the adequacy of each operator to comply with their current OSRP; therefore, there is an incentive for voluntary compliance.

The benefits of the new requirements include the following:

- Improved response time for offshore vessels to remove damaged equipment and install a capping stack;

- Reduced amount of time a well flows into the sea compared with previous well blowouts;

- More robust well designs relative to expected pressures and fluids in the well to fully contain the well after installation of the capping stack;

- Determination of the well's potential to broach to the seafloor if the well design fails under the shut-in pressure with installed capping stack; and

- Determination of the surface vessel configuration and containment capacities if the well has to flow to the surface for processing and capture.

OCS operators must demonstrate the capability to remove damaged well equipment and install a capping stack (with a pressure rating higher than the calculated mud line shut-in pressure) to stop the uncontrolled flow of oil from the well in the event of a well blowout. If the well design fails under the shut-in pressure, the operator must demonstrate the capability to flow and process the oil and gas from the well into surface containment vessels. Although not explicitly stated in the Certification NTL notice, BSEE requires operators to demonstrate that the well design is adequate to contain an uncontrolled flow.

BSEE Well Containment Screening Tool. The NAE and JIT recommended additional safeguards for well design and construction. BSEE led a joint industry task force to develop the WCST to demonstrate whether a well's design and equipment are adequate for well containment. This tool is necessary to evaluate industry compliance with the Certification NTL when applying for a permit to conduct drilling activities. The WCST allows BSEE to analyze oil-spill risk based on the mechanical and geological integrity of the well. BSEE also reviews wellbore designs and wellbore integrity to determine whether appropriate containment equipment is accessible or whether additional containment systems are required.

BSEE uses a Level 1 WCST for all initial reviews prior to APD approval. The Level 1 WCST is useful for wells that can be fully shut in without causing underground flow, using very conservative assumptions and simple calculations (no requirement for computer simulations). However, not all wells can pass a Level 1 screening successfully, because of high pressure and/or light formation fluids expected in the well. The Level 2 WCST analysis uses field/offset data and more advanced calculations to demonstrate equipment and well integrity. The Level 2 WCST analysis also identifies failure points and possible loss zones that must be addressed in a consequence analysis. The WCST has resulted in more-robust well designs that reduce the risk of prolonged well flow into the sea and increase the chance of successfully capping and stopping the flow of oil in less than 15 to 30 days. The WCST has been used to evaluate all GOM well operations including drilling, completion, water injection, and permanent abandonment.

BOEMRE Guidance: Approval Requirements for Activities That Involve the Use of a Subsea BOP or a Surface BOP on a Floating Facility. On December 13, 2010, BOEMRE issued additional guidance, *Approval Requirements for Activities That Involve the Use of a Subsea Blowout Preventer (BOP) or a Surface BOP on a Floating Facility* (BOEMRE 2010i), to encourage operators to voluntarily include additional subsea containment information in their OSRPs. The guidance indicates that BSEE will review OSRPs, in support of plan submittals, for the following specific information related to subsea containment (including that listed in the Certification NTL):

- Worst-case discharge scenario flow rate estimates;
- Offshore surface oil containment and recovery;
- Nearshore surface oil containment and recovery;
- Shoreline booming and protection strategies;
- Source abatement through direct intervention;
- Relief wells;
- Debris removal from the site of a blowout, if necessary;
- Subsea containment and capture equipment, including containment domes and capping stacks (in the event that an operator proposes a capping stack as the single containment option, the operator should explain the reasons that the well design is sufficient to allow shut-in without broach to the sea floor);
- Subsea utility equipment, including hydraulic power, hydrate control, and dispersant injection equipment;
- Riser systems;
- Remotely operated vehicles;
- Capture vessels;
- Support vessels;
- Storage facilities;
- Night operations;
- In-situ burning;
- Spotter aircraft;
- Responder communications equipment compatibility; and
- Area Contingency Plan consistency.

MWCC Deepwater Oil and Gas Capping Stack Containment Exercise in the Gulf. In the summer of 2012, BSEE will oversee a live drill conducted by MWCC to deploy and test a state-of-the-art capping stack from its on-shore base to the deepwater seabed of the Gulf of Mexico. The exercise aims to demonstrate MWCC's ability to mobilize well-control equipment in a timely fashion in the event of a well blowout. This demonstration is part of a larger scenario that will also test an operator's ability to obtain supporting systems necessary for successful containment, such as debris removal equipment and oil collection devices. The other oil and gas well-containment equipment consortium, the Helix Well Containment Group, will conduct a similar deployment exercise in the future (http://www.bsee.gov/BSEE-Newsroom/Press-Releases/2012/press05242012.aspx).

Improving Oil-Spill Response. Many of the various report recommendations pertaining to Federal oversight of oil-spill response fall outside of USDOI's immediate jurisdiction. However, BOEM and BSEE are actively collaborating with the USCG and other agencies throughout the Federal Government in this area. Other agencies are also acting on National Commission's report recommendations; for example, the USEPA is conducting dispersant research and revising Subpart J of the National Contingency Plan, which establishes the products list for dispersants.

Memoranda of Agreement between USDOI BSEE and the U.S. Department of Homeland Security USCG. This Memorandum of Agreement (MOA) clarifies the following roles and responsibilities of BSEE and the USCG for any artificial island, installation, pipeline, or other device permanently or temporarily attached to the seabed seaward of the coastline, and certain vessels, including MODUs, support vessels for subsea containment, and floating production, storage, and offloading (FPSO) (or similar) vessels, located in State and Federal waters seaward of the coastline that may be used for the purpose of responding to discharges or substantial threats of discharges:

- Oil discharge research including research and development through the Inter-Agency Coordinating Committee on Oil Pollution Research, pollution event database maintenance, and inter-agency training at BSEE's Ohmsett National Oil Spill Response and Renewable Energy Test Facility and National Offshore Training and Learning Center;

- Planning including participation in the USCG Regional Response Teams and Area Committees, development of Regional Contingency Plans and Area Contingency Plans, and Oil Spill Response Plan review;

- Preparedness including conducting unannounced drills, equipment inspections, administering the National Preparedness for Response Exercise Program, and ensuring appropriate industry oil-spill response and spill management team training;

- Coordinated oil discharge response;

- Oil discharge reporting;

- Enforcement; and

- Abatement and production resumption activities (BSEE and USCG MOA 2012).

Upcoming National NTL Regarding Oil Spill Response Planning and Oil Spill Response. The USCG Incident-Specific Preparedness Review and the National Commission report include an array of recommendations related to planning, preparedness, and response for offshore operations. The BSEE Oil Spill Response Division (OSRD) and USCG Office of Incident Management and Preparedness have established the Response Workgroup, which is a team dedicated to improving coordination of review of oil-spill response plans, coordinating joint equipment reviews, reviewing offshore response planning standards, and conducting joint response exercises. Many of these ongoing activities link directly to recommendations in the reports noted above. The outcomes of much of this work will be published in a National BSEE NTL intended to incorporate lessons learned from the Macondo well spill response.

Upcoming Improvements to 30 CFR Part 254: Oil-Spill Response Requirements for Facilities Located Seaward of the Coast Line. BSEE's OSRD is currently planning to update the regulations governing oil-spill response plan content, which will respond to OSC recommendations to improve oil-spill risk analysis and the response planning process. By the close of 2012, OSRD is planning to publish an Advanced Notice of Proposed Rulemaking to initiate the process to update 30 CFR Part 254.

BSEE Oil Spill Response Implementation Team. As part of USDOI's broad and continuing reform efforts, BSEE created a number of Implementation Teams to evaluate and pursue implementation of the various reform recommendations following the DWH event. The ongoing work of these teams lays the foundation for lasting change in the way the BSEE and BOEM implement oil-spill prevention, containment, and response measures in the future. BSEE's Oil Spill Response Implementation Team is conducting a comprehensive review of spill response and the adequacy of operators' oil-spill response plans. This team is working closely with the USCG and other Federal agencies on developing enhanced spill response plans and more effective reviews of those plans in light of lessons learned from the **DWH** oil spill response (see http://www.bsee.gov/About-BSEE/Reorganization/ImplementationTeams.aspx).

Enhanced Inspection and Enforcement Procedures, Including Strengthened Training Program. As of October 1, 2011, the new BSEE is responsible for enforcement of safety and environmental regulations. BSEE undertakes both annual scheduled inspections and periodic unscheduled (unannounced) inspections of oil and gas operations on the OCS. The inspections are to assure compliance with all regulatory constraints that allowed commencement of the operation. The annual inspections examine all safety equipment designed to prevent blowouts, fires, spills, or other major accidents. These annual inspections involve the inspection for installation and performance of all facilities' safety-system components. The primary objective of an initial inspection is to assure proper installation and functionality of their safety and pollution prevention equipment. After operations begin, additional announced and unannounced inspections are conducted. Unannounced inspections are conducted to foster a climate of safe operations, to maintain a BSEE presence, and to focus on operators with a poor performance record. These inspections are also conducted after a critical safety feature has previously been found to be defective. Poor performance generally means that more frequent, unannounced inspections may be conducted on a violator's operation. The inspectors follow the guidelines as established by the regulations, API RP 14C (API 2001a), and the specific BOEM-approved plan. The BSEE inspectors perform these inspections using a national checklist called the Potential Incident of Noncompliance (PINC) list. This list is a compilation of yes/no questions derived from all regulatory safety and environmental requirements.

BSEE has several Inspection Implementation Teams focused on addressing issues in the development of effective, risk-based approaches to offshore inspections programs, including methodologies for targeting risk, near- and long-term inspection strategies, training programs, inspection and enforcement tool enhancements, and evaluations of compliance with the SEMS rule. The BSEE Environmental Compliance and Enforcement Implementation Team is specifically focused on designing new inspection and enforcement programs relating to environmental compliance. The BSEE Regulatory Enforcement Implementation Team is evaluating the use, adequacy of, and potential gaps in its enforcement tools including incidents of noncompliance, civil penalties, and debarment of unsafe operators. The BSEE Incident Investigations Implementation Team is evaluating and developing investigative procedures for specific categories of accidents and incidents (see http://www.bsee.gov/About-BSEE/Reorganization/ImplementationTeams.aspx).

BSEE administers an active civil penalties program (30 CFR Part 250, Subpart N). A civil penalty in the form of substantial monetary fines may be issued against any operator that commits a violation that the operator fails to correct or that caused or may constitute a threat of serious, irreparable, or immediate harm or damage to life, property, or the environment. BSEE may make recommendations for criminal penalties if a knowing and willful violation occurs. In addition, the regulation at 30 CFR 250.173(a) authorizes suspension of any operation if the lessee has failed to comply with a provision of any applicable law, regulation, order or provision of a lease or permit. Furthermore, the Secretary may invoke his authority under 30 CFR 550.185(c) to cancel a nonproductive lease with no compensation in certain circumstances. Exploration and development activities may be canceled under 30 CFR 550.182 and 550.183 if certain conditions are met.

Predecessor bureaus to BSEE established a robust training program for inspectors to ensure that personnel involved in installing, inspecting, testing, and maintaining safety devices are qualified. BSEE offers numerous technical seminars to ensure that personnel are capable of performing their duties and are incorporating the most up-to-date safety procedures and technology in the petroleum industry. In 1994, the Office of Safety Management created BSEE's Offshore Training Institute to develop and implement an inspector training program. The Institute introduced state-of-the-art multimedia training to the inspector work force and has produced a series of interactive computer training modules. As of June 2011, BOEMRE established the National Offshore Training Center, thereby developing the agency's first formal training curriculum, which has been piloted with new inspectors. An additional 24 courses covering specific areas of offshore inspections will be developed. These additional training initiatives respond to recommendations from the NAE and USDOI OCS Safety Oversight Board reports.

Following the DWH oil spill, BSEE now requires multiple-person inspection teams for offshore oil and gas inspections. This internal process will improve oversight and help ensure that offshore operations proceed safely and responsibly. The new process will allow teams to inspect multiple operations simultaneously and thoroughly, and enhance the quality of inspections on larger facilities. In addition, BSEE engineers and inspectors now fly offshore to witness required testing of all ROV intervention functions on the subsea BOP stack during the stump test (on the rig floor at the surface) and testing of at least one set of rams during the initial test on the seafloor, and required function testing of autoshear and deadman systems on the subsea BOP stack during the stump test and testing of the deadman system during the initial test on the seafloor. These reviews and inspections of the BOP systems and maintenance provide additional oversight by BSEE to reduce the risk of an uncontrolled blowout by ensuring that BOP systems are maintained and functional in the event of a loss-of-well-control event.

BSEE is also developing regulations to address new BSEE enforcement and investigative tools and policies, which responds to recommendations from both the NAE and USDOI OCS Safety Oversight Board. This rule (Clarification of Enforcement and Other Regulatory Authorities) will address BSEE (1) enforcement authority, by clarifying existing practices, authorities, and remedies for violations; (2) inspection responsibilities, by more accurately representing the OCSLA requirement that BSEE will conduct yearly scheduled inspections; (3) incident investigation, by substantially rewriting and strengthening regulations pertaining to the conduct of BSEE incident investigations; and (4) describing in greater detail the sanctions and penalties that could be levied against lessees, operators, or third parties under OCSLA or other relevant legislation.

Other Reform Initiatives.

***USDOI Ocean Energy Safety Advisory Committee*.** The Secretary of the Interior chartered the Ocean Energy Safety Advisory Committee (OESC) on February 8, 2011, to facilitate the development of new regulations, collaborative research and development, advanced training, and implementation of best practices in drilling safety, well intervention and containment, and oil-spill response. The committee has several subcommittees that are working to address the findings of the various DWH event reports; reduce oil-spill risk via drilling and workplace safety, well containment, and oil-spill prevention planning reform; and address oil-spill response. OESC members are appointed by the Secretary of the Interior to represent the interests of the academic community, non-government organizations, offshore energy industry, and the Federal Government (see http://www.doi.gov/news/pressreleases/Ocean-Energy-Safety-Advisory-Committee-Sets-Goals-Agenda.cfm and http://www.bsee.gov/About-BSEE/Public-Engagement/OESC/Index.aspx).

Arctic-Specific Reform Initiatives. The National Commission only had a few recommendations specifically related to the Arctic and other frontier regions. USDOI, BOEM, and BSEE are engaged in initiatives to specifically address the unique concerns of undertaking oil and gas exploration and development in the Arctic. The discussion below highlights a few of these initiatives. More information on the Federal Government’s preparedness and response coordination efforts is available at http://www.bsee.gov/BSEE-Newsroom/BSEE-Fact-Sheet/Arctic-Fact-Sheet.aspx.

Arctic Oil Spill Response Exercise. In May 2012, BSEE participated in an oil-spill response table-top exercise that simulated the response to a well blowout in the Chukchi Sea. The exercise also included representatives from the U.S. Coast Guard, the U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service, the National Oceanic and Atmospheric Administration, the State of Alaska and the North Slope Borough, as well as officials from Shell. BSEE will also continue to participate in similar joint exercises to evaluate and improve communication and coordination among federal and state partners and industry. BSEE will also conduct a series of planned and unannounced exercises and inspections throughout the year to verify industry's ability to meet the conditions of their oil-spill response plans and effectively respond to a potential spill in the Arctic. In the event that exploratory drilling activities are approved in the Arctic, on-water exercises and drills will be conducted and on-site inspections of oil-spill response equipment will be required throughout the proposed drilling operation (http://www.bsee.gov/BSEE-Newsroom/Press-Releases/2012/press05252012.aspx).

Interagency Working Group on Coordination of Domestic Energy Development and Permitting in Alaska. Led by the USDOI, the Interagency Working Group on Coordination of Domestic Energy Development and Permitting in Alaska was established by the President to increase interagency coordination regarding the safe and responsible development of onshore and offshore energy resources and associated infrastructure in Alaska while protecting human health and the environment, as well as indigenous populations. A few of the working group's primary functions include facilitating orderly and efficient decision-making regarding the issuance of permits and conduct of environmental reviews; ensuring information sharing and integrity of scientific and environmental information and cultural and traditional knowledge; engaging in long-term planning and ensuring coordination regarding oil-spill prevention, preparedness, and response; coordinating Federal engagement with States, localities, and tribal governments; and collaborating on stakeholder outreach (see http://www.whitehouse.gov/the-press-office/2011/07/12/executive-order-13580-interagency-working-group-coordination-domestic-en).

National Research Council Study: Responding to Oil Spills in Arctic Environments**.** The NRC is currently working to assess the state of the science regarding oil-spill response and environmental assessment in the Arctic region. BSEE and BOEM are partially funding this study, which will aid in the development of oil-spill responses that adequately address prevention, containment, and response in a manner that reduces potential harm to the environment from increasing development in the Arctic. The study report will address Arctic oil spill (1) planning scenarios and prevention steps, (2) preparedness, (3) response and cleanup under Arctic conditions, and (4) baseline resource information needs for evaluating impacts and improving and developing protection and restoration measures. The study will also review new and ongoing research, identify opportunities and constraints for advancing oil-spill research, recommend strategies to advance research, and address information gaps.

Arctic Environmental Response Management Application**.** On February 2, 2012, BSEE and NOAA announced their partnership to enhance the Environmental Response Management Application (ERMA®) for the Arctic region by summer 2012. ERMA is a Web-based interactive geographic information system (GIS) tool designed to assist emergency responders and environmental resource managers in addressing incidents that may adversely affect the environment. ERMA integrates and synthesizes real-time and static data into a single interactive map to support response evaluation and decisions, as well as improves communication and coordination among responders and environmental stakeholders. ERMA was invaluable in assisting with response operations during the DWH event and is currently supporting National Resource Damage Assessment determinations. The Gulf ERMA is available for viewing at http://gomex.erma.noaa.gov/erma.html.

The new BSEE-NOAA partnership effort will reconfigure the tool to address the numerous challenges and meet the needs of responders in the remote marine Arctic environment. When operational, the Arctic ERMA will contain information such as the extent and concentration of sea ice; real-time oceanographic observations and weather data from NOAA; and the locations of ports, pipelines, and vulnerable environmental resources for spill responders to make rapid, science-informed response decisions. The BSEE-NOAA partnership aims to have the Arctic ERMA available to the response community ahead of any future drilling in Federal waters offshore Alaska (see http://www.bsee.gov/BSEE-Newsroom/Press-Releases/2012/press02072012.aspx).

***North Slope Subarea Contingency Plan*.** Improvements in planning for large-scale spills in the Arctic are currently being undertaken as part of the revision to the North Slope Subarea Contingency Plan, which serves as the guideline for establishing operations in the event of a major response effort to an oil spill or hazardous material release. This is a joint effort across the USDOI, USEPA, USCG, Alaska Department of Environmental Conservation, and numerous other Federal, State, local, Native and industry participants (ADEC et al. 2007). The most recent version of the plan can be obtained at http://dec.alaska.gov/spar/perp/ns-outreach/index.htm.

***Arctic Council*.** The National Commission recommended developing international standards for Arctic oil and gas exploration and development. The USDOI is actively engaged with other nations, through the Arctic Council and other forums, in addressing oil-spill prevention, preparedness, and response issues in the Arctic. The Arctic Council established a Task Force on Oil Spill Preparedness and Response in 2011 that is co-chaired by the U.S. Government. The task force is charged with developing an international instrument on Arctic marine oil pollution preparedness and response, as well as recommendations and/or best practices on the prevention of marine oil pollution (see http://www.arctic-council.org/index.php/en/about-us/task-forces/280-oil-spill-task-force).

Government Prevention, Containment, and Spill Response Research.

BSEE Research Programs. The BSEE Technical Assessment and Research (TA&R) Program was established in the 1970s to support research regarding operational safety and pollution prevention related to offshore oil and gas exploration and development. The primary objectives of the TA&R Program are to assess industry technological innovations and promote the use of Best Available and Safest Technologies (BAST) through regulations, rules, and operational guidelines and provide (1) technical support to Bureau decision makers; (2) research leadership; and (3) support for international research and development initiatives to enhance offshore safety and regulatory development. The TA&R Program is divided into Operational

Safety and Engineering Research (OSER) and Renewable Energy Research (REnR) (see http://www.bsee.gov/Research-and-Training/Technology-Assessment-and-Research.aspx).

The BSEE Oil Spill Response Research (OSRR) Program, which includes the National Oil Spill Response Test Facility (Ohmsett), has funded oil-spill response research focused on improving the knowledge and technologies used for the detection, containment, and cleanup of oil spills that may occur on the OCS. The BSEE OSRR Program encompasses oil-spill planning, preparedness, containment, monitoring, recovery, treatment, and response on the OCS. Information derived from the OSRR Program is directly integrated into BSEE's offshore operations and is used to make regulatory decisions pertaining to permitting and plan approval, safety and pollution inspections, enforcement actions, and training requirements. The BSEE OSRR Program is openly cooperative, bringing together funding and expertise from research partners in government agencies, industry, and the international community. Many of these collaborations are Joint Industry Projects, in which the Bureau partners with other stakeholders for the sole purpose of participating in research and development projects. BSEE disseminates the results of these projects to make this information widely available to oil -spill response personnel and organizations worldwide (see http://www.bsee.gov/Research-and-Training/Oil-Spill-Response-Research-(OSRR).aspx).

This section discusses the recent and ongoing research activities under BSEE's TA&R, OSER, and OSRR Programs related to workplace safety and incident prevention, containment, and response. For a complete list of TA&R OSER studies and their associated reports, visit http://www.bsee.gov/Research-and-Training/Operational-Safety-and-Engineering.aspx. For a complete list of OSRR and Ohmsett studies and their associated reports visit http://www.bsee.gov/Research-and-Training/Master-List-of-Oil-Spill-Response-Research.aspx and http://www.bsee.gov/Research-and-Training/Technology-Assessment-and-Research/tarprojectcategories/OHMSETT.aspx, respectively.

Improving Prevention. The NAE and JIT offered many recommendations for improving BOP reliability and performance. These reports also recommended additional safeguards for well design and construction. Alongside the regulatory upgrades discussed above, BSEE's TA&R Program is being used to address longer term technical issues involving BOP reliability and performance, and to conduct research to develop better methods of assessing cement performance in the field. These ongoing BSEE TA&R studies related to oil-spill prevention are discussed below.

Blowout Preventer Maintenance and Inspection in Deepwater Operations (Study No. 693). This study (BSEE TA&R Program in prep. j) will address and compare the current BOP maintenance, inspection, and testing practices to codes, standards, existing regulations, and industry recommended practices. Quantitative risk studies will be performed in order to identify the criticality of individual subcomponents within the BOP system, the reliability of the individual component, and the reliability of the complete BOP system.

Deepwater Blowout Preventer (BOP) Reliability & Well Kicks — Phase I Study No. 674). This study (BSEE TA&R Program in prep. f) will establish (1) an updated reliability overview of deepwater subsea BOPs used in the GOMR OCS during 2007–2009, and (2) a quantified overview of the deepwater well kick frequencies and important parameters contributing to the deepwater kick frequency in the various areas.

Analysis of Current Cementing Procedures Employed in the U.S. Outer Continental Shelf: Optimized Methods (Study No. 687). This research (BSEE TA&R Program in prep. i) will identify the current cementing practices used on the OCS and analyze them to determine the best practices. Existing practices that are incongruent with safety risks will be identified and safer alternatives will be proposed. Recommendations will be made for additional research in areas for which no acceptably safe methods exist.

Effects of Water Depth on Deepwater E&P Equipment and Operations on the OCS (Study No. 684). The objective of this study(BSEE TA&R Program 2012b) is to collaborate with offshore deepwater energy industry experts and regulators to (1) identify the critical issues and effects of water depth on equipment and operations and (2) determine the adequacy of current regulations.

Improving Spill Response. Even though much of the oil-spill response Federal oversight falls outside of USDOI's immediate jurisdiction, BSEE conducts a significant amount of research related to oil-spill recovery, treatment, and response on the OCS. The section below presents the ongoing studies currently being conducted.

Assessment of Dispersant Effectiveness using Ultrasound to Measure Oil Droplet Particle Size Distributions (Study No. 697). The goal of this project (BSEE TA&R Program in prep. k) is to develop novel ultrasonic scattering methods to measure the droplet size of dispersed oil to provide technologies to monitor the efficacy of dispersants subsea efficacy as a function of oil type, dispersant type, dispersant-to-oil ratio, water temperature, oil temperatures, and the presence of sediment on the effectiveness of dispersants.

Operational Chemical Dispersant Research at Ohmsett (Study No. 685). The overall objective of this research (BSEE TA&R Program in prep. h) is to advance the state-of-the-art and knowledge in chemical dispersant use in marine spill applications. The Ohmsett facility will be used to (1) validate the time window model for dispersant use, (2) understand the effects of dispersant type with various oil properties, and (3) understand the effectiveness of aircraft spray dosages on OCS crude oils.

Using Oil Herding Agents for Rapid-Response In Situ Burning of Oil Spills on Open Water (Study No. 683). The objective of this research (BSEE TA&R Program 2012a) is to evaluate the feasibility of using herders to enable *in situ* burning as a rapid-response technique in open water.

Laboratory-Scale Investigation of a Method for Enhancing the Effectiveness of Oil Dispersants in Destabilizing Water-in-Oil Emulsions (Study No. 681). The research (BSEE TA&R Program in prep. g) will investigate the feasibility of enhancing the de-emulsifying properties of commercially available oil dispersants by modifying the composition and fraction of polar constituents in the oil phase of water-in-oil emulsions and increasing the pH of the emulsion aqueous phase.

Effective Daily Recovery Capacity Project (Study No. 673). Effective Daily Recovery Capacity (EDRC) is the calculated capacity of oil recovery devices as determined by using a formula defined in 30 CFR 254.44, 33 CFR 154, Appendix C, and 33 CFR 155, Appendix B. The primary objectives of this project (BSEE TA&R Program in prep. e) are to (1) prepare an objective and independent assessment that scientifically validates the most appropriate methodologies for estimating the EDRC of oil-skimming systems, (2) provide recommendations for EDRC improvements to inform oil-spill planning and preparedness, and (3) make recommendations for new EDRC methodologies and guidelines for response systems deployed in nearshore and offshore operating environments.

Combining Mineral Fines with Chemical Dispersants to Disperse Oil in Low-Temperature and Low-Mixing-Energy Environments (Study No. 662). This research aims to assess the feasibility of applying a combination of dispersant and common fine mineral to treat oil slicks in low-energy regimes that are typical in cold water and the Arctic. The study hypothesis is that this combined treatment process would enhance the stability of the oil dispersion and to reduce its toxicity.

Detecting Oil on and under Sea Ice Using Ground Penetrating Radar: Development of a New Airborne System (Study No. 659). The goal is to significantly expand the practical operating window for oil detection using Ground Penetrating Radar (GPR) to cover a wider range of sea ice and climate conditions.

Open Water Multispectral Aerial Sensor Oil Spill Thickness Mapping in Arctic and High Sediment Load Conditions (Study No. 658). This project aims to validate and improve the current aerial thickness mapping system developed under the BSEE-funded research projects *Real-time Detection of Oil Slick Thickness Patterns with a Portable Multispectral Sensor* and *Development of a Portable Multispectral Aerial Sensor for Real-time Oil Spill Thickness Mapping in Coastal and Offshore Waters*. This project aims to test and validate this technology under oceanographic and environmental conditions that were not experienced during initial development, including the high-latitudes and extreme conditions of the Arctic.

Validation of the Two Models Developed to Predict the Window of Opportunity for Dispersant Use in the Gulf of Mexico (Study No. 637). This project aims to validate and improve the two correlation models developed under the BSEE-funded research project *Identification of Window of Opportunity for Chemical Dispersants on Gulf of Mexico Crude Oils*, which predicts the window of opportunity (or time-window) for successful chemical dispersant use in the GOM. The project also aims to evaluate the sensitivity of the models to water temperature, wind speed, and oil viscosity with the aim of including the effects of these parameters into the models.

Upcoming OSRR Research. In addition to the above ongoing studies, the BSEE OSRR Program has also recently identified the following study topics for potential funding this fiscal year and has requested the following information submittals: (1) feasibility of conducting subsea dispersant research at Ohmsett, (2) ice month at Ohmsett to stimulate development of new mechanical and/or chemical technologies for the recovery of oil in ice, (3) dispersant use impact on worker safety, (4) subsea chemical dispersant research, (5) methods to increase encounter rate for skimming and *in situ* burn operations, (6) mechanical technologies to facilitate and improve oil-spill containment and recovery under Arctic conditions, (7) remote sensing techniques, (8) mechanical technologies to facilitate and improve surface oil-spill containment, (9) mechanical technologies to facilitate and improve subsea oil-spill containment and removal, and (10) *in situ* burning.

Recent and Ongoing Industry Reform and Research.

Joint Industry Task Forces. Shortly after the DWH event, various industry trade associations formed four joint industry task forces (JITFs) to learn from the DWH event and advance industry practices. The JITFs are comprised of member companies and affiliates of the API, International Association of Drilling Contractors, (IADC) Independent Petroleum Association of America (IPAA), National Ocean Industries Association (NOIA), and U.S. Oil and Gas Association (USOGA). The ultimate objectives of the JITFs are to reduce risk and improve the industry's capabilities in safety, environmental performance, and spill prevention and response. Collectively, the JITFs have worked to enhance industry drilling standards to form comprehensive safe drilling operations, well-containment and intervention capability, and oil-spill response capability; not only through evaluation and revision of industry guidelines and procedures, but also active engagement with regulatory processes. The JITFs identified gaps in industry operations or practices and are addressing those gaps through recommended practices, procedures, and research and development (JITF 2012a).

Recommendations from the JITFs have led to the reform of industry standards, recommended practices, and guidelines. The JITFs continue to evaluate and improve on both new and current tools. The JITFs functions and accomplishments are summarized below, as well as other current and ongoing reform initiatives spearheaded by industry.

Prevention.

Joint Industry Operating Procedures Task Force (Procedures JITF). The Joint Industry Operating Procedures Task Force (Procedures JITF) reviewed critical processes associated with the design, drilling, and completion of deepwater wells to identify gaps between existing practices and current regulations and industry best practices. Their recommendations resulted in the revision and new development of API standards: API Standard 65-Part 2: Isolating Potential Flow Zones During Well Construction (revised), API RP 96: Deepwater Well Design and Construction (new), and API Bulletin 97: Well Construction Interface Document Guidelines (new) (see New and Revised Industry Standards below) (Procedures JITF 2012). The Procedures JITF (in conjunction with the Equipment JITF) *Final Report on Industry Recommendations to Improve Offshore Operating Procedures and Equipment* (March 2012) presents detailed information on the status of addressing the JITF's original recommendations.

Joint Industry Offshore Equipment Task Force (Equipment JITF). The Joint Industry Offshore Equipment Task Force (Equipment JITF) reviewed current BOP equipment designs, testing protocols, and documentation, and developed recommendations to close any gaps or capture improvements in these areas. Based on these initial recommendations, the Equipment

JITF formed three subgroups to address measures to enhance the use of BOPs, including (1) shearing capabilities, (2) acoustics systems, and (3) interface with remotely operated vehicles. These subgroups each produced white papers regarding their topics in January of 2011. The Equipment JITF recommendations resulted in the revision of the API Standard 53: Blowout Prevention Equipment Systems for Drilling Well (see New and Revised Industry Standards below) (Equipment JITF 2012). The Procedures JITF (in conjunction with the Equipment JITF) *Final Report on Industry Recommendations to Improve Offshore Operating Procedures and Equipment* (March 2012) presents detailed information on the status of addressing the JITF's original recommendations.

Containment.

Joint Industry Subsea Well Control and Containment Task Force (Subsea JITF). The Joint Industry Subsea Well Control and Containment Task Force (Subsea JITF) reviewed technologies and practices for controlling the release of oil from its source, including equipment designs, testing protocols, research and development, regulations and documentation to determine if enhancements were needed. The Subsea JITF identified five key areas of focus for GOM deepwater operations: (1) well containment at the seafloor; (2) intervention and containment within the subsea well; (3) subsea collection and surface processing and storage; (4) continuing research and development; (5) and relief wells (Subsea JITF 2012).

One of the first Subsea JITF recommendations implemented was to provide a near-term response capability for well containment. This was achieved through the establishment of collaborative containment companies such as the Marine Well Containment Company (MWCC) and Helix Well Containment Group (HWCG) (see Section 4.3.3.2.2 for more detail). The establishment of these companies allowed industry to comply with the requirements of the Certification NTL (NTL-2010-N10) by developing and making available to operators subsea containment systems, including capping stacks and systems for the capture of flow from a well. In many cases, these containment companies are the responsible party for implementing the recommendations made by the Subsea JITF (Subsea JITF 2012).

The Subsea JITF developed 29 recommendations on specific steps to enhance the industry's subsea control and containment capability, including 15 immediate action items (one of which was the establishment of the above containment companies). The JITF began work on an API RP for containment certification for wells with subsea BOP and BOPs on floating structures, as well as an API RP for capping stacks (Subsea JITF 2012). Both API RPs will incorporate these recommendations as appropriate. The Subsea JITF *Final Report on Industry Recommendations to Improve Subsea Well Control and Containment* (March 2012) presents detailed information on the status of addressing the JITF's original recommendations.

Spill Response.

Joint Industry Oil Spill Preparedness and Response Task Force (OSPR JITF). The Joint Industry Oil Spill Preparedness and Response Task Force (OSPR JITF) issued preliminary recommendations in its *Draft Industry Recommendation to Improve Oil Spill Preparedness and Response Report* (September 2010), which proposed potential opportunities for improvement to the oil-spill response system in the areas of planning and coordination, optimization of each response tool, research and development, and training of all parties preparing for or responding to an oil spill (OSPR JITF 2011).

Following the OSPR JITF Report, the API Oil Spill Preparedness and Response Subcommittee (OSPRS) was tasked with leading industry efforts to develop and implement plans that addressed the preliminary recommendations, while staying abreast of related initiatives on a global scale. The OSPRS prioritized and divided the recommendations into seven categories: oil-spill response planning; shoreline protection and clean-up; oil sensing and tracking, dispersants; *in situ* burning; mechanical recovery; alternative technologies. Since then, the OSPRS supported by the API Oil Spill Preparedness and Response Workgroup (OSPRW) developed a comprehensive work program around these categories and organized project teams to conduct a number of projects under each category (OSPR JITF 2011). The full details on the progress of each project under the above recommendation categories can be found in the OSPR JITF *Progress Report on Industry Recommendations to Improve Oil Spill Preparedness and Response*.

New and Revised Industry Standards.

Improving Prevention.

API Standard 65-Part 2: Isolating Potential Flow Zones during Well Construction (revised). API has worked through the Procedures JITF to improve industry safety and operations by revising its standards and RPs. API published RP 65 – Part 2, Isolating Potential Flow Zones During Well Construction, in May 2010, and then revised the document based on (1) lessons learned from the DWH incident and (2) alignment with the planned Deepwater Well Design and Construction RP (see below). The revisions resulted in the API RP becoming API Standard 65 – Part 2, second edition. The Standard was published in December 2010. The Standard contains practices for isolating potential flow zones, which is integral to maintaining well integrity. The focus of this standard is the prevention of flow through or past barriers that are installed during well construction. Barriers that seal wellbore and formation pressures or flows may include mechanical barriers such as seals, cement, or hydrostatic head; or operational barriers such as flow detection practices that result in activation of a physical barrier. The reliability of achieving flow zone isolation is dependent on the existence of both types of barriers in the total system design. BSEE has incorporated this document by reference into its Interim Final Drilling Safety Rule (see above) (API Standard 65-Part 2, 2010).

API Balloted RP 96: Deepwater Well Design and Construction (new). In June 2010, the Procedures JITFs began developing the new API RP 96 Deepwater Well Design and Construction to provide well design and operational considerations for the safe construction of a deepwater well, including the drilling and completion activity performed with subsea BOPs, a marine drilling riser, and a subsea wellhead. The RP gives examples of physical loads and design practices for subsea well completions and completion configurations that provide maximum reliability. The RP also supplements barrier documentation in API 65-2 with a more detailed description of barriers and discussion of the philosophy, number, type, testing, and management required to maintain well control. The RP has been through a first ballot for consensus and the workgroup is currently addressing comments from the second ballot. The RP is expected to be completed in 2012 (API RP 96, Ballot 1).

API Balloted Bulletin 97: Well Construction Interface Document Guidelines (new). In July 2010, the Procedures JITFs began work on a new technical bulletin entitled *Well Construction Interface Document* (WCID) guidelines. These guidelines were prepared in response to Section III, B, Recommendation 2, of the USDOI report *Increased Safety Measures for Energy Development on the Outer Continental Shelf*, dated May 27, 2010. The USDOI report proposed the development of a bridging document that would bridge the drilling contractor's required safety case to existing well design and construction documents. This WCID aims to meet that object by a bridging document between the drilling contractor's Health, Safety, and Environmental (HSE) safety case and the operator's Safety and Environmental Management System (SEMS), and will address safety and risk management considerations on a well-by-well basis. The WCID has been through a first ballot for consensus and the workgroup is currently addressing comments. The WCID is expected to be completed in 2012 (API RP 97, Ballot 1).

API Balloted Standard 53: Blowout Prevention Equipment Systems for Drilling Well (revised). Through the Equipment JITF, API is revising the third edition of API RP 53, Recommended Practices for Blowout Prevention Equipment Systems for Drilling Well. This fourth edition will be updated to an existing Standard and is likely to be completed in 2012. The third edition is incorporated by reference in the Interim Final Drilling Safety Rule under Documentation Requirements for BOP inspections and maintenance. The new Standard will present operating practices for the installation and testing of blowout prevention equipment systems during drilling; completions and well testing operations; equipment arrangements; and extreme high- and low-temperature operations. Required components of a blowout prevention system include BOPs, choke and kill lines, choke manifold, hydraulic control system, marine riser, and auxiliary equipment. The primary functions of these systems are to confine well fluids to the wellbore, provide means to add fluid to the wellbore, and allow controlled volumes to be withdrawn from the wellbore (API Balloted Standard 53, Ballot Draft 2).

API 16 Series: Drilling Well Control Systems (revised). In addition to the revision of API RP 53, API is also evaluating and revising the complete API 16 Series, Drilling Well Control Systems, which encompasses the following specifications and recommended practices (Patel et al. 2011):

1. Specification 16A (3rd Edition) — Specification for Drill-Through Equipment;

2. Specification 16C (1st Edition) — Choke and Kill Systems;

3. Specification 16D (2nd Edition) — Control Systems for Drilling Well Control Equipment and Control Systems for Diverter Equipment;

4. Specification 16F (1st Edition) — Specification for Marine Drilling riser Equipment;

5. RP 16Q (1st Edition) — Design, Selection, Operation, and Maintenance of Marine Drilling Riser Systems;

6. Specification 16R (1st Edition) — Marine Drilling Riser Couplings; and

7. Specification 16RCD (1st Edition) — Drill-Through Equipment–Rotating Control Devices.

API Specification Q2: Quality Management System Requirements for Service Supply Organizations for the Petroleum and Natural Gas Industries (new). In December 2011, API released the first edition of API Specification Q2 Quality Management System Requirements for Service Supply Organizations for the Petroleum and Natural Gas Industries. This specification defines the quality management system requirements for the oil and gas industry service supply sector. It is intended to apply to upstream activities involved in exploration, development, and production, including well construction, intervention, production, and abandonment, as well as well servicing, equipment repair/maintenance, and inspection activities (API Spec Q2 2011).

API RP 64: Diverter Systems Equipment and Operations (revised). Since diverter systems are important to overall well control capability, the API is planning to revise API RP 64 for Diverter Systems Equipment and Operations (Patel et al. 2011; ISO/TC 67 2011). API RP 64 is intended to aid in the selection, installation, testing, and operation of diverter equipment systems on land and marine drilling rigs, including barge, platform, bottom-supported, and floating rigs (API RP 64, 2007).

API RP 59: Well Control Operations (revised). The API RP 59 for Well Control Operations is currently under revision (ISO/TC 67 2011). This RP is a companion to the API RPs 53 and 64 and serves as a guide for safe well operations, including recommended practices for retaining pressure control of the well under pre-kick conditions, as well as during a kick (API RP 59 2006).

API RP 90: Annular Casing Pressure Management for Offshore Wells (revised). API RP 90 for Annular Casing Pressure Management for Offshore wells is currently under revision (ISO/TC 67 2011). This RP serves as a guide for managing annular casing pressure in offshore wells and includes recommended practices for monitoring, diagnostic testing, the establishment of a maximum allowable wellhead operating pressure (MAWOP), and documentation of annular casing pressure for the various types of offshore wells. A discussion of risk assessment methodologies for evaluating wells with annular casing pressures outside the MAWOP guidelines is also presented (API RP 90 2006).

API Technical Report PER15K-1: Protocol for Verification and Validation of High Temperature High Pressure Equipment (new). API is drafting a new technical report, *Protocol for Verification and Validation of High Temperature High Pressure Equipment*, to develop an evaluation process for high-pressure and high-temperature (HPHT) equipment in the petroleum and natural gas industries that includes design verification analysis, design validation, material selection considerations, and manufacturing process controls necessary to ensure the equipment is fit for service in the applicable HPHT environment (ISO/TC 67 2011; API TR PER15K-1 in preparation).

Other Reform Initiatives. Industry continues its efforts to identify and drive improvements through JITF efforts, as well as a across a broad spectrum of initiatives that will continue to identify and develop improvements in offshore equipment, operations, well design, well control equipment targeted at prevention and containment, and new procedures and tools for oil-spill response. The discussion below highlights several of these initiatives.

Improving Prevention.

Center for Offshore Safety — SEMS. The Center for Offshore Safety (COS) is an industry-sponsored organization focused on improving the safety of offshore operations. The COS's primary objectives are to enhance and continuously improving industry's safety and environmental performance, and provide a platform for industry collaboration and engagement with third-party stakeholders including Federal agencies.

Currently, the COS is focusing its efforts on operators' SEMS Programs and has developed a SEMS Toolkit to aid industry in the development and implementation of its SEMS Programs. Member companies are expected to maintain a level of safety performance established by the COS, as verified through the audit and certification of its SEMS Programs by COS independent third-party auditors. If a company's performance drops below the minimum performance level, the member will be expected to develop an aggressive recovery plan to re-establish adequate performance levels. If requested, the COS will provide technical assistance in the development of the recovery plan (see http://www.centerforoffshoresafety.org).

The Blowout Risk Assessment Joint Industry Project. The Blowout Risk Assessment (BORA) Joint Industry Project (JIP) research was initiated in 2011 to develop a Blowout Risk Assessment Methodology, a Blowout Risk Model, and a Blowout Risk Assessment Tool that can be used by the government and industry to evaluate the risk related to well design and drilling operations in the GOM region (Subsea JITF 2011).

BORA will identify the threats associated with every phase of drilling operations, including well design and planning, well-drilling execution, and source control and containment technology. BORA will aid in the reduction of overall blowout risk by evaluating the associated impacts of each stage on blowout risk and identifying the barriers and systems that are intended to prevent a loss of well control. BORA will also identify alternatives for mitigating the consequences if an event should occur (Delmar Engineering 2011; see https://web-server-1.delmarus.com/Engineering/Joint%20Industry%20Projects/borajip.html).

Risk assessment considerations include well type, water depth, distance from shore, geologic characteristics of the formation, meteorological and oceanic conditions, geologic hazards, rig type, BOP design, mud program, and casing and cementing program. Several aspects of well-drilling execution considered include crew training and experience; number of barriers at each stage of operation; barrier verification; management system; real-time operations monitoring of geology and drilling fluid; and BOP inspection, testing, drills, and monitoring.

Source control and containment technology aspects considered include backup BOP activation capabilities, ROV support, containment equipment, collection system, spill response cost and resources, and novel or experimental plugging options.

Overall blowout risk will be evaluated by (a) quantifying the probability of blowout events and (b) quantifying the consequence of blowout events. The quantification of blowout risk will consider mitigation measures that may have measurable impacts during design, execution, and containment. Both historical and technical data, as well as expert input, will be used to evaluate the probability of threat at each phase of drilling, their potential consequences, and the effectiveness of barriers, controls, and mitigations. The model results will illustrate the range of blowout probability, along with the relative uncertainty in blowout occurrence, as well as the magnitude range of blowout consequence. BORA will also provide a blowout database and a Web-based Blowout Risk Assessment Tool. This tool can be updated as new information is received and analyzed to stimulate the ongoing assessment of drilling practices and well control procedures that are necessary for the continual improvement of drilling safety and pollution prevention.

International Association of Oil and Gas Producers. The International Association of Oil and Gas Producers (OGP) formed the Global Industry Response Group (GIRG) to ensure the lessons learned from the investigations of the DWH event and other similar incidents worldwide were applied globally. The GIRG formed three teams to address oil-spill prevention, containment, and response — the Well Engineering Design and Equipment/Operating Procedures Team, the Capping and Containment Team, and the Oil Spill Response Team (OGP 465 2011). The Well Engineering Design and Equipment/Operating Procedures Team focused on reducing oil-spill likelihood by improving drilling safety through enhancements in industry capabilities and practices in well engineering design and procedures; and well operations management, governance, and risk management standardization. The team presented six key recommendations in its *Deepwater Wells Report* (May 2011): (1) institute a three-level internal review process to ensure adherence to processes and procedures; (2) promote a human competency management system to ensure appropriate worker knowledge, experience, and training; (3) use nationally and internationally approved standards and practices as a basis for continual industry improvement; (4) implement a well management system (like SEMS) along with bridging document to improve overall technical and operational governance of well construction; (5) apply a minimum of two permanent, independent physical barriers when a well is capable of discharging to the environment; (6) create a new Wells Expert Committee (WEC) to communicate best practices, share industry lessons learned, advocate for harmonized standards, analyze incidents, and promote research and development (OGP 463 2011).

OGP WEC. The OGP WEC was founded shortly after the GIRG Well Engineering Design and Equipment/Operating Procedures Team publication of the *Deepwater Wells Report* (May 2011). Currently the WEC has established four taskforces to address (1) BOP reliability and technology development; (2) a database of well incidents; (3) human factors including training, competence, and behaviors; and (4) international standards (see http://www.ogp.org.uk/committees/wells).

DeepStar. DeepStar is a research and development consortium leveraging the financial and technical resources of the deepwater industry, academic/research institutions, and regulators to develop and execute deepwater technology projects. DeepStar is structured into committees, such as the Subsea Systems, Floating Systems, Flow Assurance, and Drilling Completions Committees, that execute technology development projects in order to gain acceptance of the technologies by industry and regulators and ultimately apply those technologies to deepwater assets (see http://www.deepstar.org).

International Association of Drilling Contractors Health, Safety, and Environmental Case Guidelines for Mobile Offshore drilling Units. The International Association of Drilling Contractors (IADC) Health, Safety, and Environmental (HSE) Case Guidelines (IADC 2010) provide a consistent methodology based on recognized global practices and standards for developing an integrated health, safety, and environmental management system for use in reducing risks associated with offshore and onshore drilling activities. The guidelines are gaining worldwide acceptance and exposure, which assists regulatory authorities' evaluation of drilling contractors' HSE management programs by providing assurance that the programs encompass best industry practices designed to minimize operating risks (http://www.iadc.org/hsecase/index.html).

The guidelines are intended to assist drilling contractors in achieving the following:

- Develop a HSE management system that addresses the scope of drilling operations and is aligned with international standards;

- Demonstrate to senior management and external stakeholders that their HSE management system's risk reducing measures meet established goals;

- Verify compliance with applicable regulatory and contractually agreed-upon HSE requirements; and

- Demonstrate compliance with the International Safety Management Code requirements of the International Maritime Organization.

International Association of Drilling Contractors WellCAP Accreditation Program. The IADC WellCAP is an accreditation program designed to ensure that well-control training institutions adhere to a core curriculum of well-control skills for drilling operations developed by industry and benchmarked according to recognized industry standards. The curriculum includes the following well-control skills:

- Causes of well kicks; well kick indicators and warning signals; increasing formation pressure indicators and their relationship to well control; and early detection and response.

- The ability to understand the types of pressure; perform various pressure-related calculations; perform well-control monitoring and procedures (e.g., shut-in and diverter use) during all stages of well-drilling operations;

understand gas (hydrocarbon, hydrogen sulfide, and carbon dioxide) characteristics and behavior; understand the types of drilling fluids and their proper use; understand methods to maintain constant bottom-hole pressure well control; understand well-control equipment and demonstrate proper usage; subsea well control; and government, industry, and company rules, orders, and policies.

Accreditation is achieved only after an extensive review of a provider's curriculum, testing practices, faculty, facilities, and administrative procedures to ensure suitable instruction resulting in an internationally recognized training certification of competent rig crews. Industry ensures continual improvement of the program through regular updating of curriculum guidelines.

Improving Containment.

International Association of Oil and Gas Producers. The objective of the OGP GIRG Capping and Containment Team is to decrease the time it takes to stop flow from an uncontrolled well by improving well-capping response readiness and studying the feasibility of a standardized global containment system. The primary conclusions of the team were presented the *Capping and Containment Report* (May 2011) recommending industry should (1) further develop capping and dispersant injection capability; (2) continue studying the feasibility of a global containment system; and (3) negotiate a Joint Development Agreement to execute these recommendations (OGP 464 2011).

OGP Subsea Well Response Project. The OGP Subsea Well Response Project (SWRP) was established on the recommendation of the OGP GIRG Capping and Containment Team (above). The SWRP is a consortium of nine major oil companies working to design a capping toolbox with a range of equipment to enable well shut-in, design hardware for the subsea injection of dispersant, and further assess the need for and feasibility and deployment options of a global containment system (see http://subseawellresponse.com/about-swrp and http://www.ogp.org.uk/global-insight/countering-major-incidents).

Improving Spill Response.

***Oil Spill Removal Organizations*.** The OSPR JITF Report (September 2010) contained recommendations for improving oil-spill response capabilities through expanding and optimizing the various oil-spill response options. Oil Spill Removal Organizations (OSROs) have dedicated significant time and resources to implementing those recommendations. The progress of each project under the seven recommendation categories developed by the OSPRS can be found in the OSPR JITF *Progress Report on Industry Recommendations to Improve Oil Spill Preparedness and Response* (OSR JITF 2011).

***Marine Spill Response Corp*.** An example of one OSRO's improvements is the Marine Spill Response Corp's (MSRC) Deep Blue program. This program has added additional dedicated spill response and recovery platforms, contracts with vessel operators to ensure ship readiness, and enhanced its oil-finding technology by adding infrared scanners and other technologies. The MSRC also expanded its capabilities for deploying chemical dispersants, has developed better oil-burning operations, and purchased more than 21,000 ft of boom. To allow for quicker deepwater response, it has also moved its Deep Blue Responder vessel to Port Fourchon, Louisiana (http://www.nola.com/news/gulf-oil-spill/index.ssf/2012/03/oil_spill_response_group_unvei.html and http://www.msrc.org/).

International Association of Oil and Gas Producers. The OGP is spearheading several initiatives, including the OGP GIRG Oil Spill Response Team (OSR Team) and Arctic Spill Response Technology Joint Industry Programme. The GIRG-OSR Team builds on the work described in the OSPR JITF Progress Report (2011), with broader applicability to international concerns. The goal of this team is to improve the effectiveness of both surface and subsurface oil-spill response preparedness and capability. The GIRG-OSR Team issued recommendations in the *Oil Spill Response Report* (May 2011) to further strengthen future oil-spill response protocols and technologies. The team recommended that industry form the Oil Spill Response JIP to execute the report recommendations. Many of the GIRG-OSR Team recommendations are reflective of those developed by the OSPR JITF, such as improving the understanding and application of dispersants; assessing and enhancing oil-spill response and risk/hazards assessment models, global oil spill response base capacity, oil-spill trajectory and subsea plume dispersion models, and documentation of crude oil types and their properties important for spill response; developing recommended practices/standard methodologies for response exercises, *in situ* burning, oil sensing and tracking, oil-spill response communication tools, and mobilizing, managing, and integrating military and volunteer responders (OGP 465 2011).

OGP Oil Spill Response Joint Industry Project. The OGP Oil Spill Response JIP was established based on the recommendation of the OGP GIRG-OSR Team and is comprised of OGP and International Petroleum Industry Environmental Conservation Association (IPIECA) member companies. The goal of the JIP is to manage and execute all 19 recommendations of the GIRG-OSR Team *Oil Spill Response Report* (May 2011) (see http://www.ogp.org.uk/global-insight/countering-major-incidents).

OGP Arctic Spill Response Technology Joint Industry Programme. The OGP established the Arctic Spill Response Technology JIP in January 2012. The JIP brings together industry experts to evaluate and advance oil-spill preparedness and response strategies and equipment in icy waters, and to increase understanding of potential impacts of oil on Arctic marine environment (OSPR JITF 2011; see http://www.sintef.no/jip-oil-in-ice). The JIP will undertake research projects in seven key areas, including (1) behavior of dispersed oil under ice and dispersant efficacy-testing in Arctic environments; (2) Arctic spill environmental impacts and their appropriate response; (3) trajectory modeling in ice; (4) oil-spill detection and monitoring in ice and under low visibility conditions; (5) mechanical recovery; (6) *in situ* burning in Arctic environments; and (7) experimental field releases (see http://www.ogp.org.uk/; http://www.sintef.no/jip-oil-in-ice).

American Petroleum Institute Arctic Oil Spill Task Group and the Joint Industry Programme on Oil Spill Recovery in Ice. The American Petroleum Institute Arctic Oil Spill Task Group and the JIP on Oil Spill Recovery in Ice jointly published the *Spill Response in the Arctic Offshore* Report on February 2, 2012. The JIP was created to develop international research programs to raise awareness of existing Arctic oil-spill response capabilities as well as to further enhance industry knowledge and capabilities of Arctic oil-spill response. The JIP report describes the fate and behavior of oil in Arctic conditions, and discusses the response options currently available for use by industry to respond to an oil spill in the Arctic including methods of monitoring, detection, tracking, *in situ* burning, physical dispersion, chemical dispersion, mechanical containment and recovery, and shoreline protection and cleanup. The report also identifies research projects that will be conducted to improve industry capabilities and coordination in the area of Arctic oil-spill response (API and JIP 2012).

Assessing Progress.

Oil Spill Commission Action Progress Report. The OSC Action, an outgrowth of the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, issued its progress report, *Assessing Progress: Implementing the Recommendations of the National Oil Spill Commission*, on April 27, 2012. The report evaluates the progress to improve the safety of offshore drilling and spill preparedness and response made by industry, the Department of the Interior, and other Federal agencies over the past two years since the DWH event. Overall the OSC assigned a grade of “B” to the Federal Government, a “C^{+}” to industry, and a “D” to Congress for their respective enhancements. The OSC Action report evaluated progress of the OSC recommendations in five categories: (1) safety and environmental protection, (2) spill response and containment, (3) impacts and restoration, (4) ensuring adequate resources, and (5) frontier areas — the Arctic. The OSC Action reported that the Federal Government and industry have made and continue to make significant improvements in the way offshore oil operations are developed, carried out, and overseen, as well as in the ability to contain and respond to offshore oil spills. The OSC Action also recognizes the progress in implementing its recommendations for Gulf of Mexico restoration and addressing Arctic concerns; however, believes additional work is needed these areas. In addition to the current work, the OSC Action report recommends continued improvements in all these areas and especially for Congress to enact legislation to support existing and future efforts and ensure adequate resources (OSCA 2012).

U.S. Government Accountability Office Progress Report. The U.S. Government Accountability Office (USGAO) was requested by Congress to examine (1) the industry’s improved capabilities for containing subsea wells (those on the ocean floor) in the Gulf of Mexico; (2) USDOI’s oversight of subsea well containment in the Gulf of Mexico; and (3) the potential to use similar subsea well-containment capabilities in other Federal waters, such as those along the Alaska coast. The USGAO reported its findings in February 2012 in its report *Interior Has Strengthened Its Oversight of Subsea Well Containment, but Should Improve Its Documentation* (GAO 2012). The USGAO report recognized the improvements industry has made to enhance its capabilities to respond to a subsea well blowout including the establishment of the collaborative containment companies, MWCC and HWCG (GAO 2012).

The report also acknowledges the USDOI’s improvements, including new requirements for industry resources to contain a subsea well blowout, plan reviews, guidance to operators outlining information that must be provided to demonstrate that operators can respond to a well blowout, and tests of an operator’s well-containment response capabilities in two unannounced spill drills. Given these improvements, the USGAO recommends that the USDOI document a time frame for incorporating well-containment response scenarios into unannounced spill drills in order to help ensure that operators can respond effectively to a subsea well blowout. In commenting on the draft report, the USDOI concurred with the USGAO's recommendation (GAO 2012).

4.3.4 Potential Effects to Human Health

4.3.4.1 National Environmental Policy Act

The National Environmental Policy Act and its related Federal guidelines (40 CFR 1508.8; 1978) have explicit language that requires the evaluation of both direct and indirect effects of the oil and gas industry on human health as well as the effects on low-income and minority populations (CEQ 1997). NEPA regulations instruct agencies to evaluate "the degree to which the proposed action affects public health or safety" (Berner 2011). Although these mandates exist, limited health information is currently included in Federal EISs. With the addition of the discussion of health issues in the planning stages, the impacts on human health can be considered beforehand, public and decision-maker awareness can be promoted, and prevention or mitigation can be built into the operations (Bhatia 2007; Niven and McLeod 2009). This would, in essence, change the process from reactionary to precautionary, thus attempting to remove or control health issues at the source (Niven and McLeod 2009).

4.3.4.2 Potential Impacts on the Human Environment

Offshore oil and gas activities have the potential to cause both adverse and beneficial impacts on human health. The exploration and development phases of oil and gas activities are beneficial because they require a large and diverse labor force to build the platforms, exploratory rigs, and various ships, boats, and barges necessary for working offshore (Luton and Cluck 2003). Increases in the labor force can promote the economy and development of infrastructure in these communities (Berner 2011).

Effects on the human environment can be both positive and negative, specifically with respect to psychological effects. The announcement of a leasing decision can affect humans in a positive way because it can boost the economy and bring much needed infrastructure development; possible negative effects could be related to additional stress and anxiety over oil spills, effects on human health, and impacts on the natural resources that communities use for a subsistence lifestyle (NRC 2003b; Anguilera et al. 2010). Negative impacts on the human environment vary based on whether they are the result of routine events or the result of the threat/event of an accidental oil spill.

4.3.4.3 Potential Impacts of Routine Operations

As discussed in Section 4.4.14, Environmental Justice, much of the Alaska Native population resides in the coastal areas of Alaska. Any new onshore and offshore infrastructure occurring between 2012 and 2017 could be located near these populations or near areas where subsistence hunting occurs. Any adverse environmental impacts on fish and mammal subsistence resources from installation of infrastructure and routine operations of these facilities could have disproportionately higher health or environmental impacts on Alaska Native populations. Mitigation measures, cooperative agreements between Native and industry groups, and government-to-government consultations are designed to limit the effects from routine events.

The North Slope Borough, Alaska, and the Alaska regional office of BOEM, through a Memorandum of Understanding, have evaluated the effects of the oil and gas industry on humans in the region. Appendix J of the *Beaufort and Chukchi Sea Planning Areas Oil and Gas Lease Sales 209, 212, 217, and 221 Draft Environmental Impact Statement* (MMS 2008b) presents a full evaluation of these effects and is hereby incorporated by reference in this PEIS (http://www.alaska.boemre.gov/ref/EIS%20EA/ArcticMultiSale_209/_DEIS.htm).

Public concerns regarding pollution of locally harvested fish and game, loss of traditional food sources and hunting grounds, and rapid social changes are examples of negative impacts on humans in Alaska. The harvesting of wildlife resources in the North Slope of Alaska contributes widely to the cultural, nutritional, and economic way of life of the residents living there (NRC 2003b). These impacts could affect both physical and mental health of Native tribal communities. Changes in the traditional way of life can lead to deteriorating physical well-being and mental health as well as increased domestic violence and substance abuse. North Slope tribal communities are concerned about the impacts of noise associated with routine operations on bowhead whale migration routes, as they depend on these whales for subsistence (NRC 2003b). If the whales migrate farther offshore, there are increased safety risks for the whalers themselves who must travel in more dangerous seas to hunt. Increased stress and anxiety from oil and gas development may contribute to the mental health issues of Alaskans (NRC 2003b).

The increased development has increased the smog and haze near some villages, which could be the cause for increased instances of asthma. Air quality is a major concern for the residents who live there (NRC 2003b). The impacts of the proposed action on air quality and related health concerns are discussed in Section 4.4.4. Increased rates of diabetes are likely the result of residents consuming higher concentrations of nonsubsistence foods such as shortening, lard, butter, and bacon, and consuming less fish and marine mammal products (NRC 2003b).

However, the increased revenue from the oil and gas industry can promote the economy and improve infrastructure of these more remote locations, resulting in beneficial impacts (Berner 2011). Alaska Natives have recognized that they have benefited by receiving monies to spend on public works and facilities, as well as better health care and counseling centers (NRC 2003b).

4.3.4.4 Potential Impacts of Accidental Spills

A number of studies conducted throughout the world have examined the effects of oil spills on the mental and physical health of exposed individuals and populations. These studies have identified a relatively common set of psychological and physiological effects incurred by spill response workers, fishermen, local communities, and others (Park and Holliday 1999; Janjua et al. 2006; Zock et al. 2007; Meo et al. 2008; Rodriguez-Trigo et al. 2010; also see reviews by Aguilera et al. [2010] and Goldstein et al. [2011]). Psychological effects may include increased rates of depression, anxiety, and post-traumatic stress. Physiological effects may include a variety of respiratory symptoms; irritation of the eyes and mucous membranes; and increased incidence of headaches, nausea, and dizziness. Similar effects may be expected in the event of an oil spill in the GOM and Alaska planning areas.

4.3.4.4.1 Gulf of Mexico. The impacts on human health as a result of oil spills can be broken down into several categories. Goldstein et al. (2011) list the categories as "those related to worker safety; toxicological effects in workers, visitors, and community members; mental health effects from social and economic disruption; and ecosystem effects that have consequences for human health." Initial concerns focus on the short-term toxicological effects to humans such as nausea, dizziness, eye irritation, headaches, and respiratory and dermal irritation, but more research is necessary to understand long-term effects (Janjua et al. 2006; Goldstein et al. 2011). Other immediate effects of particular concern are heat stroke and exhaustion and the inappropriate use of personal protective equipment by cleanup crews. Impacts on air quality include the emission of pollutants from the oil and the fire emissions that are hazardous and possibly fatal to humans at very high concentrations, as well as the dispersant mist resulting from the application of the chemical dispersants on the oil. The impacts of the proposed action on air quality are fully discussed in Section 4.4.4.

After an accidental release of oil into the environment, the more volatile, water-soluble, and degradable compounds will be weathered and degraded, leaving behind the heavier (higher molecular weight), less degradable, less toxic components. These heavier components will ultimately undergo weathering and degradation, but at much slower rates. These heavier components, when combined with sand on beaches, form tar balls, which can be encountered by beachgoers for some time. Humans walking along the beach may be exposed to these components via skin (dermal) contact (OSAT-2 2011). Beachgoers may also inhale petroleum hydrocarbons present as vapors or attached to airborne particles (OSAT-2 2011). Following the DWH event and subsequent cleanup, small surface residual balls (SSRBs) of tar remained on beaches following cleanup. These SSRBs are the oil residues left behind following cleanup by mechanical and/or manual means, and consist primarily of sand (up to 96%) mixed with and coating small amounts of residual oil (less than 13% of an SSRB) (OSAT-2 2011). A risk assessment examined both short-term (90 days of exposure in 1 year) and long-term (30-year exposure period) exposures to oil residues via skin contact, ingestion, and inhalation (OSAT-2 2011). Calculated potential cancer and non-cancer (physiological) health effects were below EPA acceptable health-based risk and hazard levels. It should be noted that oil seeps are extensive throughout the continental slope and naturally contribute hydrocarbons to the sediments and water column (Sassen et al. 1993; OSAT-2 2011).

In the case of the DWH event, elevated rates of post-traumatic stress disorder, depression, alcohol abuse, and conflicts between domestic partners were observed (Osofsky et al. 2011; Goldstein et al. 2011). A mental health assessment conducted in Louisiana following the DWH event identified increased symptoms of anxiety, depression, and post-traumatic stress (Osofsky et al. 2011). A large part of the GOM region's economy is based on the oil and gas industry and the harvesting of seafood. Restrictions placed on these industries due to an oil spill can increase the anxiety levels of humans and may contribute mental health issues (see studies cited in Goldstein et al. 2011).

Oil spills have the potential to impact certain groups of people more than others based on their current state of health. For example, GOM coast populations include communities that are still recovering from Hurricane Katrina, and among the 50 States, Louisiana ranks 44th to 49th (depending on the metric used, with 1st being the best) in the overall health of residents, rates of infant death, deaths from cancer, premature deaths, deaths from cardiovascular causes, high-school graduations, children living in poverty, health insurance coverage, and violent crime (Goldstein et al. 2011). As discussed in Section 4.4.14, there are areas in the GOM with environmental justice concerns. It is possible these low-income and minority populations could be affected to a greater extent than the general population because of their dietary reliance on wild coastal resources, their reliance on these resources for other subsistence purposes such as sharing and bartering, their limited flexibility in substituting wild resources with those purchased, and their likelihood of participating in cleanup efforts and other mitigating activities.

4.3.4.4.2 Arctic and Cook Inlet. The Native tribes of the North Slope have serious concerns about what would happen if there was an accidental oil spill in the Arctic region. An oil spill could have physical, psychological, social, economic, spiritual, and cultural impacts on the Native Alaskans. Major areas of concern are with impacts on subsistence resources (especially the bowhead whale), air quality, and oil spill cleanup. These concerns are related to how and if it would be cleaned up and how the International Whaling Commission would react if the spill greatly impacted the bowhead whale population (NRC 2003b). The impacts of the proposed action on air quality are discussed in Section 4.4.4. The North Slope Borough, Alaska, and the Alaska regional office of BOEM have, through a Memorandum of Understanding, evaluated the effects of the oil and gas industry on humans in the region. Appendix J of the *Beaufort and Chukchi Sea Planning Areas Oil and Gas Lease Sales 209, 212, 217, and 221 Draft Environmental Impact Statement* (MMS 2008b) presents a full evaluation of these effects.

Human populations in Arctic regions, especially indigenous populations, have been found to exhibit comparatively poorer health status than non-Arctic populations (AMAP 2009). While infant death rates are lower and population longevity has improved, the rates of several chronic diseases (such as cardiovascular disease and diabetes) have been increasing. These changes in health status are not uniform across Arctic populations, and are influenced by a number of determinants of health related to socioeconomic, dietary, and cultural influences. One factor relates to exposure of indigenous populations to contaminants, primarily through traditional food consumption (subsistence) (AMAP 2009). Persistent contaminants (organic chemicals and metals) moving through food chains and accumulating in food items have the potential to contribute to health impacts.

While oil spills in Alaska can affect human health the same ways as discussed for the GOM, the major concerns in Alaska involving the impacts on human health due to oil spills relate to the subsistence lifestyle of Native Alaskans. Humans can be affected through contact with the contaminants, such as through inhalation, skin contact, or intake of contaminated foods; through reduced availability of subsistence resources; through interference with subsistence harvest patterns; and stress due to fears of long-term implications of the spill (MMS 2007e as referenced in MMS 2008b; also see discussions presented in Section 4.4.12 of this Final PEIS).

As discussed in Section 4.4.14, there are areas in the Alaska region that are of environmental justice concern. Much of the Alaska Native population resides in the coastal areas of Alaska, and subsistence activities of Native communities could be affected by accidental oil spills, with the potential health effects of oil spill contamination of subsistence foods being the main concern. Mitigation measures, cooperative agreements between Native and industry groups, and government-to-government consultations are designed to limit the effects from oil spills.

4.3.4.5 Conclusion

Offshore oil and gas activities have the potential to affect the health status of human populations. Of particular concerns are adverse impacts that may occur as a consequence of accidental oil spills. Potential impacts on human health may affect both physiological and mental health of exposed individuals and populations. Mental health impacts may include an increased incidence of depression, anxiety, and post-traumatic stress. Physiological impacts may include a variety of respiratory symptoms, irritation of the eyes and mucous membranes, and an increased incidence of headaches, nausea, and dizziness. In Alaska, oil spills may affect not only the abundance of subsistence resources, but may lead to contaminant concentration in subsistence food items, thus contributing to reduced health status of affected populations.

Health effects are discussed throughout this PEIS, as appropriate. The State of Alaska is currently developing an approach to integrate health analysis into the EIS by way of a Health Impact Assessment (HIA) (Berner 2011). An HIA is a scientific method used to assess the potential effects of a policy on the health of a population and the distribution of those effects, and it brings together stakeholders to find a solution (Quigley et al. 2006; Berner 2011). The overall purpose of HIAs is "to inform and influence decision making on proposals and plans, so health protection and promotion are effectively integrated into them" (Quigley et al. 2006). This programmatic-level EIS acknowledges that there will be impacts on human health, both positive and negative, from the proposed action, but it is a broad-level document discussing the impacts over entire planning areas. It would be more appropriate to discuss impacts to site-specific populations at the lease sale level when a better understanding of who will be affected is clear.

4.3.5 Invasive Species

EO 13112, *Invasive Species*, defines invasive species as species that are non-native (or alien) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Invasive species can be plants, animals, or pathogens. Nationwide, invasive species are associated with environmental damages and losses totaling over $138 billion annually (Pimentel et al. 2000). More than 50,000 invasive species have been documented to date in the United States, and roughly 42% of threatened and endangered species in this country are considered at risk primarily because of invasive species (Pimentel et al. 2005). Effects of invasive species can be devastating on both habitat and native species and may (1) include a decrease in biological diversity of native ecosystems, (2) decrease the quality of important habitats for native fish and invertebrate species, (3) reduce habitats needed by threatened and endangered species, (4) increase direct and indirect competition with aquatic plants and animals, and (5) pose human health risks (http://www.invasivespeciesinfo.gov/whatis.shtml).

Oil and gas activities may play a part in the introduction of invasive species or may provide substrate and habitat encouraging the establishment of invasive species. Drillships and semisubmersibles are used and relocated throughout the world's oceans. Over time, fouling, encrusting, and boring organisms will attach to these devices. Unintentional introductions may occur when these drilling rigs are relocated to a new region such as the GOM. These same drillships and semisubmersibles may transport and release ballast water containing invasive plankton, larval invertebrates, or even fish, which may then become established due to the availability of acceptable habitat, plentiful food supply, and lack of predators.

Since 1998, there have been at least 16 documented cases of rigs being brought into the GOM from other parts of the world. Some rigs operating in the GOM were constructed or recently modified in Singapore, Taiwan, and Scotland. Newly built rigs undergoing their last year of construction stand in waters of surrounding shipyards. A year is sufficient time for fouling and encrusting organisms to colonize rig surfaces. One large semisubmersible was kept in Mobile Bay, Alabama, for 1 yr. Prior to being placed in Mobile Bay, it had spent 6 months drilling off the coast of Trinidad.

Oil and gas drilling rigs, platforms, and pipelines provide substrate and habitat for sessile organisms. Invasive mussels, barnacles, and corals are known to use rigs and platforms as attachment sites. Many marine organisms require hard surfaces to use as attachment sites for all or part of their natural history. Jellyfish have a polyp stage that requires hard substrate. Polyps settling on rigs in one location and then transported to another region can asexually reproduce. One polyp can produce up to 300 new jellyfish. Currently, there are thousands of oil and gas platforms in the GOM, each of which can provide a hectare or more of hard substrate that can support algae, mollusks, and other sessile invertebrates (Atchison et al. 2008). No-activity-zone natural reefs provide 104.5 km^2 (40.3 mi^2) of hard substrate, which could be used for settlement sites.

Above-water platform structures may also encourage the colonization of new habitat by invasive species. Many migratory bird species use the platform structures as stopover spots while crossing the GOM (Russell 2005). Ongoing research funded by BOEM is studying the interactions between migrating birds and oil and gas structures off the Louisiana coast.

A number of invasive species have been recorded from the OCS planning areas considered for oil and gas leasing in the proposed action. In the GOM, invasive species reported since the mid-1900s include the brown mussel (*Perna perna*), the Australian spotted jellyfish (*Phyllorhiza punctata*), the pink jellyfish (*Drymonema dalmatina*), two species of hydroids (*Cordylophora caspia* and *Garveia franciscana*), a sea anemone (*Diadumene lineata*), a polychaete worm (*Hydroides elegans* and *Ficopomatus enigmaticus*), the Atlantic copepod (*Centropages typicus*), four barnacle species (*Balanus amphitrite*, *B. reticulatus*, *B. trigonus*, and *Tetraclita stalactifera stalactifera*), and four species of isopod (*Sphaeroma walkeri*, *S. terebrans*, *Limnoria* spp., and *Ligia exotica*). Some of these species are native to other parts of the world (e.g., the brown mussel is native to Africa and South America), while other species are native to North American marine habitats but not to the GOM (e.g., the Atlantic copepod *Centropages typicus*). Suggested avenues of initial introduction of these various species include discharge of ballast water, dumping of ballast rock, or attachment to vessel surfaces.

Although invasive species are a worldwide problem, Alaska has far fewer invasive species compared to the rest of the nation (Fay 2002). Relatively few aquatic invasive species have been introduced and become established in Alaska compared to other States. This is, in part, due to Alaska's plant and animal transportation laws, geographic isolation, northern climate, small human population, and relatively few concentrated disturbed habitat areas (Fay 2002). However, a non-native amphipod and a colonial tunicate have been found in Alaskan waters. Potential introduction pathways include the movement of large ships and ballast water from the United States west coast and Asia, and the relocation of previously used docks and pier timbers (ADFG 2012). While invasive species impacts, to date, are low, potential threats must be monitored because a significant portion of Alaska's economy, including sport and commercial fishing, depends upon the pristine and natural quality of its aquatic ecosystems. Climate change may also affect the ability of marine invasives to become established (Invasive Species Advisory Committee 2010). For example, changes in water temperature or precipitation regimes (and associated runoff into coastal waters) may make areas more favorable for an invasive species to become established or spread.

Exploratory drilling of Federal leases offshore of Alaska requires bringing rigs and/or vessels to Alaska. Such rigs or vessels may come from the GOM, the West Coast, or foreign waters and be contaminated with species alien to Alaska. Such species may be attached to the hull structure (e.g., sponges and barnacles), hitch a ride on the vessel (e.g., rats, insects, crustaceans, and mollusks), or be transported via ballast water (e.g., crustaceans and mollusks). Once brought to Alaska, alien species contaminating a rig or vessel may subsequently disperse into Alaska's ecosystems.

Although introduction of invasive species to Alaskan waters could occur through the import and placement of offshore oil/gas structures, historically the threat has not been considered significant because of the very low level of offshore drilling in Alaskan waters. The Alaska Aquatic Nuisance Species Management Plan (Fay 2002) considers activities other than oil/gas structures major pathways for the introduction of aquatic alien species, including aquaculture; aquarium trade; biological control; boats, ships, and aircraft; channels, canals, and locks; live bait; nursery industry; scientific research institutions, schools, and public aquariums; recreational fisheries enhancement; restaurants; and seafood retail and processing. However, the potential for introduction of invasive species may increase with increased drilling, together with potential climate-related changes in environmental baseline conditions (such as water quality and currents).

Vessels, including those used by the oil/gas industry, do pose more potential for introducing invasive species than oil/gas structures. For example, Hines and Ruiz (2000) reported finding 13 species of crustaceans and 1 species of fish arriving at Port Valdez in the ballast water of oil tankers voyaging from San Francisco Bay or Long Beach, California. The issue of invasive species and ballast water is managed by the USCG under the National Invasive Species Act of 1996. The USCG has promulgated regulations (33 CFR Part 151) to make compliance with ballast water guidelines mandatory. Therefore, oil- or gas-related vessels are required to abide by these requirements in order to reduce the potential for introduction of invasive species.

4.4 ENVIRONMENTAL IMPACTS OF ALTERNATIVE 1 – PROPOSED ACTION

4.4.1 Exploration and Development Scenario

4.4.1.1 Gulf of Mexico

Oil and gas leasing and development have been occurring in the GOM for over 50 years. There are a total of 29,097 lease blocks (each approximately 23 km^2 [3 mi × 3 mi]) and a total of 3,280 active platforms in the Western, Central, and Eastern GOM OCS Planning Areas. Predictable patterns of activity have become established for the planning areas, and these were used to estimate future activity within the GOM OCS Region Planning Areas that could occur under this scenario (Table 4.4.1-1). This scenario of future development and activity was generated using best professional judgment for the purpose of analysis only and does not constitute official forecasts or policy recommendations.

In general, the major activity types under a given lease can include exploration, development, and production (see Table 4.4.1-1). The onset and timing of different activity types that may result from a lease sale in the Program will vary within and between Planning Areas over the 40- to 50-year life of the Program. For example, relatively more exploration drilling is expected to occur in the first 5–10 years of the Program, whereas relatively more development drilling and production will occur later in the Program. The types of activities included in the scenario in Table 4.4.1-1 may occur anywhere within the GOM planning areas included in the proposed action (Figure 4.4.1-1). Figure 4.4.1-2 shows the anticipated onset and timing of exploration and development drilling, as well as oil and gas production associated with the 12 lease sales potentially held under the Program. Although the actual levels of OCS activity will fluctuate with market supply and demand for oil and gas, similar temporal trends are expected. The peak in exploration drilling is expected to occur between 5 and 10 years after the Program is initially approved. Shallow-water exploration drilling generally occurs before deepwater drilling. Development drilling and platform construction are expected to lag behind

TABLE 4.4.1-1 Proposed Action (Alternative 1) – Exploration and Development Scenario for the GOM

Scenario Element	Gulf of Mexico
Number of sales	12
Years of activity	40–50
Potentially available oil (Bbbl)[a]	2.7–5.4
Potentially available natural gas (tcf)	12–24
Platforms	200–450
FPSOs[b]	0–2
No. of exploration and delineation wells	1,000–2,100
No. of development and production wells	1,300–2,600
Miles of new pipeline	2,400–7,500
Vessel trips/week	300–600
Helicopter trips/week	2,000–5,500
New pipeline landfalls	0–<12
New pipe yards	4–6
New natural gas processing facilities	0–12
Platforms removed with explosives	150–275
Drill Muds/Well (tons)	
Exploration and delineation wells	1,000
Development and production wells	1,000
Drill Cuttings/Well (tons)	
Exploration and delineation wells	1,200
Development and production wells	1,200
Produced Water/Well/yr (tbbl)[c]	
Oil well	130 (highly variable)
Natural gas well	35 (highly variable)
Bottom Area Disturbed (ha)[d]	
Platforms	150–2,500
Pipeline	2,000–11,500

[a] Bbbl = billion barrels.

[b] Floating production, storage, and offloading systems.

[c] Based on 1.04 bbl produced water/bbl of oil, and 86 bbl produced water/1 million cf gas (Clark and Veil 2009); tbbl = thousand barrels.

[d] Assumes 0.67 ha (1.6 ac) per platform and 0.8–1.6 ha (2.0–4.0 ac) per mile of pipeline.

FIGURE 4.4.1-1 Gulf of Mexico Planning Areas Where Leasing for Oil and Gas Development May Occur under the 2012-2017 OCS Leasing Program

exploration drilling by several years. A secondary peak in development drilling associated with more costly deepwater and ultra-deepwater development operations is expected to occur approximately 15–20 years into the Program. Peak production is expected to occur after 2030. It is also notable that these types of temporal trends have been occurring related to all approved OCS oil and gas programs since 1980. In the analysis of potential environmental impacts associated with the leasing program, additional assumptions are used to identify potential oil and gas development activity levels to more specific marine and coastal areas under consideration in a particular analysis. The GOM OCS may be divided into continental shelf and slope regions, and this distinction is important to both the occurrence of oil and gas within the GOM hydrocarbon basin and to ecosystem characteristics and processes within the GOM Large Marine Ecosystem. Assumed levels of oil and gas infrastructure and production that would occur on the continental slope and shelf are shown in Table 4.4.1-2. This information suggests that while the amounts of well drilling and gas production will be approximately the same on the shelf as on slope (51% versus 49%, respectively), most new platforms will be installed in shallow water (in depths <200 m [<660 ft]) on the continental shelf. In contrast, most oil production (93%) will occur in deeper water (at depths >200 m [>660 ft]) on the continental slope. Consistent with this scenario, deepwater wells are expected to have a comparatively greater worst-case discharge.

This assumed difference by depth of infrastructure development and oil and gas production suggests similar differences in the resources that could be affected by normal exploration and development (E&D) activities on the OCS. For example, 87% of all new

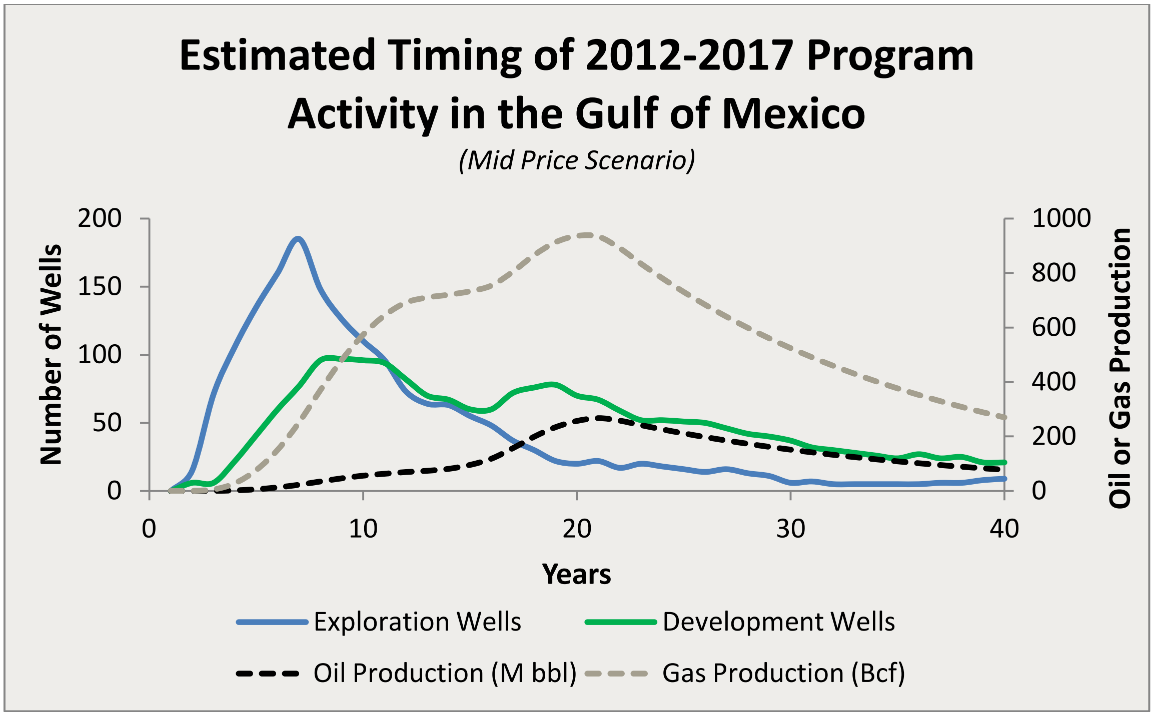

FIGURE 4.4.1-2 Estimated Timing of Exploration, Development, and Production from Gulf of Mexico Lease Sales during the 2012-2017 OCS Leasing Program

TABLE 4.4.1-2 Depth Distribution of New Infrastructure and Expected Natural Gas and Oil Production on the GOM OCS

			% of New Wells		% of New Platforms		% of New Gas Production		% of New Oil Production	
OCS Depth Zone (m)	OCS Area	OCS Sub-area	OCS Area	OCS Sub-area	OCS Area	OCS Sub-area	OCS Area	OCS Sub-area	OCS Area	OCS Sub-area
0–60	Shelf	Inner	52	37	95	87	51	37	7	5
60–200		Outer		15		8		14		2
200–800	Slope	Upper	48	12	5	2	49	7	93	12
800–1,600		Mid		20		2		22		44
1,600–2,400				-[a]		-		-		-
>2,400		Lower		16		1		20		37

[a] No wells, platforms, or production are expected for this depth range.

platform development is assumed to occur in waters of the inner continental shelf at depths of 60 m (about 200 ft) or less (Table 4.4.1-2). Thus, resources occurring in these shallower areas may be expected to be more likely to encounter, and be affected by, normal well development and operation than would resources restricted to deeper areas of the OCS.

4.4.1.2 Alaska – Cook Inlet

The Cook Inlet has had oil and gas operations in State waters since the late 1950s and currently possesses a well-established oil and gas infrastructure. There has been no oil and gas activity in the Cook Inlet Planning Area. A single sale in Cook Inlet is included in the proposed action as a special interest sale, meaning that the planning process for the sale will not start until industry expresses an interest in holding the sale. The most recent OCS lease sale in Cook Inlet was in 2004 when no leases were purchased. The most recent sale in which OCS leases were purchased occurred in 1997 when two leases were purchased. Appraisal activity for an offshore prospect (Cosmopolitan) leased in this sale was conducted from an onshore location.

Table 4.4.1-3 summarizes the assumed levels of exploration and development that could occur under the proposed action (Alternative 1). Oil and gas development that could occur in the Cook Inlet OCS Planning Area under the proposed action is expected to use both new and existing infrastructure. Exploration drilling would employ fixed rigs (such as jack-up and mobile gravity-base rigs) in water depths up to 150 ft (46 m) and floating rigs (semisubmersible rigs, drill ships, or barges) in deeper water areas. Production wells will most likely use fixed platforms with subsea well tie-backs to supplement on-platform wells. New subsea pipelines would connect offshore installations to existing onshore facilities. Oil and gas would be carried by new onshore pipelines over relatively short distances to existing oil refineries in Nikishi and natural gas transmission facilities in the Kenai area, respectively. Relative timing of exploration and development drilling, platform construction, and oil and gas production is generally comparable to that in the GOM.

4.4.1.3 Alaska – Arctic

In contrast to oil and gas development in the GOM OCS, and with the exception of a single production site (Northstar) that has an actual surface location in Alaskan State waters, there has been no development activity from a structure in Arctic OCS areas. Since 1979, ten lease sales have been held in the Beaufort Sea Planning Area and three in the Chukchi Sea Planning Area (http://www.boem.gov/uploadedFiles/BOEM/About_BOEM/BOEM_Regions/Alaska_Region/Leasing_and_Plans/Leasing/Alaska%20Region%20Lease%20Sales%20To%20Date.pdf). The 2008 Lease Sale 193 for the Chukchi Sea Planning Area (MMS 2007b) is of note because of the high industry interest expressed through the acquisition of 487 leases and the more than $2.6 billion received by the government in high bids. No activity has resulted from this lease sale because of litigation that remains unresolved at the time this PEIS is being written. The scenario put forth for the Arctic in the 2012–2017 Program in Table 4.4.1-4, however, assumes that the exploration and development activities anticipated as a result of Sale 193 will have occurred prior to the beginning of the development and production activities listed in the

TABLE 4.4.1-3 Proposed Action (Alternative 1) – Exploration and Development Scenario for Cook Inlet

Scenario Element	Cook Inlet
Number of sales	1
Years of activity	40
Oil production (Bbbl)[a]	0.1–0.2
Natural gas production (tcf)[a]	0–0.7
Platforms	1–3
No. of exploration and delineation wells	4–12
No. of development and production wells	42–114
Miles of new offshore pipeline	25–150
Miles of new onshore pipeline[b]	50–105
Vessel trips/week	1–3
Helicopter trips/week	1–3
New pipeline landfalls	0–1
New shore bases	0
New processing facilities	0
New waste disposal facilities	0
Platforms removed with explosives	0
Drill Fluids/Well (bbl)	
Exploration and delineation wells	500 – discharged at well site
Development and production wells	All treated and disposed of in the well
Drill Cuttings (dry rock)/Well (tons)	
Exploration and delineation wells	600 – discharged at well site
Development and production wells	All treated and disposed in the well
Bottom Area Disturbed (ha)	
Platforms (1.5 ha/platform)	1.5–4.5
Pipeline (1.4 ha/mile)	35–210
Surface Area Disturbed (ha)	
Pipeline (7.3 ha/mile)	365–770

[a] Bbbl = billion barrels; tcf = trillion cubic feet.

[b] New onshore pipelines would deliver oil to existing refineries in Nikiski and natural gas to transmission facilities in the Kenai area.

TABLE 4.4.1-4 Proposed Action (Alternative 1) – Exploration and Development Scenario for Arctic Alaska

Scenario Element	Beaufort Sea	Chukchi Sea
Number of sales	1	1
Years of activity	50	50
Oil production (Bbbl)[a]	0.2–0.4	0.5–2.1
Natural gas production (tcf)[b]	0–2.2	0–8.0
Platforms	1–4	1–5
No. of exploration wells	6–16	6–20
No. of production wells	40–120	60–280
No. of subsea production wells	10	18–82
Miles of new offshore pipeline	30–155	25–250
Miles of new onshore pipeline	10–80	0
Vessel trips/week	1–12	1–15
Helicopter trips/week	1–12	1–15
New pipeline landfalls	0	0
New shore bases	0	0
Drill Fluids/Well (bbl)		
Exploration and delineation wells	500 – discharged at well site	500 – discharged at well site
Development and production wells	All treated and disposed of in the well.	All treated and disposed of in the well.
Drill Cuttings (dry rock)/Well (tons)		
Exploration and delineation wells	600 – discharged at well site	600 – discharged at well site
Development and production wells	All treated and disposed in the well.	All treated and disposed in the well.
Bottom Area Disturbed		
Platforms (1.5 ha/platform)	1.5–6.0	1.5–7.5
Pipeline (1.4 ha/mile)	42–217	35–350
Surface Soil Disturbed		
Pipeline[c]	73–584	0

[a] Bbbl = billion barrels.

[b] Assumes that a natural gas pipeline from the North Slope will be operating by 2020 and have capacity for new supplies in 2030–2035; tcf = trillion cubic feet.

[c] Assumes 46 m (150 ft) wide construction ROW; 7.3 ha (18 ac)/mi.

table. In particular, the scenario was developed using the assumptions that the discovery and development of a 1-Bbbl oil field has already occurred, a pipeline has been installed from the OCS production area in the Chukchi Sea to Point Belcher near Wainwright, Alaska, and support base facilities have been constructed there as well. As a result of these assumptions, the scenario in Table 4.4.1-4 includes no new pipeline landfalls or support bases, since these would have already been constructed in support of OCS operations resulting from Lease Sale 193 (BOEMRE 2011j). In addition, oil discoveries less than 1 Bbbl were assumed not to be economically feasible in the Program, because an initial larger field needed to justify the construction of a pipeline to shore and coastal service facilities. It is assumed that development as a result of lease sales under the Proposed Action Alternative would utilize existing infrastructure, and that fields smaller than 1.0 Bbbl could be produced.

The PEIS assumes that the most probable locations for oil and gas activities in the Arctic OCS will be in the areas that have been already leased in recent sales (Figure 4.4.1-3). While activities within the entire Chukchi and Beaufort Sea Planning Areas are considered in the analyses that follow, it is assumed that these areas in Figure 4.4.1-3 reflect industry's current assessment of the best hydrocarbon prospects through its large investments in acquiring the leases. It is reasonable to assume that industry will continue to explore and develop these areas before moving into other areas currently considered less promising. Based on historical information and recent industry trends, BOEM anticipates that new exploration drilling as a result of the proposed lease sales under this Program will not begin in the Arctic until 2018, and that most drilling will occur within 7 years. Most development drilling and platform construction associated with the single Chukchi or Beaufort lease sale is not expected to occur until after 2025.

In the Beaufort Sea Planning Area, exploration is assumed to use artificial gravel islands or extended-reach drilling in shallow waters (<6 m [20 ft]), mobile platforms in mid-depths (6–18 m [20–60 ft]), and drill ships in deeper areas of the shelf. Because of severe winter ice pack conditions, it is assumed that development would be limited to the shelf and to depths less than 91 m (300 ft) and platform installation would occur only in the summer (open water) season. Production operations will use gravity-base platforms or gravel islands in shallow water (<12 m [40 ft]) and larger gravity-base platforms in deeper waters (up to 91 m [300 ft]). Oil produced at the platforms will be delivered via trenched subsea pipelines to existing onshore facilities.

In the Chukchi Sea Planning Area, with its greater water depths (>30 m [100 ft]) and more remote location, exploration drilling is expected to employ drill ships. As in the Beaufort Sea, concerns regarding severe winter ice conditions will also limit exploration and development to the shelf and depths <91 m (300 ft) and only in the summer (open water) season. Production operations will use large gravity-base structures with trenched subsea pipelines to transport the oil to landfalls.

In both areas, elevated onshore pipelines will convey the oil from the landfall facilities to production facilities at Prudhoe Bay for ultimate entry to the Trans-Alaska Pipeline System (TAPS). Natural gas development and production are not expected to begin until around 2035 in the Arctic. Gas pipelines would need to be installed before gas production could begin. Once

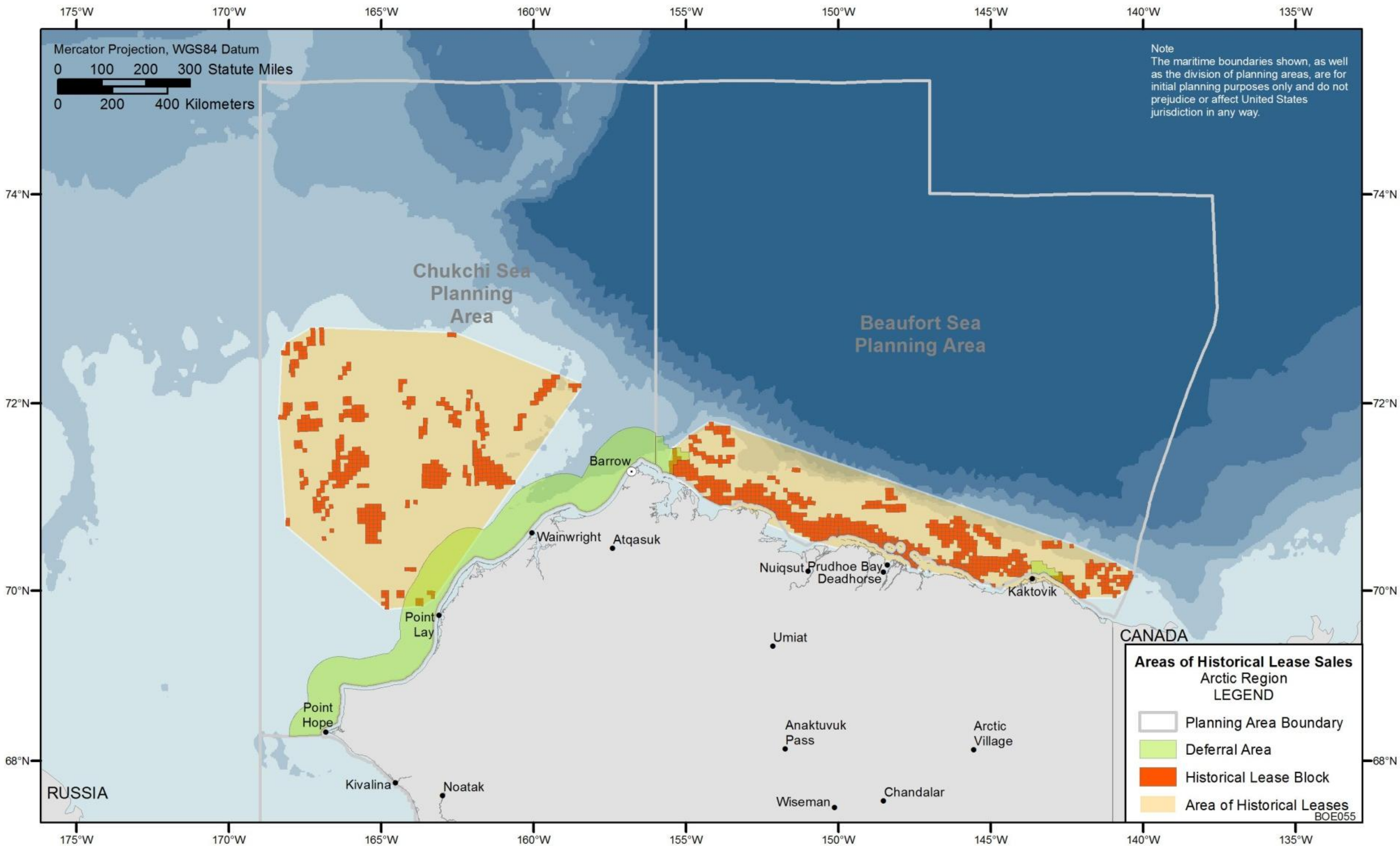

FIGURE 4.4.1-3 Areas of Historical Lease Sales in the Beaufort and Chukchi Seas OCS Planning Areas

produced, gas would be transported by new subsea and overland pipelines that would be constructed through the same corridor as the existing offshore oil pipeline. This offshore pipeline would be trenched into the seafloor as a protective measure against ice damage. A second new pipeline would be required to transport gas from shore to a main transportation hub near Prudhoe Bay, on the assumption that a natural gas pipeline connecting the North Slope with the lower 48 States will be in place and operational by 2020. Natural gas from the Chukchi and Beaufort Seas may be transported by new and existing aboveground pipelines for entry into such a pipeline (assuming capacity is available in the 2030–2035 time frame).

4.4.2 Accidental Spill Scenario

Oil spills are unplanned accidental events. Depending on the phase of O&G development and the location, magnitude, and duration of a spill, natural resources that may be affected include marine mammals, marine and coastal birds, sea turtles, fish, benthic and pelagic invertebrates, water quality, marine and coastal habitats, and areas of special concern (such as marine parks and protected areas). Spills may also affect a variety of socioeconomic conditions such as local employment, commercial and recreational fisheries, tourism, and subsistence. For this PEIS, assumptions have been made about the occurrence and location of small and large oil spills associated with the Program.

The source and number of assumed small and large accidental spills are based on the volume of anticipated oil production in each area, the assumed mode of transportation (pipeline and/or tanker), and the spill rates for large spills. It is also assumed that these spills would occur with uniform frequency over the life of the proposed action. Platform spills are assumed to occur in areas proposed for lease consideration. Pipeline spills are assumed to occur between the proposed lease areas and existing infrastructure. Tanker and barge spills are assumed to occur along the tanker and barge routes from the lease areas to shore facilities.

As discussed in Section 4.3.3, loss of well control, a type of platform spill, has the potential to result in the largest volume across oil spills. Between 1971 and 2010, more than 41,500 exploratory and development/production operation wells were drilled on the OCS, and almost 16 billion bbl (Bbbl) of oil was produced. During the period of 1971 to 2010, there were 253 well control incidents during exploratory and development/production operations on the OCS. These incidents were associated with exploratory and development drilling, completion, workover, and production operations. Of these well control incidents, 52 resulted in crude, condensate, diesel, or drilling mud releases ranging from <1 bbl to 450 bbl. The loss of well control, explosion, and fire on the DWH mobile offshore drilling unit (MODU) resulted in the release of an estimated 4.9 million bbl of crude oil until the well was capped on July 15, 2010.

Spills from tankers carrying oil produced in the Beaufort and Chukchi Sea Planning Areas are assumed to occur outside of those planning areas. It is assumed that oil produced in the Beaufort and Chukchi Sea Planning Areas would be delivered by offshore and onshore pipe to TAPS, with subsequent delivery to the Valdez terminal facilities followed by tanker transport to West Coast ports. Some tankering could also occur in the GOM to transport oil from FPSO facilities expected to operate in areas of the GOM distant from existing pipelines.

4.4.2.1 Expected Accidental Events – Spill Size Assumptions

Spill size will vary greatly depending on the amount of oil released over a period of time as a result of a single accidental event. For this PEIS, hypothetical spill sizes were developed using OCS and U.S. historical spill databases. Table 4.4.2-1 presents the spill assumptions for the GOM, the Beaufort and Chukchi Seas, and Cook Inlet. The sizes of the assumed spills for each spill type (platform, pipeline, tanker, or barge) are approximately equal to the median spill sizes of historical spills for each spill type. Two categories of spill sizes are considered: small and large.

4.4.2.1.1 Small Spills. Analysis of historical data from the GOM, Pacific, and Alaska OCS regions shows that small spills occur most frequently (Anderson et al. 2012; MMS 2007c, 2008a). Examination of these data also shows that most offshore oil spills have been <1 bbl in size, and these small spills accounted for approximately 95% of all OCS spills but less than 5% of the total volume of oil spills on the OCS (Anderson et al. 2012; Anderson and LaBelle 2000). Most of the total volume of OCS oil spilled (95%) has been from spills ≥10 bbl. On the basis of the historical OCS spill data, for this PEIS small spills are considered to be <1,000 bbl in volume (Table 4.4.2-1). Small spills are further divided into two groups: spills <50 bbl and spills ≥50 bbl but <1,000 bbl (Table 4.4.2-1).

4.4.2.1.2 Large Spills. The spill-size assumptions used in this PEIS for expected large spills are based on the reported spills from exploration and production in the GOM and Pacific OCS and what is anticipated as likely to occur (Anderson et al. 2012; MMS 2007c, 2008a; Anderson and LaBelle 2000); there have been no large oil spills in the Alaska OCS region. For this PEIS, a large spill is considered to be ≥1,000 bbl. Between 1964 and 1999, there were 11 platform spills and 16 pipeline spills ≥1,000 bbl on the OCS (Anderson and LaBelle 2000). Between 2000 and 2010, there were 2 platform spills and 4 pipeline spills ≥1,000 bbl (Anderson et al. 2012). The median sizes of these large spills from pipelines and platforms for 1964–2010 are 4,550 and 7,000 bbl, respectively (Anderson et al. 2012). The median sizes of these large spills from pipelines and platforms for 1996–2010 are 1,700 and 5,100 bbl, respectively (Anderson et al. 2012). From 1971 to 2010, the DWH event in 2010 was the only loss of well control incident on the OCS that resulted in a spill volume ≥1,000 bbl. The scenario for a low-probability CDE is discussed separately below.

4.4.2.1.3 Expected Accidental Events – Spill Number Assumptions. The number of spills assumed to occur during the years of activity of the proposed action is estimated by multiplying the oil spill rate for each of the spill size groups by the projected oil production as a result of the proposed action. Details on the methodology for estimating spill rates (and thus mean spill number) can be found in Anderson et al. (2012). As shown in Table 4.4.2-1, most spills assumed to occur during the duration of the proposed action would be in the small-volume category (<1,000 bbl). As the spill size increases, the occurrence rate decreases, so the number of estimated spills decreases. Estimates of the number of large spills for the Beaufort Sea and Chukchi Sea Planning Areas were also derived from fault-tree modeled rates and compared to

TABLE 4.4.2-1 Oil Spill Assumptions for the Proposed Action (Alternative 1)

		Number of Spill Events[a]		
		Gulf of Mexico Region	Arctic Region	South Alaska Region
Scenario Elements	Assumed Spill Volume	Western, Central, and Eastern Planning Areas	Beaufort and Chukchi Planning Areas	Cook Inlet
Oil Production (Bbbl)[b]		2.7–5.4	0.7–2.5	0.1–0.2
Large (bbl)	≥1,000			
pipeline	1,700[c]	2–5	1–2	1 spill from either
platform	5,100[d]	1–2	1	
tanker	3,100	1		
Small (bbl)[e]	≥50 to <1,000	35–70	10–35	1–3
	≥1 bbl to <50	200–400	50–190	7–15

[a] The assumed number of spills are estimated using the 1996–2010 spill rates found in Anderson et al. (2012). The ≥1,000 bbl spill rate for pipelines is 0.88 spills/Bbbl. The ≥1,000 bbl spill rate for platforms is 0.25 spills/Bbbl. The ≥1,000 bbl spill rate for tankers is 0.34 spills/Bbbl in U.S. waters and 0.46 spills/Bbbl for Arctic North Slope tankers (1989 to 2008). The ≥50 to <1,000 bbl spill rate for pipelines and platforms combined is 12.88 spills/Bbbl. The ≥1 to <50 bbl spill rate for pipelines and platforms combined is 74.75 spills/Bbbl. For the Alaska OCS region, the 1996–2010 spill rates were compared to fault-tree rates in Bercha Group Inc. (2006, 2008a,b, 2011). The greater number of spills from Anderson et al. (2012) is represented here. Note that spill volumes for spills ≥10,000 bbl are not reported for the 1996–2010 period because there were no such pipeline spills and only one platform spill (i.e., the DWH event). For the 1996–2010 period, Anderson et al. (2012) reports an assumed ≥10,000 bbl spill rate of 0.18 spills/Bbbl for pipelines and 0.13 spills/Bbbl for platforms.

[b] Bbbl = billion barrels.

[c] During the last 15 years (1996–2010), 7 oil spills ≥1,000 bbl occurred from U.S. OCS pipelines. The median spill size was 1,720 bbl. The maximum spill size between 1996 and 2010 from U.S. OCS pipelines was 8,212 bbl.

[d] During the last 15 years (1996–2010), 2 oil spills ≥1,000 bbl occurred from U.S. OCS platforms. During Hurricane Rita, one platform and two jack-up rigs were destroyed, and a combined total of 5,066 bbl was spilled. The median spill size, when not accounting for a decreasing trend in the rate of platform spills, over 1964–2010, is 7,000 bbl.

[e] The number of spills <1000 bbl is estimated using the total spill rate for both pipeline and platform spills.

the rates from Anderson et al. (2012) (Bercha Group, Inc. 2011). In all cases, the Anderson et al. (2012) estimates were the more conservative estimates and were used in lieu of specific fault-tree models which are considered at the lease sale stage.

4.4.2.2 An Unexpected Accidental Event and Spill – Catastrophic Discharge Event

As discussed in Section 4.3.3, a CDE is a low probability, very large volume spill that if one were to occur it would have the potential for severe environmental consequences. Although CDEs are unexpected, such spills may result from OCS exploration, development, and production operations involving facilities, tankers, and pipelines. The CDE size assumptions below are derived assuming a loss of well control event as explained in Section 4.3.3.

Catastrophic Discharge Event – Spill Size and Number Assumptions. The CDE estimate is intended to provide a scenario for a low-probability event with the potential for catastrophic consequences. Past oil spills that may be relevant include the *Exxon Valdez* oil spill (262,000 bbl) (non-OCS program related) in Prince William Sound in south central Alaska, the Ixtoc oil spill (3,500,000 bbl) (non-OCS program related) in the western GOM, and the DWH event (4,900,000 bbl) in the northern GOM (McNutt et al. 2011). For this PEIS, CDE estimates were developed for each program area, taking into account considerations such as water depth, weather conditions (such as ice cover), and the potential availability of response equipment for drilling relief wells. The spill size assumptions for such highly unlikely and unexpected events are presented in Table 4.4.2-2. The likelihood of occurrence of such events is discussed in more detail in Section 4.3.3.

For the GOM planning areas, the CDE volumes range from 900,000 to 7,200,000 bbl, depending on the depth at which the loss of well control occurs (Table 4.4.2-2). For the Cook Inlet Planning Area, the CDE volume estimates range from 75,000 to 125,000 bbl, depending on the availability of a rig to drill a relief well. For the Chukchi Sea and Beaufort Sea Planning Areas, the CDE volume estimates range from 1,400,000 to 2,100,000 bbl and 1,700,000 to 3,900,000 bbl, respectively.

4.4.3 Potential Impacts on Water Quality

4.4.3.1 Gulf of Mexico

This section analyzes impacts on GOM coastal and marine waters. Coastal waters, as defined here, include the bays and estuaries along the coast and State waters extending out to the inward boundary of the territorial seas. Marine waters extend from this boundary out to the Exclusive Economic Zone, or approximately 322 km (200 mi) from the coast.

Table 4.1.1-1 details impacting factors associated with oil and gas activities and the development phase in which they can occur. The following factors affecting water quality have been identified: disturbance of bottom sediments, wastes and disposal, vessel traffic, and

TABLE 4.4.2-2 Catastrophic Discharge Event Assumptions[a]

Program Area	Volume (million bbl)	Duration (days)	Factors Affecting Duration
Gulf of Mexico	0.9–7.2	30–90	Water depth and drill depth determines timing of relief well
Arctic			
Chukchi Sea	1.4–2.2	40–75	Type of drill rig used and rig availability to drill relief well during open water season
Beaufort Sea	1.7–3.9	60–300	Type of drill rig, timing of drilling relative to ice conditions, and rig availability to drill relief well
Cook Inlet	0.075–0.125	50–80	Availability of rig to drill relief well

[a] The GOM OCS Region has estimated the discharge rate and duration for a catastrophic spill event for both shallow and deep water (in part) based on information gathered from shallow water and deepwater well tests and flow rates validated by the Ixtoc (1979) and the DWH (2010) oil spills. The Alaska OCS Region has estimated a very large oil-spill scenario based on a reasonable, maximum flow rate for each OCS planning area, taking into consideration geologic conditions and well log data. The Alaska OCS Region modeled the flow of fluids from a representative reservoir into the well and flow up through the borehole based on formation thickness, porosity, and permeability; oil saturation, viscosity, and gas content; and reservoir pressure and temperature. The number of days until a hypothetical blowout and discharge from a well could be contained was also estimated. Different assumptions about the type of drilling rig, timing of drilling, nature of ice conditions, and relief well operations underlie the CDE scenarios in the Chukchi Sea and Beaufort Sea; therefore, the scenarios are not directly comparable. The time period required to drill a relief well and kill the well in the Chukchi Sea is explained in detail in BOEMRE (2011j). The relief well is drilled and killed within the open water season. Over half of the 75-day estimate includes transport of relief well rig to the site and drilling of the actual relief well. The greater range in spill duration in the Beaufort reflects different assumptions about the drilling rig and timing of drilling relative to seasonal ice conditions. The scenario range incorporates both open- and late open-water season and winter blowout scenarios (the late open-water season may delay the relief well drilling until the following open-water season). These are discharge volumes and do not account for decreases in volume from bridging, containment, or response operations. Note that under BOEM and BSEE regulations, exploration and development plans and oil spill response plans must incorporate a separate worst-case discharge calculation derived from individual well parameters and characteristics.

accidental spills. The water quality stressor activities associated with oil and gas development are shown in Table 4.4.3-1.

Discharges to waters of the GOM are regulated by National Pollution Discharge Elimination System (NPDES) OCS General Permit No. GMG290000 until Sept. 30, 2012, for the western GOM (off of Texas and Louisiana) and NPDES OCS General Permit No. GMG460000 until March 31, 2015, for the eastern GOM, including the Mobile and Viosca Knoll lease blocks in the Central Planning Area. Permits issued under Section 402 of the Clean Water Act for offshore activities must comply with any applicable water quality standards and/or Federal water quality criteria, as well as with Section 403 of the Clean Water Act. Water quality standards consist of the following: designated uses of the water body, water quality criteria to protect those uses and determine whether they are being attained, and anti-degradation policies to help protect high quality water bodies. Discharges from offshore activities near State water boundaries must comply with all applicable State water quality standards.

Section 403 of the Clean Water Act requires that NPDES permits for discharges to the territorial seas, the contiguous zone, and the ocean be issued in compliance with the U.S. Environmental Protection Agency's (USEPA's) regulations for preventing unreasonable degradation of the receiving waters. Prior to permit issuance, ocean discharges must be evaluated against USEPA's published criteria for determination of unreasonable degradation. Unreasonable degradation, as defined in the NPDES regulations (40 CFR 125.121[e]), encompasses the following:

1. Significant adverse changes in ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities.

2. Threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms.

3. Loss of aesthetic, recreational, scientific, or economic values that is unreasonable in relation to the benefit derived from the discharge.

Common impacts on water quality in both coastal and marine areas include impacts from vessel traffic, well drilling, and operational discharges. During drilling, drilling muds are circulated down a hollow drill pipe, through the drill bit, and up the annulus between the drill pipe and the borehole. Drilling muds are used for the lubrication and cooling of the drill bit and pipe. The muds also remove the cuttings that come from the bottom of the oil well and help prevent loss of well control by acting as a sealant. The drilling muds carry drill cuttings (i.e., crushed rock produced by the drill bit) to the surface. The drilling muds are then processed on the platform to remove the cuttings and recycled back down the well. The separated cuttings are, in most cases, discharged to the ocean. There are three classes of drilling muds used in the industry: water-based muds (WBMs), oil-based muds (OBMs), and synthetic-based muds (SBMs) (Neff et al. 2000). The WBMs used in most offshore drilling operations in U.S. waters consist of fresh- or saltwater, barite, clay, caustic soda, lignite, lignosulfonates, and/or water-soluble polymers. The OBMs use mineral oil or diesel oil as the base fluid rather than fresh- or

TABLE 4.4.3-1 Water Quality Impact Matrix

	Water Quality			
Stressor and O&G Activity	Coastal Water	Shelf Water	Deepwater	Marine Water
Vessel Traffic Exploration, Construction, Operation, Decommissioning	X	X	X	X
Well Drilling: Exploration, Development	X	X	X	X
Pipelines: Trenching, Landfalls, Construction	X	X		X
Chemical Releases: Drilling, Normal Operational Discharges, Sanitary Wastes	X	X	X	X
Platforms: Anchoring, Mooring, Removal	X	X	X	X
Onshore Construction	X			
Oil Spills	X	X	X	X

saltwater. They offer several technical advantages over WBMs for difficult drilling operations; however, because of their persistence and adverse environmental effects, OBMs and associated cuttings have been banned from ocean discharges in U.S. waters and must be transported to shore for disposal (Neff et al. 2000). The SBMs are a family of products developed in the 1990s to provide drilling performance similar to that of oil-based fluids, but with improved biodegradation characteristics and decreased ecotoxicity (Neff et al. 2000). The types that would be used most frequently would be those that meet the requirements of the NPDES permit. The SBM-wetted cuttings are permitted for ocean discharge, while the spent fluid is transported to shore for reuse or disposal (Neff 2010).

Discharges of drilling muds and cuttings during normal operations are regulated by NPDES general permits issued by USEPA. In areas where disposal of drilling muds and/or cuttings at sea are permitted under an NPDES general permit and BOEM and BSEE regulations, their environmental effects are localized because of settling, mixing, and dilution (Montagna and Harper 1996; Neff et al. 2000; Continental Shelf Associates 2004c). The majority of cuttings are found within 250 m (820 ft) of a drilling site (Continental Shelf Associates 2004c). Constituents of SBM cuttings have been found in an approximately 1 ha (2.5 ac) area surrounding a drilling rig at concentrations that may cause harm to wildlife (Neff et al. 2000).

Produced water is water that is brought to the surface from an oil-bearing formation during oil and gas extraction. It is the largest individual discharge produced by normal operations. Small amounts of oil are routinely discharged in produced water during OCS operations. The USEPA has set an effluent limitation of 29 mg/L for the oil content of produced waters (MMS 2007c). Produced water may contain specialty chemicals added to the well for process purposes (e.g., biocides and corrosion inhibitors) and chemicals added during treatment of the produced water before its release to the environment (e.g., water clarifiers). Produced water can have elevated concentrations of several constituents, including salts, petroleum hydrocarbons, some metals, and naturally occurring radioactive material (NORM). Petroleum hydrocarbons in produced water discharges are a major environmental concern. The most abundant hydrocarbons in produced water are benzene, toluene, ethylbenzene, and xylenes

(BTEX) and low-molecular-weight saturated hydrocarbons. The BTEX compounds rapidly evaporate into the atmosphere, leaving behind less volatile, heavier compounds (weathering) (NRC 2003b). Polycyclic aromatic hydrocarbons (PAHs) are heavier hydrocarbons in produced water and are a concern because of the toxicity of some PAHs and their persistence in the marine environment (Rabalais et al. 1991).

The NORM waste in produced water includes the radium isotopes Ra-226 and Ra-228 and is a concern because it is radioactive. However, in produced water discharges, radium coprecipitates with barium sulfate and is not available for uptake by organisms (Neff 2002).

Generally, the amount of produced water is low when production begins but increases over time near the end of the field life. In a nearly depleted field, production may be as high as 95% water and 5% fossil fuels (Rabalais et al. 1991). The National Research Council (2003a) estimated that the total amount of produced water being released into GOM waters was 660 million bbl/yr in the 1990s. Between 1996 and 2005, the annual volume of produced water varied between 432 million bbl/yr and 686 million bbl/yr, with an average discharge of 596 million bbl/yr (MMS 2007c).

Before being discharged into the ocean, produced water is typically treated and must meet NPDES requirements regarding discharge rate, contaminant concentration, and toxicity, thereby reducing the potential for contamination. However, the discharge of produced water into the sea may degrade water and sediment quality in the immediate vicinity of the discharge point because of its potential constituents. Studies have shown contaminated sediments exist in areas up to 1,000 m (3,280 ft) from a produced water discharge point, indicating water quality in that zone has been affected by produced water discharges (Rabalais et al. 1991). Because discharge points are typically much farther apart than 1,000 m (3,280 ft), no interactions that would measurably affect water quality are expected between them, and background concentrations are expected to exist away from the immediate discharge location. Two recent studies have shown that produced water discharges do not make a significant contribution to the hypoxic conditions that are seen in the GOM (Veil et al. 2005; Bierman et al. 2007).

Normal operations for the proposed action would also involve the use of vessels with associated impacts. Compliance with NPDES permits and USCG regulations would prevent or minimize most impacts on the environment caused by ship traffic.

The placement of drilling units and platforms would disturb bottom sediments and produce turbidity in the water. This impact would be unavoidable; however, these impacts would be temporary and water quality would return to normal (e.g., background concentrations of suspended solids) within minutes to hours without mitigation because of mixing, settling, and dilution.

4.4.3.1.1 Impacts of Routine Operations.

Coastal Waters. Routine activities potentially affecting coastal water quality include pipeline landfalls, well completion activities, platform construction, and operation discharges.

The estimated exploration and development scenario for the GOM for the proposed action is presented in Table 4.4.1-1 and estimated depth distribution of the activities in Table 4.4.1-2.

Construction and installation of exploratory and development wells (up to 100 and 600, respectively), platforms (up to 450), and offshore pipelines (up to 12,000 km [7,500 mi]) would affect water quality and disturb habitats (see Table 4.4.1-1). Such activities would disturb bottom sediments and increase the turbidity of the water in the area of construction. Trenching operations to bury pipelines would produce turbidity (i.e., increased suspended solids) in the coastal waters along pipeline corridors. The disturbance of bottom sediments caused by these operations would be unavoidable. However, these impacts would be temporary, and water quality would return to normal (i.e., background concentrations) without mitigation, once these activities were completed because of settling and mixing.

Construction of new onshore support facilities (up to 11 pipeline landfalls, 6 pipe yards, and 12 processing facilities) could affect the quality of nearshore and fresh waters in the GOM Planning Areas. During land site preparation, vegetation is typically cleared from the area, compacting the topsoil, because of the constant movement of heavy machinery. This compaction would reduce the water retention properties of the soil and increase erosion and surface runoff from the site. Water quality would be degraded by increases in site runoff of particulate matter, heavy metals, petroleum products, and chemicals to local streams, estuaries, and bays. Proper siting of facilities and requirements associated with NPDES construction permits should largely mitigate these impacts.

The OCS service and construction vessel traffic to and from platform sites within the planning area (up to 600 vessel trips per week) would also affect water quality through the permitted release of operational wastes. Routine vessel-associated discharges that could affect coastal water quality include sanitary wastes and bilge water. Bilge water discharges from support vessels could contain petroleum and metals from machinery. Bilge water and sanitary discharges to larger coastal water channels would produce local and temporary effects because of the large volume of water available to dilute the discharges and the presence of currents that would promote mixing. However, in confined portions of some channels, there might be insufficient water volume or currents for mixing and dilution. In such regions, water quality could be degraded. Compliance with applicable NPDES permits and USCG regulations would prevent or minimize most impacts on receiving waters. Discharges in coastal areas are regulated by State-issued or Federal NPDES permits specifically for coastal areas.

Produced water discharges were banned in coastal waters of the GOM in the late 1990s, and reinjection of produced water is practiced in coastal areas to avoid discharges (NRC 2003b; Wilson 2007).

Marine Waters. Marine waters can be divided into continental shelf waters and deep waters. Continental shelf waters are defined as those waters that lie outside of the coastal waters and have a depth less than 305 m (1,000 ft). Deep waters are located in regions that are equal to or deeper than 305 m (1,000 ft).

Routine operations that could affect water quality include anchoring, mooring, drilling and well completion activities, well testing and cleanup operations, flaring/burning, facility installation and operations, support service activities, decommissioning, and site clearance. Construction and installation of exploratory and development wells (up to 1,200), platforms (up to 450), and offshore pipelines (up to 12,000 km [7,500 mi]) would affect water quality and disturb habitats (see Table 4.4.1-1).

As with coastal areas, OCS vessel traffic to and from platform sites within the planning area (up to 600 vessel trips per week) would also affect water quality through the permitted release of operational wastes (such as bilge water). Because of the relatively small volumes that would be discharged, these waste materials would be quickly diluted and dispersed, and any impacts on water quality would be highly localized and temporary. Compliance with applicable NPDES permits and USCG regulations would prevent or minimize most impacts on receiving waters.

Sanitary and domestic waste and deck drainage would occur from platforms, drilling vessels, and service vessels as part of normal operations and could contribute to water quality degradation. However, sanitary and domestic wastes would be routinely processed through onsite waste treatment facilities before being discharged overboard, and deck drainage would be treated onsite to remove oil and then discharged. Sand and sludge recovered from the treatment processes would be containerized and shipped to shore for disposal. Impacts on water quality from such discharges would require no mitigation because of the treated nature of the wastes, the small quantities of discharges involved, and the mixing and dilution of the wastes with large volumes of water.

Discharges associated with drilling and production are discussed in Section 4.4.3.1. Normal operations for the proposed action would also involve the use of vessels with associated impacts, such as those discussed for related impacts on coastal areas. Compliance with NPDES permits and USCG regulations would prevent or minimize most impacts on the environment.

The placement of drilling units and platforms would disturb bottom sediments and produce turbidity in the water. Pipeline trenching, required in water depths less than 61 m (200 ft), would also produce turbidity along pipeline corridors. This impact would be unavoidable; however, these impacts would be temporary, and water quality would return to normal (e.g., background concentrations of suspended solids) within minutes to hours without mitigation because of mixing, settling, and dilution.

As discussed in Section 3.4.1.2, hypoxic conditions exist on the Louisiana-Texas shelf. The size of the hypoxic zone varies from year to year. The hypoxic zone attained a maximum measured extent in 2002, when it encompassed about 22,000 km^2 (8,494 mi^2). Normal operations from oil and gas production in the GOM could affect the extent and severity of the hypoxic zone through discharges and accidental releases. Very preliminary calculations reveal that ammonium and oil and grease contained in produced water are a small percentage of that contributed by the Mississippi River to the hypoxic zone (Rabalais 2005). A study that monitored oxygen-demanding substances and nutrients in the produced water discharges from

50 platforms found that produced water discharges contributed less than 1% of the oxygen-demanding substances to the hypoxic zone (Veil et al. 2005).

For the proposed action, the compositions and volumes of discharges would be expected to be about the same as those observed historically, and compliance with existing NPDES permits would minimize impacts on receiving waters (e.g., through limitations on concentrations of toxic constituents). Water quality likely would recover without mitigation when discharges ceased because of dilution and dispersion.

Although deepwater operations and practices are similar to those used in shallower environments, there are some significant differences. Three of these are seafloor discharges from pre-riser and riserless drilling operations, discharge of cuttings wetted with SBFs, and more extensive and frequent use of chemical products to enhance oil and gas throughput because of the temperatures and pressures present at the seafloor, including their use within pipelines to facilitate the transport of large quantities of methanol and other chemicals to and from the shore.

Floating production facilities are used in deepwater rather than conventional, bottom-founded (i.e., fixed) platforms. These deepwater facilities include floating production semisubmersibles, tension leg platforms, and spars (Harbinson and Knight 2002). Often these facilities are surface hubs for several subsea systems. Therefore, in deep water, there will be far fewer and more widely spaced surface facilities than on the shelf, but these facilities will have increased discharges of produced waters over time due to the larger volume being processed.

In order to enhance the throughput of oil and gas in deep water, more extensive and frequent use of some chemical products is anticipated because of the temperatures and pressures encountered at the seafloor. Chemicals most likely to be present in deepwater operations and drilling include monoethylene glycol, methanol, corrosion inhibitors, and biocides (Grieb et al. 2008). The toxicity of these substances varies, but the impact on water quality would be temporary and localized (within feet of a release), due to the small quantities in which they would likely be released and the amount of dilution and mixing that would occur in a subsea environment (Grieb et al. 2008).

Deepwater activities could incrementally increase support activities and the expansion, construction, or modification of onshore support bases due to the deeper draft of these support vessels. The impacts resulting from this growth would be common to all OCS support facilities (point-source waste discharges, runoff, dredging, and vessel discharges) and not specific to deepwater activities. Short-term degradation of water quality might increase at a few support base locations that would be expected to grow as a consequence of deepwater activities (including Corpus Christi, Galveston, and Port Fourchon).

4.4.3.1.2 Impacts of Expected Accidental Events and Spills.

Coastal Waters. Accidental releases could affect the quality of coastal water in the GOM. The magnitude and severity of impacts would depend on spill location and size, type of product spilled, weather conditions, and the water quality and environmental conditions at the time of the spill.

Under the proposed action, the number and types of spills assumed to occur in the GOM Planning Area include up to seven large spills (i.e., ≥1,000 bbl), up to five spills at a volume of 1,700 bbl from pipelines, up to two spills at a volume of 5,000 bbl from platforms, and up to one spill at a volume of 3,100 bbl from a tanker. Between 35 and 70 small spills with volumes between 50 and 999 bbl are assumed to occur, as well as between 200 and 400 very small spills with volumes between 1 and 50 bbl (Table 4.4.2-1).

Weathering processes that transform the oil, such as volatilization, emulsification, dissolution, chemical oxidation, photo-oxidation, and microbial oxidation, may reduce impacts of oil spills in the GOM Planning Areas on coastal water quality (NRC 2003b; NOAA 2005). Dissolution, which is a small component of weathering, can be important to biological communities because the most soluble fractions are often the most toxic (Shen and Yapa 1988). Because oil is generally less dense than water, it would tend to float on the sea surface. Lighter oil fractions such as BTEX would readily evaporate from the surface and, therefore, would not be a continuing source of potential water contamination. Following a spill, light crude oils can lose as much as 75% of their initial volume to evaporation as the lighter components (e.g., BTEX) change from the liquid to the gas phase; medium-weight crude oils can lose as much as 40% (NRC 2003b).

If a large spill occurred in enclosed coastal waters or was driven by winds, tides, and currents into an enclosed coastal area, water quality would be adversely affected. These impacts could be increased if they occurred in areas with degraded water quality, such as areas continuing to be affected by the DWH. Similarly, if a large tanker spill were to happen near port, adverse impacts on coastal waters could occur. In such a low-energy environment (i.e., an environment in which there is limited wave and current activity), the oil would not be easily dispersed, and weathering could be slower than it would be in the open sea. Effects on water quality could persist if oil reached coastal wetlands and was deposited in fine sediments, becoming a long-term source of pollution because of remobilization. In such locations, spill cleanup might be necessary for the recovery of the affected areas. Potential impacts from spill response and cleanup activities are discussed below. As a result of the DWH event, residual oil was still being removed from shorelines as of March 2012 (ERMA 2012a, b). However, supratidal buried oil, small surface residue balls, and submerged oil mats are three types of residual oil from the DWH spill in the nearshore zone that were identified as being more damaging to completely remove from coastal habitats than to let them remain and naturally attenuate (OSAT-2 2011). The OSAT-2 (2011) concluded that the residual oil had a relatively minor impact on resources compared with the potential negative impact to those resources that could be sustained through cleanup activities. Oiled shorelines might also be washed with warm or cold water, depending on the shore’s location.

Small oil spills (<1,000 bbl) or very small oil spills (<50 bbl) would produce small but measurable impacts on water quality. Assuming that all small and very small spills would not occur at the same time and place, water quality would rapidly recover without mitigation because of mixing, dilution, and weathering. However, impacts could be increased if they occurred in areas with degraded water quality and/or areas continuing to be affected by the DWH event, the extent of which could change over the duration of the Program.

Marine Waters. Accidental releases could affect the quality of marine waters in the GOM Planning Areas. The number and types of spills assumed to occur in the GOM Planning Areas are the same as those discussed above for coastal waters. The magnitude of these impacts and the rate of recovery would depend on the location and size of the spill, the type of product spilled, weather conditions, and environmental conditions at the time of the spill. Failures of production-related piping, seals, and connections have been identified as key risks for releases that may affect water quality in deepwater environments, with loss of well control presenting the highest risk of environmental impacts (Grieb et al. 2008). Because of the depths of some deepwater drilling operations, servicing any leak identified during subsea drilling and production operations would be more difficult and require remotely operated vehicles for depths greater than 610 m (2,000 ft) (Grieb et al. 2008). Each piping connection presents a potential for leakage due to human error, corrosion, or erosion (Grieb et al. 2008). In general, oil spilled below the surface rises rapidly as droplets that coalesce to form a slick. Standard response procedures for a spill could then be used.

Because deepwater operations can be located far from shore, tankers could be used to shuttle crude oil to shore stations. This transport of oil from operations in deep water has the potential to produce spills that could affect coastal waters within a very short time if the spill occurred near the port. It is expected that such spills could release approximately 3,100 bbl of oil. Such a release could retain a large volume of oil in the slick at the time it contacted land.

If it is assumed that all small (<1,000 bbl) and very small (<50 bbl) spills would not occur at the same time and place, water quality would rapidly recover without mitigation because of mixing, dilution, and weathering.

Spill Response and Cleanup. Spill response and cleanup activities in coastal and marine water could include, depending on location, use of chemical dispersants, *in situ* burning, use of vessels and skimmers, and beach cleaning and booming (BOEMRE 2011j).

Dispersants are combinations of surfactants and solvents that work to break surface oil into smaller droplets that then disperse on the surface and into the water column. Many factors affect the behavior, efficacy, and toxicity of a particular dispersant, including water temperature, surface salinity, wave and wind energy, light regime, water depth, type of oil, concentration of dispersant, how the dispersant is applied (constant or intermittent spikes), and exposure time to organisms. Dispersants are used to degrade an oil spill more quickly through increasing surface area and to curtail oil slicks from reaching shorelines (Word et al. 2008). As oil breaks into smaller droplets, it can distribute vertically in the water column. If oil droplets adhere to sediment, the oil can be transported to the seafloor and interstitial water in the sediment. In shallow nearshore waters, wind, wave, and current action would more likely mix the dispersant-oil mixture into the water column and down to the seafloor environment. Chemically dispersed oil is thought to be more toxic to water column organisms than physically dispersed oil, but the difference is not clear-cut, and generally the toxicity is within the same order of magnitude (NRC 2005b).

In situ burning is used to reduce an oil spill more quickly and to curtail oil slicks from reaching shorelines. *In situ* burning could increase the surface water temperature in the immediate area and produce residues. The uppermost layer of water (upper millimeter or less) that interfaces with the air is referred to as the microlayer. Important chemical, physical, and biological processes take place in this layer, and it serves as habitat for many sensitive life stages and microorganisms (GESAMP 1995). Disturbance to this layer through temperature elevation could cause negative effects on biological, chemical, and physical processes.

Residues from *in situ* burning can float or sink depending on the temperature and age of the residue. Floating residue can be collected; however, residues that sink could expose the benthic waters and sediment to oil components as the residue degrades on the seafloor.

The NOAA Office of Response and Restoration states, "Overall, these impacts [from open water *in situ* burning] would be expected to be much less severe than those resulting from exposure to a large, uncontained oil spill" (NOAA 2011d).

Oiled shorelines might be washed with warm or cold water, depending on the shore's location. Oil dispersants and surface washing agents used to clean up a spill could also be a source of impacts to water quality for coastal areas in the event of a spill (EIC and NCSE 2010; CRRC 2010). Beach cleaning and booming activities could result in effects from suspended sediment in waters and resettlement of sediments elsewhere, possible resuspension of hydrocarbons, and runoff of treatment-laden waters that could affect nearshore temperature and nutrient concentrations (BOEMRE 2011j).

4.4.3.1.3 Impacts of an Unexpected Catastrophic Discharge Event. A CDE is considered to be an unexpected, low-probability event unlikely to occur during routine operations (see Section 4.4.2.2. For the GOM Planning Areas, a CDE is assumed to have a volume of 0.9-7.2 million bbl and last from 30 to 90 days (Table 4.4.2-2). A catastrophic discharge event in either coastal or marine water could present sustained degradation of water quality from hydrocarbon contamination in exceedance of State and Federal water and sediment quality criteria. These effects could be significant depending upon the duration and area impacted by the spill. Additional effects on water quality would occur from response and cleanup vessels, *in situ* burning of oil, dispersant use, discharges and seafloor disturbance from relief well drilling, and activities on shorelines associated with cleanup, booming, beach cleaning, and monitoring.

A CDE occurring below the seafloor, outside the wellbore, would have the potential to resuspend sediments and move large quantities of bottom sediments. Some sediment could travel at rates of up to 2.1 km/day (1.3 mi/day), depending on sediment size and bottom currents (Hamilton 1990). Sediments could also be destabilized to the point of mass movement at depth. Large-scale sediment resuspension could potentially release heavy metals into the water column, changing its water chemistry (Caetano et al. 2003). Sediments also have the potential to become contaminated with oil components, because oil components may adsorb onto marine detritus that could be deposited on the seafloor.

A CDE at depth would introduce large quantities of hydrocarbons into the water column, with dispersed (chemically or mechanically) and suspended oil droplets potentially creating a plume at depth. A CDE would also cause large patches of sheen and/or oil on the water surface. Mitigation efforts, such as burning, could also introduce hydrocarbons into the water column. Introduction of chemicals, such as the PAHs present in crude oil, into the water column via the spill or cleanup efforts could have acutely toxic and chronic sublethal effects on the marine environment; however, the effects are poorly understood, and more research is needed. Dissolved oxygen levels would be a concern due to the release of a carbon source into the water column. Data collected in the area of the DWH event indicated that dissolved oxygen levels decreased by about 20% below long-term average values for the GOM, but the levels were not considered hypoxic (NOAA 2010d).

A CDE could also include release of natural gas into the water column. Methane and other natural gas constituents are carbon sources, and their introduction into the marine environment could reduce the dissolved oxygen levels due to microbial degradation of the methane, potentially creating hypoxic or “dead” zones. However, evidence from the DWH event indicates that natural gas released from the well was rapidly broken down by bacterial action with little oxygen drawdown (Camilli et al. 2010; Kessler et al. 2011).

Response efforts would decrease the amount of oil remaining in GOM waters, but it is assumed that natural processes would aid the degradation of the oil and gas released during a CDE. Natural processes will physically, chemically, and biologically aid the degradation of oil (NRC 2003b). The physical processes involved in degradation of oil include evaporation, emulsification, and dissolution; the primary chemical and biological degradation processes include photo-oxidation and biodegradation (NRC 2003b).

Impacts to water quality from the DWH event may be relevant to a future CDE and are discussed in more detail in Section 3.4.1.4.

4.4.3.1.4 Impact Conclusions.

Routine Operations. Overall coastal and marine water quality impacts due to routine operations and operational discharges under the proposed action would be unavoidable. Compliance with NPDES permit requirements would reduce or prevent most impacts on receiving waters caused by discharges from normal operations. Water quality would recover when discharges ceased because of dilution, settling, and mixing. Impacts on water quality from routine operations associated with the Program are expected to be minor to moderate.

Expected Accidental Events and Spills. Expected accidental oil spills could reduce water quality, and these impacts would be unavoidable. The magnitude of the impacts would depend on the specific location affected and the nature and magnitude of the activity/accident. Small spills would be expected to result in minor, short-term impacts on coastal and marine water quality. A large spill in coastal waters could result in longer term impacts on water quality, but cleanup efforts would reduce the likelihood of long-term impairment. A large spill in marine waters would be expected to have temporary impacts on water quality; however, cleanup efforts and evaporation, dilution, and dispersion would minimize the long-term impacts. Impacts on water quality from large accidental spills associated with the Program are expected to be minor to major, depending on the location, timing, magnitude of the event, and the effectiveness of containment and cleanup activities.

An Unexpected Catastrophic Discharge Event. In the unlikely event of a low-probability CDE, impacts to water quality would be moderate to major. A CDE could present sustained degradation of water quality from hydrocarbon contamination in exceedance of State and Federal water and sediment quality criteria. Impacts from a CDE would depend on the spill size and composition, weather conditions, and the location of the spill, as well as the effectiveness of response actions.

4.4.3.2 Alaska – Cook Inlet

This section analyzes impacts on coastal and marine waters in the Cook Inlet Planning Area. Coastal waters, as defined here, include the bays and estuaries along the coast and State waters extending out to the inward boundary of the territorial seas. Marine waters extend from this boundary out to a water depth of 200 m (656 ft).

Section 4.1.1 details impacting factors for activities associated with oil and gas activities and the development phases in which they can occur. The following factors affecting water quality have been identified: disturbance of bottom sediments, wastes and disposal, vessel traffic, and accidental spills. The water quality stressor activities associated with oil and gas are shown in Table 4.4.3-1. Note that no onshore construction or pipeline landfalls are anticipated for the Cook Inlet Planning Area for the lease sales during 2012-2017 period.

Discharges to waters of Cook Inlet are regulated by NPDES OCS General Permit No. AKG-31-5000 until July 2, 2012. USEPA is scheduled to transfer the NPDES General Permit program over to the Alaska Department of Environmental Conservation (ADEC) by the end of October, 2012 (ADEC 2012a). Permits issued under Section 402 of the Clean Water Act for offshore activities must comply with any applicable water quality standards and/or Federal water quality criteria, as well as with Section 403 of the Clean Water Act. Water quality standards consist of the following: designated uses of the water body, water quality criteria to protect those uses and determine whether they are being attained, and anti-degradation policies to help protect high quality water bodies. Discharges from offshore activities near State water boundaries must comply with all applicable State water quality standards.

Section 403 of the Clean Water Act requires that NPDES permits for discharges to the territorial seas, the contiguous zone, and the ocean be issued in compliance with USEPA's regulations for preventing unreasonable degradation of the receiving waters. Prior to permit issuance, ocean discharges must be evaluated against USEPA's published criteria for determination of unreasonable degradation. Unreasonable degradation, as defined in the NPDES regulations (40 CFR 125.121[e]), encompasses the following:

1. Significant adverse changes in ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities.

2. Threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms.

3. Loss of aesthetic, recreational, scientific, or economic values that is unreasonable in relation to the benefit derived from the discharge.

Specific water quality effects information related to NPDES regulated discharges in the Cook Inlet planning area is provided by USEPA (Tetra Tech 2006).

Common impacts on water quality in both coastal and marine areas include those from vessel traffic, well drilling, and operational discharges. The types of impacts expected are the same as those discussed above in Section 4.4.3.1.

4.4.3.2.1 Impacts of Routine Operations.

Coastal Waters. Routine activities potentially affecting coastal water quality include pipeline landfalls, well completion activities, platform construction, and operational discharges. The estimated exploration and development scenario for Cook Inlet is presented in Table 4.4.1-3.

Construction and installation of exploratory and development wells (up to 12 and 114, respectively), platforms (up to 3), and offshore pipelines (up to 240 km [150 mi]) would affect water quality and disturb habitats (see Table 4.4.1-3). Trenching operations to bury pipelines would produce turbidity (i.e., increased suspended solids) in the coastal waters along pipeline corridors. Increased water turbidity would also result from placing drilling units and platforms. The disturbance of bottom sediments caused by these operations would be unavoidable. However, these impacts would be temporary, and water quality would return to normal (i.e., background concentrations) without mitigation, once these activities were completed, because of settling and mixing.

Construction of new onshore pipelines (up to 169 km [105 mi]) would also impact coastal water quality in the Cook Inlet Planning Area. Proper siting of facilities and requirements associated with NPDES construction permits would largely mitigate these impacts. The impacts on water quality would range from negligible to minor, depending on site location and construction and mitigation activities.

Increased turbidity from construction and installation activities would occur in the immediate area of the activity. Contaminants introduced into Cook Inlet waters by these activities would be diluted and dispersed by complex currents associated with the tides (diurnal tidal variations at the upper end of the Cook Inlet at Anchorage can be 9 m [30 ft]), estuarine circulation, wind-driven waves, and Coriolis forces (MMS 2003a; Royal Society of Canada 2004). Seawater enters the Lower Cook Inlet from the Gulf of Alaska at the Kennedy

Entrance south of the Kenai Peninsula, and fresh water enters the inlet from numerous streams along the east, north, and west shorelines; major freshwater inputs include the Susitna and Kenai Rivers. Seawater circulates northward in Cook Inlet along its eastern boundary, mixes with fresh water in the northern end, and flows southward along the western boundary. Water exits the lower Cook Inlet through Shelikof Strait and discharges into the Gulf of Alaska (MMS 2002a). Surface currents in Cook Inlet can exceed 5 knots (5.7 mph), and bottom currents can reach 1.5 knots (1.7 mph) (Royal Society of Canada 2004). Approximately 90% of waterborne contaminants would be flushed from the lower Cook Inlet within about 10 months (MMS 2003a). Contaminants flushed from Cook Inlet would pass through Shelikov Strait and enter the Gulf of Alaska. Because of dilution, settling, and flushing, impacts from these activities would be local and temporary.

In addition to affecting the turbidity of coastal waters in the Cook Inlet, construction activities would produce waste materials. The majority of wastes generated during construction and developmental drilling would consist of drill cuttings and spent muds (MMS 2002a). Drilling muds and cuttings generated when installing exploration and delineation wells would be discharged at the well site. The volume of drilling fluids and cuttings vary depending upon the well characteristics, but, in general, fluids average approximately 500 bbl/well, and drill cuttings would comprise the equivalent of approximately 600 tons/well of dry rock. Thus, under the proposed action, up to 6,000 bbl of drilling fluids and up to 7,200 tons of drill cuttings could be disposed of in the waters of the Cook Inlet Planning Area. All drilling muds and cuttings associated with development and production wells would be treated and reinjected into the well. Discharge of drilling muds and cuttings would increase turbidity in the vicinity of the well. The discharge would contain trace metal and hydrocarbon constituents that would be suspended in the water column and subsequently deposited on the seafloor. These drilling discharges must comply with NPDES permit requirements regarding the discharge amount, rate, and toxicity, which would greatly reduce the impact to water quality.

During drilling, drilling muds are circulated down a hollow drill pipe, through the drill bit, and up the annulus between the drill pipe and the borehole. Drilling muds are used for the lubrication and cooling of the drill bit and pipe. The muds also remove the cuttings that come from the bottom of the oil well and help prevent loss of well control by acting as a sealant. The drilling muds carry drill cuttings (i.e., crushed rock produced by the drill bit) to the surface. The drilling muds are then processed on the platform to remove the cuttings and recycled back down the well. The separated cuttings are, in most cases, discharged into the ocean. As discussed in Section 4.4.3.1, three classes of drilling muds are used in the industry: WBMs, OBMs, and SBMs (Neff et al. 2000). The WBMs used in most offshore drilling operations in U.S. waters consist of fresh- or saltwater, barite, clay, caustic soda, lignite, lignosulfonates, and/or water-soluble polymers. The OBMs use mineral oil or diesel oil as the base fluid rather than fresh- or saltwater. They offer several technical advantages over WBMs for difficult drilling operations; however, because of their persistence and adverse environmental effects, OBMs and associated cuttings have been banned from ocean discharges in U.S. waters and must be transported to shore for disposal (Neff et al. 2000). The SBMs are a family of products developed in the 1990s to provide drilling performance similar to that of oil-based fluids, but with improved biodegradation characteristics and decreased ecotoxicity (Neff et al. 2000). The types that would be used most frequently would be those that meet the requirements of the NPDES permit. The

SBM-wetted cuttings are permitted for ocean discharge, while the spent fluid is transported to shore for reuse or disposal (Neff 2010).

Discharges of drilling muds and cuttings during normal operations are regulated by NPDES general permits issued by USEPA. In areas where disposal of drilling muds and/or cuttings at sea is permitted under an NPDES general permit and BOEM and BSEE regulations, the environmental effects of such disposal are localized because of settling, mixing, and dilution (Montagna and Harper 1996; Neff et al. 2000; Continental Shelf Associates 2004c). The majority of cuttings are found within 250 m (820 ft) of a drilling site (Continental Shelf Associates 2004c). Constituents of SBF cuttings have been found in an approximately 1-ha (2.5-acre) area surrounding a drilling rig at concentrations that may cause harm to wildlife (Neff et al. 2000).

Because all produced water would be discharged down hole, there would be no impacts on water quality from these operational discharges. Domestic wastewater would also be generated by these activities. This material would be injected into a disposal well. Solid wastes, including scrap metal, would be hauled offsite for disposal at an approved facility.

The OCS service and construction vessel traffic to and from platform sites within the planning area (up to nine vessel trips per week) would also affect quality through the permitted release of operational wastes. Routine vessel-associated discharges that could affect coastal water quality include sanitary wastes and bilge water. Bilge water discharges from support vessels could contain petroleum and metals from machinery. Bilge water and sanitary discharges to larger coastal water channels would produce local and temporary effects because of the large volume of water available to dilute the discharges and the presence of currents that would promote mixing. However, in confined portions of some channels, there might be insufficient water volume or currents for mixing and dilution. In such regions, water quality could be degraded. Compliance with applicable NPDES permits and USCG regulations would prevent or minimize most impacts on receiving waters. Discharges in coastal areas are regulated by State-issued or Federal NPDES permits specifically for coastal areas.

The National Research Council (2003b) estimated that the total amount of produced water being released into Cook Inlet waters was 45.7 million bbl/yr in the 1990s. Produced water can contain hydrocarbons, salts, and metals at levels toxic to marine organisms. Before being discharged into the ocean, produced water is typically treated and must meet NPDES requirements regarding discharge rate, contaminant concentration, and toxicity, thereby reducing the potential for sediment contamination. However, under the current NPDES permits, new facilities would not be allowed to discharge produced water into Cook Inlet. Under the proposed action, it is anticipated that all produced waters would be treated and reinjected into the well. Therefore, no impacts on water quality are expected to result from produced water.

Marine Waters. Routine operations that could affect marine water quality in the Cook Inlet Planning Area include anchoring, mooring, drilling and well completion activities, well testing and cleanup operations, flaring/burning, facility installation and operations, support service activities, decommissioning, and site clearance. These activities would disturb the seafloor and increase the suspended sediment load in the water column. Offshore pipelines in

Alaska are normally placed in a dredged trench in waters less than about 60 m (197 ft) deep. Dredged material from the trenches can be used to cover the pipeline. As these operations are reversed and structures removed, increased turbidity would reoccur. In general, plumes from these activities extend a few hundred meters to a few kilometers down current, but the length of the plume would depend on rate and duration of discharge, sediment grain size, current regime, source type, water column turbulence, and season. The direction of plume movement would be influenced by the general circulation pattern in the planning area and local ambient conditions. Suspended sediments in the plumes are expected to have toxicity ranges that are generally described as nontoxic to slightly toxic (National Academy of Sciences 1983). Overall, it is anticipated that the impacts on water quality from routine operations would be localized and temporary. As with coastal water impacts, dilution, settling, and rapid flushing would minimize any long-lasting impacts on water quality.

Adverse water quality impacts would also be produced by routine discharges of domestic waste (e.g., wash water, sewage, and galley wastes) and deck drainage (platform and deck washings, and gutters and drains, including drip pans and work areas). Domestic waste would increase suspended solids in the receiving water, thereby increasing turbidity and biological oxygen demand. Sanitary and domestic wastes are monitored in accordance with the NPDES permit. Established effluent limitations and guidelines published in 40 CFR Part 435, and operator compliance should minimize impacts on ambient water quality. Such impacts would be local and temporary.

The principal discharges of concern during drilling would be muds and cuttings. Drilling muds and cuttings generated when installing exploration and delineation wells would be discharged at the well site. All drilling muds and cuttings associated with development and production wells would be treated and reinjected into the well. See the discussion above for coastal waters for further information on potential impacts of discharging drilling muds and cuttings.

During operations, all produced water would be reinjected into the well in the Cook Inlet Planning Area, there produced water generated from activities associated with the proposed action would have no impacts on marine water quality.

As with coastal waters, OCS vessels traveling to and from platform sites within the planning area (up to three vessel trips per week per platform) could affect local water quality as a result of operational discharge of waste fluids. Because of dilution, settling, and flushing, water quality impacts from such discharges would be localized and temporary.

4.4.3.2.2 Impacts of Expected Accidental Events and Spills.

Coastal Waters. Accidental releases could affect the quality of coastal water in the Cook Inlet. The magnitude and severity of impacts would depend on the spill location and size, type of product spilled, weather conditions, and the water quality and environmental conditions at the time of the spill.

Under the proposed action, the number and types of spills assumed to occur in the Cook Inlet Planning Area include up to one large spill (i.e., ≥1,000 bbl) from either a platform (5,100 bbl) or a pipeline (1,700 bbl), up to three small spills with volumes between 50 and 999 bbl; and up to 15 very small spills with volumes between 1 and 50 bbl (Table 4.4.2-1). For conservative analysis (i.e., one in which impacts would be greater than those that would actually occur), all the spills are assumed to occur in Cook Inlet coastal waters. Such spills would adversely affect water quality. A spill in isolated coastal waters, in shallow waters under thick ice, or in rapidly freezing ice could cause sustained degradation of water quality to levels that are above State or Federal criteria for hydrocarbon contamination. Concentrations could exceed the chronic criterion of 0.015 ppm total hydrocarbons, but this exceedance would probably occur over a relatively small area. Persistent small spills in such areas could result in local chronic contamination. In most cases, spills would be rapidly diluted. In some cases, however, water quality could be degraded to a greater extent.

Weathering processes that transform the oil, such as volatilization, emulsification, dissolution, chemical oxidation, photo-oxidation, and microbial oxidation, may reduce impacts of oil spills on coastal water quality in the Cook Inlet Planning Area (NRC 2003b; NOAA 2005). Dissolution, which is a small component of weathering, can be important to biological communities because the most soluble fractions are often the most toxic (Shen and Yapa 1988). Because oil is generally less dense than water, it would tend to float on the sea surface. Lighter oil fractions such as BTEX would readily evaporate from the surface and, therefore, would not be a continuing source of potential water contamination. Following a spill, light crude oils can lose as much as 75% of their initial volume to evaporation as the lighter components (e.g., BTEX) change from liquid to gas phase; medium-weight crude oils can lose as much as 40% (NRC 2003b).

Spills would tend to move in directions consistent with established circulation patterns for the planning area (i.e., northward along the Kenai Peninsula and southward along the Alaska Peninsula). Actual flow paths would be affected by winds, tides, ice cover, temperature, and cleanup activities.

If a large spill were to happen near port, there could be adverse effects on coastal waters. In such a low-energy environment (i.e., an environment in which there is limited wave and current activity), the oil would not be easily dispersed, and weathering could be slower than it would be in the open sea. Effects on water quality could persist if oil reached coastal wetlands and was deposited in fine sediments, becoming a long-term source of pollution because of remobilization. In such locations, spill cleanup might be necessary for the recovery of the affected areas. Potential impacts to water quality from spill cleanup activities are discussed below.

Assuming that all small sized (<1,000 bbl) and very small (<50 bbl) spills would not occur at the same time and place, water quality would rapidly recover without mitigation because of mixing, dilution, and weathering.

Under Arctic conditions (i.e., cold water and cold air temperatures), weathering processes, such as volatilization, would also be much slower than in warmer climates

(MMS 2008b); under calm conditions and cold temperatures in restricted waters, vertical mixing and dissolution would be reduced (MMS 2008b). If the spill were to occur on ice or under ice, oil would be trapped and essentially remain unchanged until breakup occurred and the ice began to melt. The volatile compounds from such a spill would be more likely to freeze into the ice within hours to days rather than dissolve or disperse into the water below the ice. A hydrocarbon plume in the water column underneath the ice could persist with concentrations that exceed background levels in Cook Inlet, as discussed in Section 3.4.2, for a distance greater than that in the open sea (MMS 2008b). Impacts on coastal waters from a large spill would depend on the season, type, and composition of the spill, weather conditions, and size of the spill.

Marine Waters. Accidental hydrocarbon releases in the marine environment can occur at the surface from tankers or platforms or at the seafloor from the wellhead or pipelines. The number of potential spills estimated for Cook Inlet marine waters are conservatively assumed to be the same as those discussed above for coastal waters. In general, oil spilled below the surface rises rapidly as droplets that coalesce to form a slick. Standard response procedures for a spill could then be used. In open marine waters, evaporation, advection, and dispersion generally reduce the effects of toxic oil fractions and their degradation products to below State and Federal criteria for hydrocarbon contamination. Sustained degradation of water quality to levels exceeding the chronic criterion of 0.015 ppm total hydrocarbon contamination is unlikely. However, levels could exceed this standard over several thousand square kilometers for a short period of time (about 30 days), depending on the size, location, and season of the spill. Marine spills would tend to move in directions consistent with established circulation patterns for the planning area (i.e., northward along the Kenai Peninsula and southward along the Alaska Peninsula). Actual flow paths would be affected by winds, tides, ice cover, temperature, and cleanup activities. The persistence of oil slicks would generally last less than 1 year. Large oil spills assumed under this alternative would become more likely as the volume of assumed oil production increases. Water quality would eventually recover, but recovery time could be decreased by oil-spill cleanup activities.

Spill Response and Cleanup. Spill response and cleanup activities in both coastal and marine waters could include, depending on location, use of chemical dispersants, *in situ* burning, use of vessels and skimmers, drilling of a relief well, and beach cleaning and booming (BOEMRE 2011j). Potential impacts to water quality from each of these spill response and cleanup activities are discussed above in Section 4.4.3.1.2. However, clean up of large spills in the open sea off of south central Alaska could be hindered by several factors. There could be limited access to oil slicks contained between ice floes during a large part of the year. There could also be reduced oil flow into recovery devices because of increased viscosity and precipitation of wax crystals, as well as decreased oil adhesion to the recovery unit material and a high percentage of free water in the recovered product due to mixing of the oil slick with slush ice and snow (MMS 2008b). In winter, icebreakers could affect the movement of spilled oil that may be trapped beneath or in the ice (BOEMRE 2011j).

If an oil spill occurred in winter, *in situ* burning would be limited by the lack of open water to collect oil and open water in which to burn it. If burning could occur in winter on a limited scale, sea ice would melt in the immediate vicinity of the burn.

4.4.3.2.3 Impacts of an Unexpected Catastrophic Discharge Event. A CDE is considered an unexpected, low-probability event unlikely to occur during routine operations (Section 4.4.2.2). For the Cook Inlet Planning Area, a low-probability CDE is assumed to have a volume of 75,000-125,000 bbl and a duration of 50–80 days (Table 4.4.2-2). A catastrophic discharge event in coastal or marine water could present sustained degradation of water quality from hydrocarbon contamination in exceedance of State and Federal water and sediment quality criteria. These effects could be significant depending upon the duration and area impacted by the spill. Additional effects on water quality could occur from response and cleanup vessels, *in situ* burning of oil, dispersant use, discharges and seafloor disturbance from relief well drilling, and activities on shorelines associated with cleanup, booming, beach cleaning, and monitoring. Impacts from the spill would again depend on the spill size and composition, weather conditions, and the location of the spill.

Broken ice occurs in the northern and western portions of lower Cook Inlet during fall and winter. If an open water spill were to occur at this time, the ice would contain the oil somewhat and reduce spreading. However, oil cleanup is also more difficult in broken ice conditions. Oil from spills occurring in the winter may be trapped under ice, resulting in localized degradation of water and/or sediment quality.

Impacts to water quality from the DWH event are discussed in Section 3.4.1.4. However, differences between the GOM and the Cook Inlet Planning Area in terms of seasonality, weather and wind patterns, sea ice, and surface water temperatures make extrapolations from the DWH event and a CDE in the Cook Inlet Planning Area problematic.

4.4.3.2.4 Impact Conclusions.

Routine Operations. Overall coastal and marine water quality impacts due to routine operations and operational discharges under the proposed action would be unavoidable. Compliance with NPDES permit requirements would reduce or prevent most impacts on receiving waters caused by discharges from normal operations. Water quality would recover when discharges ceased because of dilution, settling, and mixing. Impacts on water quality from routine operations associated with the Program are expected to be minor to moderate.

Expected Accidental Events and Spills. Expected accidental oil spills could reduce water quality, and these impacts would be unavoidable. In the presence of cold temperatures and ice, cleanup activities could be more difficult. The magnitude of the impacts would depend on the specific location affected and the nature and magnitude of the activity/accident. Small spills would be expected to result in minor, short-term impacts on coastal and marine water quality. A large spill in coastal waters could result in longer term impacts on water quality, but cleanup efforts would reduce the likelihood of long-term impairment. A large spill in marine waters would be expected to have temporary impacts on water quality; however, cleanup efforts and evaporation, dilution, and dispersion would minimize the long-term impacts. Impacts on water quality from large accidental spills associated with the Program are expected to be minor to major, depending on the location, timing, magnitude of the event, and effectiveness of spill response activities.

An Unexpected Catastrophic Discharge Event. In the unlikely event of a low-probability CDE, impacts to water quality would be moderate to major. A catastrophic discharge event could present sustained degradation of water quality from hydrocarbon contamination in exceedance of State and Federal water and sediment quality criteria. These effects could be significant depending upon the duration and area impacted by the spill. Impacts from the event would depend on the spill size and composition, weather conditions, the location of the spill, and the effectiveness of containment and cleanup responses.

4.4.3.3 Alaska – Arctic

This section analyzes impacts on coastal and marine waters in the Arctic region. Coastal waters, as defined here, include the bays and estuaries along the coast and State waters extending out to the inward boundary of the territorial seas. Marine waters extend from this boundary out to a water depth of 200 m (656 ft).

Table 4.1.1-1 details impacting factors associated with oil and gas activities and the development phase in which they can occur. The following factors affecting water quality have been identified: disturbance of bottom sediments, wastes and disposal, vessel traffic, and accidental spills. The water quality stressor activities associated with oil and gas development are shown in Table 4.4.3-1.

The 2006 Arctic NPDES General Permit for wastewater discharges from Arctic oil and gas exploration (No. AKG-33-0000) expired on June 26, 2011. USEPA reissued separate NPDES exploration general permits for the Beaufort Sea and the Chukchi Sea in January 2012 for public review. USEPA plans to reissue the final permits by October 2012. When exploration General Permits for the Beaufort and Chukchi Seas are reissued, operators will be required to apply for coverage under the reissued permits. Public comments on the proposed Arctic oil and gas exploration permits were collected through March 30, 2012. USEPA Region 10 will post updates to the following Web site as they become available: http://yosemite.epa.gov/r10/water.nsf/npdes+permits/arctic-gp.

Permits issued under Section 402 of the Clean Water Act for offshore activities must comply with any applicable water quality standards and/or Federal water quality criteria, as well as with Section 403 of the Clean Water Act. Water quality standards consist of the following: designated uses of the water body, water quality criteria to protect those uses and determine whether they are being attained, and anti-degradation policies to help protect high quality water bodies. Discharges from offshore activities near State water boundaries must comply with all applicable State water quality standards.

Section 403 of the Clean Water Act requires that NPDES permits for discharges to the territorial seas, the contiguous zone, and the ocean be issued in compliance with USEPA's regulations for preventing unreasonable degradation of the receiving waters. Prior to permit issuance, ocean discharges must be evaluated against USEPA's published criteria for determination of unreasonable degradation. Unreasonable degradation, as defined in the NPDES regulations (40 CFR 125.121[e]), encompasses the following:

1. Significant adverse changes in ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities.

2. Threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms.

3. Loss of aesthetic, recreational, scientific, or economic value that is unreasonable in relation to the benefit derived from the discharge.

Specific water quality effects information related to NPDES regulated discharges in the Beaufort Sea and Chukchi Sea Planning Areas is provided in draft form by USEPA (USEPA 2012a; USEPA 2012b).

Common impacts on water quality in both coastal and marine areas include those from vessel traffic, well drilling, and operational discharges. The types of impacts expected are the same as those discussed above in Section 4.4.3.1.

4.4.3.3.1 Impacts of Routine Operations.

Coastal Waters. Construction and installation of exploratory wells (up to 16 in the Beaufort Sea Planning Area and up to 20 in the Chukchi Sea Planning Area), development wells (up to 120 in the Beaufort Sea Planning Area and up to 280 in the Chukchi Sea Planning Area), subsea production wells (up to 10 in the Beaufort Sea Planning Area and up to 82 in the Chukchi Sea Planning Area), platforms (up to 4 in the Beaufort Sea Planning Area and up to 5 in the Chukchi Sea Planning Area), and offshore pipelines (up to 249 km [155 mi] in the Beaufort Sea Planning Area and up to 402 km [250 mi] in the Chukchi) would affect water quality. Such activities would disturb bottom sediments and increase the turbidity of the water in the area of the construction. Because pipelines in shallow waters are buried using a trenching method, installation would initially release sediment to the water column. Moderate impacts on water quality (i.e., turbidity) from such construction and installation activities would occur in the immediate area of the activity. These impacts would be local and short term as settling and mixing occurred.

Drilling muds and cuttings generated when installing exploration and delineation wells would be discharged at the well site. All drilling muds and cuttings associated with development and production wells would be treated and reinjected into the well or hauled offsite for disposal. For exploration wells, the volume of drilling fluids and cutting vary depending upon the well characteristics, but, in general, fluids average approximately 500 bbl/well and drill cuttings would comprise the equivalent of approximately 600 tons/well of dry rock. Thus, under the proposed action, up to 8,000 bbl of drilling fluids and up to 9,600 tons of drill cuttings could be disposed of in the waters of the Beaufort Sea Planning Area and up to 10,000 bbl of drilling fluids and up to 12,000 tons of drill cuttings could be disposed of in the waters of the Chukchi Sea Planning Area. Discharge of drilling muds and cuttings would increase turbidity in the vicinity of the well. The discharge would contain trace metal and hydrocarbon constituents that would be suspended in the water column and subsequently deposited on the sea floor. These drilling discharges must comply with NPDES permit requirements regarding the discharge amount, rate, and toxicity, which would greatly reduce the impact to water quality. USEPA has signaled its intent to eliminate the authorization to discharge non-aqueous drilling fluids and associated drill cuttings, allowing only WBMs and cuttings to be discharged except during active bowhead whaling activities in the Beaufort Sea, unless the Agency authorizes such discharge after review of the operator's evaluation of the feasibility of drilling facility storage capacity and land-based disposal alternatives.

Because of climatic conditions in the Arctic region, there would be a number of additional operations specific to the Arctic (e.g., constructing and maintaining ice roads [MMS 2002c] and ice islands). In addition to affecting the turbidity of coastal waters in the Arctic region, construction activities would also produce waste materials. Contaminants would also be released to the coastal waters during every ice breakup from fluids entrained in ice roads and ice islands (Skolnik and Holleyman 2005). Entrained contaminants from vehicle exhaust, grease, antifreeze, oil, and other vehicle-related fluids would pass directly into the sea at each breakup (MMS 2002c). These discharges are not expected to be major; however, they would occur throughout the life of a development area.

Construction of new onshore pipelines (up to 129 km [80 mi] in the Beaufort Sea Planning Area and none in the Chukchi Sea Planning Area) would also affect coastal water quality in the Arctic region. Proper siting of facilities and requirements associated with construction permits would largely mitigate these impacts. The impacts on water quality would range from negligible to minor, depending on site location and construction and mitigation activities.

The OCS service and construction vessel traffic to and from platform sites within the planning area (up to 12 vessel trips per week in the Beaufort Sea Planning Area and up to 15 vessel trips per week in the Chukchi Sea Planning Area) would also affect water quality through the permitted release of operational wastes. Compliance with applicable NPDES permits and USCG regulations would prevent or minimize most impacts on receiving waters.

Marine Waters. Routine operations that could affect marine water quality in the Arctic region include anchoring, mooring, drilling and well completion activities, well testing and cleanup operations, flaring/burning, facility installation and operations, support service activities, decommissioning, and site clearance. Activities such as dredging trenches for pipelines and constructing artificial islands would disturb the seafloor and increase the suspended sediment load in the water column. These suspended sediments have toxicity ranges that are generally described as nontoxic to slightly toxic (National Academy of Sciences 1983). Turbidity and plumes containing sediments would depend on the season, sediment grain size, the rate and duration of discharge within the disturbed areas, and the currents present. This additional suspended sediment load would be temporary, and impacts on water quality would be localized.

The majority of wastes generated during construction and development would consist of drill cuttings and spent muds (MMS 2002c). Drilling muds and cuttings generated when installing exploration and delineation wells would be discharged at the well site. All drilling muds and cuttings associated with development and production wells would be treated and reinjected into the well. Some waste also would be generated during operations from well-workover rigs. Domestic wastewater and produced waters generated by these activities would also be injected into the disposal well. Solid wastes, including scrap metal, would be hauled offsite for disposal at an approved facility. Impacts on water quality from these activities would be negligible.

Turbidity on a smaller scale would also result from retrieving anchors used to control the movement of vessels while dredging and setting pipes or placing platforms. These types of disturbances would not occur if drillships, which use dynamic positioning rather than anchors, were used, a standard procedure in Chukchi Sea exploration.

The OCS service and construction vessel traffic to and from platform sites within the planning area (up to 12 vessel trips per week in the Beaufort Sea Planning Area and up to 15 vessel trips per week in the Chukchi Sea Planning Area) would also affect water quality through the permitted release of operational wastes. Compliance with applicable NPDES permits and USCG regulations would prevent or minimize most impacts on receiving waters.

4.4.3.3.2 Impacts of Expected Accidental Events and Spills.

Coastal Waters. Accidental releases could affect the quality of coastal water in the Arctic region. The magnitude and severity of impacts would depend on the location of the spill, spill size, type of product spilled, weather conditions, and the water quality and environmental conditions at the time of the spill. Under the proposed action, the number and types of spills assumed to occur in the Arctic region include up to three large spills (i.e., ≥1,000 bbl): up to two spills at a volume of 1,700 bbl from pipelines and up to one spill at a volume of 5,000 bbl from a platform. Between 10 and 35 small spills with volumes between 50 and 999 bbl are assumed to occur and between 50 and 190 very small spills with volumes between 1 and 50 bbl (Table 4.4.2-1).

If a large spill were to occur in enclosed coastal waters or were driven by winds, tides, and currents into a semi-enclosed coastal area, water quality would be adversely affected. With limited wave and current activity in coastal waters, the oil would not be easily dispersed, and weathering could be slower than in the open sea (see discussion in Section 4.4.3.1.2). Under Arctic conditions (i.e., cold water and cold air temperatures), weathering processes, such as volatilization, would also be much slower than in warmer climates (MMS 2008b); under calm conditions and cold temperatures in restricted waters, vertical mixing and dissolution would be reduced (MMS 2008b). If the spill were to occur on ice or under ice, oil would be trapped and essentially remain unchanged until breakup occurred and the ice began to melt. The volatile compounds from such a spill would be more likely to freeze into the ice within hours to days rather than dissolve or disperse into the water below the ice. A hydrocarbon plume in the water column underneath the ice could persist with concentrations that exceed background levels of hydrocarbons in the Arctic, as discussed in Section 3.4.3, for a distance greater than that in the open sea (MMS 2008b). Spills in first-year ice would melt out in late spring or early summer. Spills in multi-year ice would melt out later in the summer or in subsequent summers. Spills released from the ice would be relatively unweathered and would have the characteristics of fresh oil. Impacts on coastal waters from a large spill would depend on the season, type and composition of the spill, weather conditions, and size of the spill.

Effects on water quality could persist even longer if oil were to reach coastal wetlands and be deposited in fine sediments, becoming a long-term source of pollution because of remobilization. In such locations, spill cleanup could be necessary for recovery of the affected areas. Shoreline cleanup operations could involve crews working with sorbents, hand tools, and heavy equipment. The magnitude and severity of impacts from such spills would depend on the nature of the coastal area associated with the spill, the spill size and composition, and the water quality and condition of resources affected by the spill.

Cleanup of large spills in the open sea could be hindered by several factors. There could be limited access to oil slicks contained between ice floes during a large part of the year. There could also be reduced oil flow into recovery devices because of increased viscosity and precipitation of wax crystals, as well as decreased oil adhesion to the recovery unit material and a high percentage of free water in the recovered product due to mixing of the oil slick with slush ice and snow (MMS 2008b). Impacts from the spill would again depend on the spill size and composition, weather conditions, and the location of the spill.

Based on the assumption that all small (<1,000 bbl) and very small (<50 bbl) spills do not occur at the same time and place, water quality would rapidly recover without mitigation, due to mixing, dilution, and weathering.

Marine Waters. Under Arctic conditions (i.e., cold water and air temperatures), weathering processes would be much slower than in warmer climates (MMS 2008b). Seasonality and the specific spill location would cause variability in effects (e.g., summer versus winter in the Beaufort and Chukchi Seas). If a spill were to occur, oil would be trapped and essentially remain unchanged until breakup occurred and the ice began to melt. The volatile compounds from such a spill would be more likely to freeze into the ice within hours to days rather than dissolve or disperse into the water below the ice. A hydrocarbon plume in the water column underneath the ice could persist with concentrations that are above background levels for a distance that would be five times greater than that in the open sea (MMS 2008b).

If it is assumed that all small (<1,000 bbl) and very small spills (<50 bbl) would not occur at the same time and place, water quality would rapidly recover without mitigation because of mixing, dilution, and weathering.

Spill Response and Cleanup. Spill response and cleanup activities in both coastal and marine waters could include, depending on location, use of chemical dispersants, *in situ* burning, use of vessels and skimmers, drilling of a relief well, and beach cleaning and booming (BOEMRE 2011j). Potential impacts to water quality from each of these spill response and cleanup activities are discussed above in Section 4.4.3.1.2. However, cleanup of large spills in the open sea within the Beaufort and Chukchi Seas could be hindered by several factors. There could be limited access to oil slicks contained between ice floes during a large part of the year. There could also be reduced oil flow into recovery devices because of increased viscosity and precipitation of wax crystals, as well as decreased oil adhesion to the recovery unit material and a high percentage of free water in the recovered product due to mixing of the oil slick with slush ice and snow (MMS 2008b). In winter, icebreakers could affect the movement of spilled oil that may be trapped beneath or in the ice (BOEMRE 2011j).

If an oil spill occurred in winter, *in situ* burning would be limited by the lack of open water to collect oil and open water in which to burn it. If burning could occur in winter on a limited scale, sea ice would melt in the immediate vicinity of the burn.

4.4.3.3.3 Impacts of an Unexpected Catastrophic Discharge Event. For the Chukchi Sea Planning Area, a low-probability CDE is assumed to have a volume of 1.4–2.2 million bbl and a duration of 40-75 days (Table 4.4.2-2). For the Beaufort Sea Planning Area, a CDE is assumed to have a volume of 1.7-3.9 million bbl with a duration of 60-300 days (Table 4.4.2-2). A CDE in coastal or marine waters in either planning area could present sustained degradation of water quality from hydrocarbon contamination in exceedance of State and Federal water and sediment quality criteria. These effects could be significant depending upon the duration and area impacted by the spill. Additional effects on water quality could occur from response and cleanup vessels, *in situ* burning of oil, dispersant use, discharges and seafloor disturbance from relief well drilling, and activities on shorelines associated with cleanup, booming, beach cleaning, and monitoring. Impacts from the event would again depend on the spill size and composition, weather conditions, and the location of the spill. Impacts to water quality from the DWH event are discussed in Section 3.4.1.4. However, differences between the GOM and the Beaufort and Chukchi Seas in terms of seasonality, weather and wind patterns, sea ice, and surface water temperatures make extrapolations from the DWH event and a CDE in the Beaufort or Chukchi Seas problematic.

Decomposition and weathering processes for oil are much slower in cold waters than in temperate regions. In marine waters, advection and dispersion would reduce the effects of a release of toxic oil fractions or their toxic degradation products, including products resulting from photo-oxidation. Isolated or coastal waters under thick ice or a fresh spill in rapidly freezing ice, however, would not be exposed to advection and dispersion. Spills released from the ice would be relatively unweathered and would have the characteristics of fresh oil. Before the oil was released from the ice, the contaminated ice could drift for hundreds of kilometers. If oil contacted a shoreline, mixed into the shoreline, and then dispersed, elevated concentrations of hydrocarbons could occur in the water and sediments offshore of the oiled shoreline.

4.4.3.3.4 Impact Conclusions.

Routine Operations. Overall coastal and marine water quality impacts due to routine operations and operational discharges under the proposed action would be unavoidable. Compliance with NPDES permit requirements would reduce or prevent most impacts on receiving waters caused by discharges from normal operations. Water quality would recover when discharges ceased because of dilution, settling, and mixing. Impacts on water quality from routine operations associated with the Program are expected to be minor to moderate.

Expected Accidental Events and Spills. Expected accidental oil spills could reduce water quality, and these impacts would be unavoidable. In the presence of cold temperatures and ice, cleanup activities could be more difficult. The magnitude of the impacts would depend on the specific location affected and the nature and magnitude of the activity/accident. Small spills would be expected to result in minor and short-term impacts on coastal and marine water quality. A large spill in coastal waters could result in longer term impacts on water quality, but cleanup efforts would reduce the likelihood of long-term impairment. A large spill in marine waters would be expected to have temporary impacts on water quality; however, cleanup efforts and evaporation, dilution, and dispersion would minimize the long-term impacts. Impacts on water quality from expected large accidental spills associated with the Program are expected to be minor to major, depending on the location, timing, magnitude of the event, and the effectiveness of containment and cleanup activities.

An Unexpected Catastrophic Discharge Event. In the unlikely event of a low-probability CDE, impacts to water quality would be moderate to major, depending on the location, timing, and magnitude of the event. A catastrophic discharge event could present sustained degradation of water quality from hydrocarbon contamination in exceedance of State and Federal water and sediment quality criteria. These effects could be significant depending upon the duration and area impacted by the spill. Impacts from the event would depend on the spill size and composition, weather conditions, the location of the spill, and the effectiveness of spill containment and cleanup activities.

4.4.4 Potential Impacts on Air Quality

4.4.4.1 Gulf of Mexico

In the GOM west of 87.5° W longitude, OCS air emissions are regulated by BOEM according to 30 CFR 250.302-304. BOEM reviews projected air emissions information from an operator submitting a plan for exploration or development activities. If the projected annual emissions exceed a certain threshold, which is determined by the distance from shore, the operator needs to perform a modeling analysis to assess air quality impacts on onshore areas. If the modeled concentrations exceed defined significance levels in an attainment area, which is an area that meets the National Ambient Air Quality Standards (NAAQS), best available control technology would be required on the facility. If the affected area is classified nonattainment, further emission reductions or offsets may be required. Projected contributions to onshore pollutant concentrations are also subject to the same limits that the USEPA applies to the onshore areas under its Prevention of Significant Deterioration (PSD) program (MMS 2007d).

Facilities located east of 87.5° W longitude would be under the USEPA jurisdiction, which regulates air emissions as prescribed in 40 CFR Part 55. For facilities located within 40 km (25 mi) of a State's seaward boundary, the regulations are the same as would be applicable if the emission source were located in the corresponding onshore area and would include State and local requirements for emission controls, emission limitations, offsets, permitting, testing, and monitoring. For facilities located beyond 40 km (25 mi) of a State's seaward boundary, the basic Federal air quality regulations apply, which include the USEPA emission standards for new sources, the PSD regulations, and Title V permits. PSD applies to sources that, depending on the source type, could potentially emit more than either 100 tpy or 250 tpy of a criteria pollutant or precursor. Title V applies to sources that could potentially emit more than 100 tpy of any regulated pollutant other than greenhouse gases (GHGs). In 75 FR 31514, the USEPA promulgated the Greenhouse Gas Tailoring Rule, bringing emissions of GHGs under the PSD and Title V requirements. New source GHG thresholds for PSD are 75,000 tpy CO_2e for sources already subject to PSD for another pollutant and 100,000 tpy CO_2e for other new sources.[16] For Title V, the thresholds are 100,000 tpy CO_2e and 100 tpy based on mass. Which threshold applies to a particular source, how the potential emissions are calculated, and what controls are required if the applicable threshold is exceeded are all issues determined in discussions with regulators during the air permit application and approval process (MMS 2007d).

The USEPA has established NAAQS for six criteria pollutants — nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter (PM; PM_{10}, PM with an aerodynamic diameter of 10 μm or less; and $PM_{2.5}$, PM with an aerodynamic diameter of 2.5 μm or less), carbon monoxide (CO), lead (Pb), and ozone (O_3) — because of their potential adverse effects on human health and welfare. The health and environmental effects of air pollutants have been summarized by the USEPA (USEPA 2011a). Ambient levels of criteria pollutants except Pb can contribute to respiratory illnesses, especially in persons with asthma, children, and the elderly, and PM and CO can also aggravate cardiovascular diseases.

Ozone Formation. O_3 in the atmosphere is formed by photochemical reactions involving primarily nitrogen oxides (NO_x) and volatile organic compounds (VOCs). It is formed most readily in the summer season, with high temperatures, lower wind speeds, intense solar radiation, and an absence of precipitation; high O_3 episodes are typically associated with slow-moving, high-pressure systems characterized by light winds and a shallow boundary layer (NRC 1992). O_3 can irritate the respiratory system, reduce lung function, and aggravate asthma. Repeated exposure to O_3 pollution for several months may cause permanent lung damage. Children, adults who are active outdoors, and people with respiratory problems are the most at risk from high O_3. High levels of O_3 are also accompanied by a mix of organic radicals, which also causes adverse health effects. O_3 interferes with the ability of plants to produce and store food, which makes them more susceptible to disease, insects, other pollutants, competition, and harsh weather. It may also cause damage to the leaves of trees and other plants, thereby affecting the health and appearance of vegetation in cities, National Parks, and recreation areas. O_3 may reduce forest growth and crop yields, potentially affecting species diversity in ecosystems (USEPA 2011a).

Acid Deposition and Visibility. Gaseous pollutants undergo various chemical reactions in the atmosphere to form small particles, which remain airborne for extended periods of time. NO_x compounds react with ammonia and moisture to form ammonium nitrate particles, which

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[16] There is an additional requirement that the source's GHG emissions also meet the 100/250 tpy non-GHG threshold based on mass (total GHG emissions without considering the global warming potential of individual gases).

contribute to $PM_{2.5}$ concentrations. SO_2 combines with moisture to form tiny sulfate particles, which may also contribute to adverse health effects. In addition, gaseous NO_x and SO_2 can dissolve into cloud water. These acidic chemicals eventually return to the ground in either wet (e.g., rain, snow) or dry (e.g., gases, particles) forms, commonly referred to as acid deposition or acid rain (USEPA 2011b). Dry deposition is equally as important as wet deposition. The deposition often takes place hundreds of kilometers from the source. Acid deposition can damage forests and crops, change the makeup of soil, and may, in some cases, make lakes and streams acidic and unsuitable for fish. Deposition of nitrogen from NO_x emissions also contributes to nitrogen load in water bodies, especially estuaries and near-coastal ecosystems. Acid deposition accelerates the decay of building materials and paints, including irreplaceable monuments, statues, sculptures, and other cultural resources. Particulate matter, including sulfate and nitrate particles and organic aerosols that form part of photochemical smog, reduces atmospheric visibility in areas including National Parks, Monuments, and Wilderness Areas (USEPA 2011b).

In general, the most important source of visibility degradation is from $PM_{2.5}$ in the 0.1 to 1 μm size range, which covers the range of visible light (0.4–0.7 μm) (Malm 1999). These particles are directly emitted into the atmosphere through fuel burning. However, other sources arise through chemical transformation of NO_2, SO_2, and VOCs into nitrates, sulfates, and carbonaceous particles. Existing visibility in the eastern United States, including the GOM States, is impaired due to $PM_{2.5}$ containing primarily sulfates and carbonaceous material. High relative humidity (over 70%) can play an important factor in visibility impairment, especially in the GOM coastal areas, where relative humidity is higher than 70% throughout the year. These particles are generally hygroscopic, and thus the absorption of water by the particulate matter makes them grow to a size that enhances their ability to scatter light and hence aggravates visibility reduction. Over the open waters of the GOM, a study of visibility from platforms off Louisiana revealed that significant reductions in Louisiana coastal and offshore visibility are almost entirely due to transient natural occurrences of fog (Hsu and Blanchard 2005). Episodes of haze are short-lived and affect visibility much less. Offshore haze can result from plume drift generated from coastal sources (MMS 2007d).

4.4.4.1.1 Impacts of Routine Operations. Under the proposed action, construction and operation of up to 2,100 exploration and delineation wells, up to 2,600 development and production wells, up to 12,100 km (7,500 mi) of new pipeline, up to 12 new pipeline landfalls, up to 6 new pipe yards, and up to 12 new natural gas processing facilities, and the removal of up to 275 platforms with explosives will result in emissions that could affect air quality in the GOM. These activities would generate emissions from stationary sources at the drilling/well sites and from support vessels and aircraft over the 40- to 50-year period of the Program (Table 4.4.1-1). There could be up to 600 vessel trips/wk and 5,500 helicopter trips/wk under the proposed action.

Emissions. The type and relative amounts of air pollutants generated by offshore operations vary according to the phase of activity. There are three principal phases of oil and gas activities operations: exploration, development, and production. Activities affecting air quality include seismic surveys, drilling activities, platform construction and emplacement, pipeline

TABLE 4.4.4-1 Estimated 40-Year Total Air Emissions from OCS Activities in the Gulf of Mexico Planning Areas, Proposed 2012-2017 Leasing Program

	Emissions (10^3 tons)					
Activity	NO_x	SO_x	PM_{10}	$PM_{2.5}$	CO	VOC
Development/production wells	314.17–604.52[a]	0.27–0.51	4.88–9.36	4.82–9.25	58.23–111.57	6.22–11.93
Drilling exploration/delineation wells	320.81–610.61	0.27–0.52	4.97–9.44	4.91–9.33	59.32–112.51	6.34–12.04
Helicopters	1.82–3.34	0.45–0.82	0.35–0.65	0.35–0.65	22.24–40.91	4.39–9.08
Oil tanker/barge cruising/idling – Lower 48 States	0.00–5.6	0.00–0.73	0.00–0.11	0.00–0.11	0.00–0.57	0.00–4.83
Pipe-laying vessels	32.56–94.99	5.53–16.13	1.23–3.58	1.23–3.58	6.76–19.71	1.23–3.58
Platform construction	7.31–13.17	1.05–1.88	0.17–0.31	0.17–0.31	0.95–1.71	0.17–0.31
Platform production	122.54–225.34	1.68–3.08	1.12–2.07	1.10–2.03	134.83–247.94	109.69–201.71
Platform removal	7.31–13.17	1.05–1.88	0.17–0.31	0.17–0.31	0.95–1.71	0.17–0.31
Support vessels	220.59–405.64	29.72–54.66	3.82–7.03	3.82–7.03	21.01–38.64	3.82–7.03
Survey vessels	3.99–7.4	0.48–0.89	0.06–0.11	0.06–0.11	0.33–0.62	0.06–0.11
Total	1,031.11–1,983.79	40.49–81.11	16.78–32.97	16.64–32.71	304.63–575.9	132.25–250.22

[a] The range of values reflects the low and high end of the exploration and development scenarios for the Program.

Sources: Industrial Economics, Inc. et al. 2012; Wolvovsky 2012.

laying and burial operations, platform operations, flaring, fugitive emissions, support vessel and helicopter operations, and evaporation of VOCs during transfers and spills. Principal emissions of concern are the criteria pollutants and their precursors: NO_x, sulfur oxides (SO_x),[17] PM_{10} and $PM_{2.5}$, CO, and VOC. Releases of toxic chemicals could be a concern around oil spills and *in situ* burning and especially during accidental releases of hydrogen sulfide (H_2S) at platforms.

Wilson et al. (2010) provided a comprehensive emission inventory of oil and gas activities in the GOM for the year 2008, showing that support vessels and platforms rank first and second, respectively, as NO_x emitters with natural gas engines being the largest source on platforms. Support vessels are the largest SO_x emitters, while the drilling rigs also emit large amounts of SO_x. Albeit small, the primary SO_x sources on platforms are diesel engines used in drilling. The largest sources of PM_{10} are support vessels, drilling rigs, and production platforms. VOCs come mostly from production platforms, where the primary sources are cold vents, followed by fugitive sources. Fugitive sources include oil and gas processing, pump and compressor seals, valves, connectors, and storage tanks. Natural gas engines on platforms account a considerable portion of CO emissions (Wilson et al. 2010).

The 40-year total air emissions from the proposed action were estimated using the most recently available exploration and development scenario for 2012-2017, as shown in Table 4.4.4-1. These emissions were estimated by BOEM (Wolvovsky 2012) using emission factors from the Offshore Environmental Cost Model (Industrial Economics, Inc. et al. 2011).

In terms of absolute amounts, the largest emissions would be NO_x followed by CO, with lesser amounts of VOC, SO_x, PM_{10}, and $PM_{2.5}$ in order of descending emissions. Under both the high and low scenarios, drilling and delineation wells would be the largest source of NO_x, PM_{10}, and $PM_{2.5}$ (helicopters are comparable for PM_{10} and $PM_{2.5}$), support vessels would be the largest source of SO_x, and platform production would be the largest source of CO and VOCs. Emissions from the Program would initially be lower in the first few years as exploratory wells were drilled and platforms started producing oil and gas. During the last half of the Program, emissions would decrease as production decreased and some platforms were removed (MMS 2007d).

It is estimated that about 10% of the crude oil produced in deep water in the GOM would be transported to shore via tanker, while in shallow waters about 1% of production would be transported by barge. The transport of crude oil would result in VOC emissions from loading operations and breathing losses during transit. VOC emissions would also occur during unloading and ballasting in port. There would also be emissions of NO_x, SO_2, and PM_{10} from the ships' engines (MMS 2007d).

Impacts on Criteria Pollutants Other Than Ozone. BOEM performed a cumulative air quality modeling analysis of platform emissions in a portion of the GOM in 1992 (MMS 1997b). The area modeled included most of the coastline of Louisiana and extended

[17] Sulfur dioxide (SO_2) belongs to the family of sulfur oxides (SO_x). For emissions, SO_2 accounts for most of SO_x, and thus these are used interchangeably.

eastward to include coastal Mississippi and Alabama. Facility emissions were obtained from the emissions inventory used in the GOM air quality study (MMS 1995a). The emission values were multiplied by a factor of 1.4 to account for growth. The modeled onshore annual average NO_2 concentrations were generally somewhat greater than 1 microgram per cubic meter ($\mu g/m^3$). The highest values appeared in the Mississippi River Delta region, where a maximum concentration of 6 $\mu g/m^3$ was calculated, which is 6% of the national standard for NO_2. The highest predicted annual, maximum 24-hr, and maximum 3-hr average SO_2 concentrations were 1.1, 13, and 98 $\mu g/m^3$, respectively. These values are 1, 4, and 7% of the NAAQS for the respective averaging periods. Modeling was not performed for PM_{10} or $PM_{2.5}$, but the concentrations would be lower because of lower emission rates. The projected emissions for the proposed action would be lower than the emissions used in the modeling and scattered further offshore; thus, the impacts would be correspondingly lower. Existing concentrations of NO_2, SO_2, PM_{10}, and $PM_{2.5}$ in the GOM coast States are well within the NAAQS, so emissions from the proposed action would not result in any exceedance of the NAAQS.

The highest predicted NO_2 and SO_2 concentrations in the 1992 emissions modeling were well within the maximum allowable PSD Class II increments for those pollutants. Any concentrations resulting from the emissions associated with the proposed action should also be within the PSD Class II increments.

The maximum allowable increase for the annual average NO_2 concentration in the Class I Breton National Wilderness Area (NWA) is 2.5 $\mu g/m^3$. The highest predicted annual average NO_2 concentration in Breton from the year 1992 emission sources was 3.6 $\mu g/m^3$, which exceeds the Class I increment and indicates that the question of increment consumption at Breton NWA could be of concern (MMS 1997b, 2007d).

The highest predicted SO_2 concentrations in Breton NWA were 0.3, 4.5, and 9.7 $\mu g/m^3$ for the annual, maximum 24-hr average, and maximum 3-hr average concentrations, respectively. The maximum allowable concentration increases for PSD Class I areas are 2.0, 5.0, and 25 $\mu g/m^3$, respectively. Based on this result, SO_2 concentrations from the proposed action would be within the Class I maximum allowable increases (MMS 1997b, 2007d).

Comparing Impacts to PSD Increments

Several points should be considered when air quality impacts are compared to PSD increments. First, the PSD program applies to individual sources, not programs. Emissions from an individual source such as a platform or set of platforms could differ from the emissions being modeled in a particular study. Second, increment tracking is a cumulative process that sets a maximum allowable increase above a baseline concentration. It is unlikely that a permitting agency would permit a single source to consume all of the increment. Last, PSD applies only to major sources, generally sources with the potential to emit more than 250 tons/yr, except for the 100 tons/yr threshold for 28 source categories. OCS oil and gas production activities are subject to a 250 tons/yr threshold. Regardless of the *actual* emissions, a source's *potential* emissions could exceed the 250 tons/yr threshold. Determining potential emissions and available PSD increment allowances requires consultation with the cognizant regulators.

Because of continuing concern about the combined impact of offshore and onshore emission sources on the PSD Class I increments in Breton NWA, BOEMRE has collected an emission inventory for OCS facilities located within 100 km (62 mi) of the Breton Class I area.

A modeling study (2000–2001) to the baseline years (1977 for SO_2 and 1988 for NO_2) revealed that none of the allowable SO_2 or NO_2 increments had been fully consumed (Wheeler et al. 2008). The maximum annual, 24-hr, and 3-hr SO_2 increments consumed with the Breton NWA were –1.07, 1.18, and 1.80 μg/m^3, respectively. A decrease in annual SO_2 concentration resulted from a general decrease in SO_2 emissions from onshore and offshore sources since 1977. The maximum allowable concentration increases for PSD Class I areas are 2.0, 5.0, and 25 μg/m^3, respectively. The maximum annual NO_2 increment consumed within the Breton NWA was 0.10 μg/m^3, for which the maximum allowable NO_2 increment is 2.5 μg/m^3. In addition, BOEM consults with the U.S. Fish and Wildlife Service (USFWS), the Federal land manager of the Breton NWA area, for plans within 100 km (62 mi) of Breton that exceed a certain emission threshold. The use of low-sulfur fuel is a requirement (MMS 2007d).

No modeling has been performed for CO. In OCS waters, CO emission sources less than about 7,000 tons/year would not have any significant effect on onshore air quality and are exempt from air quality review under BOEM air quality regulations (MMS 2007d). This is based on air quality modeling that was performed to support the BOEM air quality rules. As shown in Table 4.4.4-1, CO emissions from the proposed action are higher than 7,000 tons/year. However, CO emissions are comparable to NO_2 and SO_2 emissions, and their associated impacts are well within the NAAQS discussed above. In addition, CO standards (40,000 and 10,000 μg/m^3 for 1- and 8-hr averages, respectively) are more than one order of magnitude higher than those for NO_2 and SO_2. Therefore, no significant impacts from CO associated with the proposed action would be anticipated.

Impacts on Ozone. As discussed in MMS (2007d), the impacts from OCS activities on O_3 were evaluated in the GOM air quality study (MMS 1995a). The study focused on the O_3 nonattainment areas in southeast Texas and the Baton Rouge, Louisiana, areas. It was determined through modeling that OCS sources contributed little to onshore O_3 concentrations in either of these areas. At locations where the model predicted 1-hr average O_3 levels above 120 parts per billion (ppb), which was then the NAAQS, the OCS emissions contributed less than 2 ppb to the total concentrations. These contributions occurred in only a small geographic area during any particular episode. At locations where the model predicted O_3 levels were much less than 120 ppb, the highest OCS contributions were about 6–8 ppb. When the modeling was performed after doubling the OCS emissions, the highest OCS contributions at locations where the predicted O_3 levels exceeded the standard was 2–4 ppb.

Again, as noted in MMS (2007d), more recent O_3 modeling was performed using a preliminary GOM-wide emissions inventory for the year 2000 to examine the O_3 impacts with respect to the 1997 8-hr O_3 standard of 80 ppb (effective May 27, 2008, the 8-hr O_3 standard was lowered to 75 ppb). One modeling study focused on the coastal areas of Louisiana extending eastward to Florida (Haney et al. 2004). This study showed that the impacts of OCS emissions on onshore O_3 levels were very small, with the maximum contribution of 1 ppb or less at locations where the standard was exceeded. The other modeling effort dealt with O_3 levels in southeast Texas (Yarwood et al. 2004). The results of this study indicated a maximum contribution of 0.2 ppb or less to areas exceeding the standard.

Due to the complex, nonlinear nature of the photochemical production of ozone in the atmosphere, changing emissions of ozone precursors by a given percentage may not produce a corresponding percentage change in O_3 concentrations. However, the projected emissions from the proposed action would be smaller than the emissions used in the models to ensure that contributions to O_3 levels from actions associated with the proposed action would be smaller than the figures above.

Impacts on Visibility. The application of the VISCREEN visibility screening model (USEPA 1992) to individual OCS facilities has shown that the emissions are not large enough to significantly impair visibility. It is not known to what extent aggregate OCS sources contribute to visibility reductions. However, the individual emission sources from the proposed action are relatively small and scattered over a large area, and it is not expected that they would have a measurable impact on acid deposition or visibility (MMS 2007d).

Greenhouse Gas Emissions and Climate Change. Estimates were made of the 40-year total GHG emissions of CO_2, CH_4, and N_2O for all projected OCS oil and gas Program activities (Wolvovsky 2012). Emission estimates for the various activities were largely based on emission factors from the Offshore Environmental Cost Model (Industrial Economics, Inc. et al. 2011). Air emissions resulting from the Program were estimated by considering the exploration and development scenarios presented in Table 4.4.4-1. Emissions are given in terms of teragrams (Tg) of CO_2e, where one Tg is 10^{12} g (10^6 metric tons). This measure takes into account a global warming potential (GWP) factor, which accounts for the relative effectiveness of a gas to contribute to global warming with respect to the same amount CO_2. In these calculations, CH_4 is given a GWP of 21, while N_2O is given a GWP of 310.

Table 4.4.4-2 lists the 40-year total calculated emissions of CO_2, CH_4, and N_2O from activities associated with the Program and compares them with current (2009) U.S. GHG emissions from all sources (USEPA 2011l). The projected CO_2 emissions from the Program are about 0.025-0.049 % of all current CO_2 emissions in the United States. The Program CH_4 emissions are about 0.054-0.101% of the current CH_4 emissions in the United States, which is slightly higher than CO_2. The projected N_2O emissions from the Program are about 0.004-0.008% of all current N_2O emissions in the United States. If CO_2, CH_4, and N_2O emissions are combined, the Program emissions are about 0.027–0.046% and 0.027–0.045% of the nationwide total of three GHG emissions and of all GHG emissions, respectively. The estimated total global GHG emissions in 2005 were approximately 38,726 Tg CO_2e (74 FR 66539). The estimated Program GHG emissions are about 0.0046%–0.0078% of the total global GHG emissions.

As noted in Section 3.3, GHG emissions are one of the causes of climate change. Climate change is a global phenomenon and predicting climate change impacts requires consideration of large scale or even worldwide GHG emissions, not just emissions at a local level. Climate change predictive capability (modeling) lacks the ability to estimate the impact of GHGs from a particular source or sources such as oil and gas activities associated with the Program. What their impact, if any, would be is determined not only by the emissions from the oil and gas activities themselves, but also by the GHG emissions of other sources throughout the world and whether these other emissions are expected to increase or decrease. In addition, since

TABLE 4.4.4-2 Projected Greenhouse Gas Emissions from Oil and Gas Activities in the Gulf of Mexico Planning Areas, 2012-2017 Leasing Program[a]

Pollutant	2012-2017 Program[b] (Tg CO_2e)	2012-2017 GOM (Tg CO_2e)[c]	Total 2009 U.S. Emissions from All Sources (Tg CO_2e)	2012-2017 GOM as Percentage of Total 2009 U.S. Emissions
CO_2	58.30–117.27	55.72–106.79	5,505.2	0.025–0.049
CH_4	15.4–29.67	15–27.6	686.3	0.054–0.101
N_2O	0.47–0.95	0.47–0.91	295.6	0.004–0.008
$CO_2 + CH_4 + N_2O$	74.18–147.89	71.18–120.5	6,487.1	0.027–0.046
All GHGs[d]	74.18–147.89	71.18–120.5	6,633.2	0.027–0.045

[a] Emissions in the table represent 40-year totals, except the third column, which presents total 2009 U.S. emissions.

[b] Sum of the GHGs from GOM, Cook Inlet, and the Beaufort Sea and Chukchi Sea Planning Areas in this table and Tables 4.4.4-4 and 4.4.4-6.

[c] One Tg is equal to 10^{12} g, or 10^6 metric tons. The CO_2e for a gas is derived by multiplying the mass of the gas by the associated GWP, which accounts for the relative effectiveness of a gas to contribute to global warming with respect to the same amount CO_2. In these calculations, CH_4 is given a GWP of 21, while N_2O is given a GWP of 310.

[d] Total U.S. GHG emissions also include hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride emissions. Estimates of emissions from the Program were not made for these compounds, but they are assumed to be very small.

Sources: Industrial Economics, Inc. et al. 2012; USEPA 2011l; Wolvovsky 2012.

some GHG gases, such as CO_2, may persist in the atmosphere for up to a century, the potential impacts of any source may extend well beyond the active lifetime of the source or program. This said, given the small percentage contributions of oil and gas activities in the GOM to global GHG emissions, the potential impact on climate change would probably be small. Section 3.3 provides some baseline considerations for climate change and Section 4.4.3 and Sections 4.4.6 through 4.4-15 discuss potential impacts to specific impact areas.

4.4.4.1.2 Impacts of Expected Accidental Events and Spills. Under the proposed action, the number and types of spills assumed to occur in the GOM include up to eight large spills (≥1,000 bbl) from both pipeline and platforms including one tanker spill and between 235 and 470 small spills (<1,000 bbl) over the 40- to 50-year period of the Program (Table 4.4.2-1). Evaporation of oil from these spills and emissions from spill response and cleanup activities including *in situ* burning, if used, have the potential to affect air quality in the GOM.

Spills and *In Situ* Burning. Evaporation of small accidental oil spills would cause small, localized increases in VOCs. Most of the emissions would occur within a few hours of the spill and would decrease after that period. Large spills would result in emissions over a large area and a longer period of time. The impacts at a given location would depend on the size, location, and duration of the spill and meteorological conditions such as wind speed and direction. Hanna and Drivas (1993) modeled the emissions of various hydrocarbon compounds from a large spill. A number of these compounds, including BTEX and hexane, are classified by the USEPA as hazardous air pollutants. The results showed that these compounds evaporate almost completely within a few hours after the spill occurs. Ambient concentrations peak within the first several hours after the spill starts and are reduced by two orders of magnitude after about 12 hr. The heavier compounds take longer to evaporate and may not peak until about 24 hr after spill occurrence. Total ambient VOC concentrations are high in the immediate vicinity of an oil spill, but concentrations are much reduced after the first day (MMS 2007d). Spreading of the spilled oil and action by winds, waves, and currents would further disperse VOC concentrations to extremely low levels over a relatively larger area. Concentrations of criteria pollutants would remain well within NAAQS (MMS 2008b). Over time, air quality would return to pre-spill conditions.

Diesel fuel oil could be spilled either in transit or from accidents involving vehicles, vessels, or equipment. A diesel spill would evaporate faster than a crude oil spill. Ambient hydrocarbon concentrations would be higher than those of a crude oil spill but would persist for a shorter time. Also, because any such spill probably would be smaller than some potential crude oil spills, any air quality effects from a diesel spill likely would be lower than those for other spills (MMS 2008b).

In situ burning of spilled crude or diesel would generate a plume of black smoke and emissions of NO_2, SO_2, CO, PM_{10}, and $PM_{2.5}$ that would temporarily affect air quality, but the effects would be small. Fingas et al. (1995, 2011) describe the results of a monitoring program of a burn experiment at sea. The program involved extensive ambient measurements during two experiments in which approximately 300 bbl of crude oil was burned. During the burn, CO, SO_2, and NO_2 were measured only at background levels and were frequently below detection levels. Ambient levels of VOCs were high within about 100 m (328 ft) of the fire, but were significantly lower than those associated with a nonburning spill. Polyaromatic hydrocarbons (PAHs) were largely burned by the fire and were lower in soot than in the oil. Particulates at sea level were of concern only up to 150 m (492 ft) downwind. Measured concentrations of PAHs were low. It appeared that a major portion of these compounds was consumed in the burn. Effects of *in situ* burning for spilled diesel fuel would be similar to those associated with a crude oil spill (MMS 2008b).

A major component of the pollution from a fire would be soot. Soot would cling to plants near the fire but would tend to clump and wash off vegetation in subsequent rains. Potential contamination of shoreline and onshore vegetation would be limited, however, because oil and gas activities under the proposed action would be at least 15 km (9.3 mi) offshore, with the exception of any oil- or gas-transport pipelines (MMS 2008b).

Smoke from burning crude oil would contain PAHs. Benzo(a)pyrene, which often is used as an indicator of the presence of carcinogenic varieties of PAHs, is present in crude oil smoke in very small amounts, but in quantities approximately three times larger than in unburned oil (Evans 1988). Investigators have found that, overall, the oily residue in smoke plumes from crude oil is mutagenic, although not highly so. McGrattan et al. (1995) modeled smoke plumes associated with *in situ* burning. Modeling has shown that the surface concentrations of particulate matter do not exceed the health criterion of 150 μg/m^3 beyond about 5 km (3 mi) downwind of an *in situ* burn. This result appears to be supported by field experiments conducted off Newfoundland and in Alaska (MMS 2007d). This is quite conservative, as this health standard is based on a 24-hr average concentration rather than a 1-hr average concentration. After the burn, air quality would rapidly return to pre-burn conditions.

Hydrogen Sulfide. An accidental release of H_2S in the atmosphere could present a serious hazard to platform workers and persons in close proximity to a platform. H_2S concentrations of 20 ppm, the OSHA ceiling level that must not be exceeded during any part of the workday, cause irritation to exposed persons within minutes and concentrations of 500 ppm are deadly. All OCS operators involved in production of sour gas or oil that could result in atmospheric H_2S concentrations above 20 ppm are required to file an H_2S Contingency Plan with BOEM. The plan contains measures to prevent serious injury or death to personnel. Under a worst-case scenario of an accidental release at a very large facility with a throughput of 100 million cubic feet of gas per day with high H_2S concentration levels (on the order of 20,000 ppm), near-calm wind, and stable atmospheric conditions, the H_2S levels are predicted to be 500 ppm at about 1 km (0.6 mi) from the facility and 20 ppm at several kilometers from the source (MMS 2001c). Most "sour gas" facilities have H_2S concentrations below 500 ppm, which would result in H_2S levels of 20 ppm that are confined to an area within the dimensions of a typical platform (MMS 2007d).

In the case of an aquatic H_2S release, the gas is soluble in water, so a small gas leak would result in almost complete dissolution into the water column. Larger leaks would result in less dissolution and could result in release into the atmosphere if the surrounding waters reach saturation. Because the oxidation of H_2S in water takes place slowly, there should not be any appreciable zones of hypoxia. H_2S levels can have adverse impacts on mammals, birds, and fish (MMS 2001c).

4.4.4.1.3 Impacts of an Unexpected Catastrophic Discharge Event. For the purposes of analysis, a low-probability CDE event in the GOM is assumed to range in size from 900,000 and 7,200,000 bbl, and have a duration of 30–90 days (Table 4.4.2-2). Evaporation of oil from these spills and emissions from spill response and cleanup activities including *in situ* burning, if used, have the potential to result in minor to moderate impacts to air quality in the GOM.

A CDE in the GOM could emit regulated pollutants into the atmosphere. This may affect air quality impacts during some phases of the event. The greatest impacts on air quality conditions would occur during the initial explosion of gas and oil and during the spill response and cleanup. Impacts could continue for days during the initial event and could continue for months during spill response and cleanup. Therefore, while the impacts could be large during these two phases, overall, the emissions from a CDE would be temporary and, over time, air quality in the GOM would return to pre-event conditions (BOEMRE 2011j).

In a CDE, oil may be burned to prevent it from entering sensitive habitats. During an *in situ* burn, the conditions exist (i.e., incomplete hydrocarbon combustion and the presence of chlorides in seawater) such that dioxins and furans could potentially form. (Dioxins and furans are a family of extremely persistent chlorinated compounds that magnify in the food chain, and dioxins are a group of potentially cancer-causing chemicals.) A total of 410 controlled burns (corresponding to about 5% of the total leaked oil) were conducted during the DWH event (Lubchenco 2010). Measurements of dioxins and furans during the DWH event *in situ* burning were made and their emission factors were derived (Aurell and Gullett 2010). These measurements were taken in the plume at locations to which the public and workers would not generally have access. The estimated levels of dioxins and furans produced by the *in situ* burns were similar to those from residential woodstove fires and slightly lower than those from forest fires, according to USEPA researchers (Schaum et al. 2010), and thus, concerns about bioaccumulation in seafood were alleviated. The reports found that while small amounts of dioxins were created by the burns, workers, onshore residents, and residents consuming fish would all have lifetime incremental cancer risks less than 6×10^{-8}, well below USEPA's target risk level of 10^{-4} to 10^{-6}.

Although there are relatively few studies on air quality impacts to human health following oil spills, some lessons can be learned from the 1991 Kuwaiti oil field. In the Kuwaiti event, 600 oil wells were set on fire. These burnings produced a composite smoke plume of gaseous constituents (e.g., NO_x, SO_x, CO_2, etc.), acid aerosols, VOCs, metal compounds, PAHs, and particulate matter. Petruccelli et al. (1999) found that soldiers' reported eye and upper respiratory tract irritation, shortness of breath, cough, rashes, and fatigue were associated with proximity to the Kuwaiti oil fires and that the incidence of symptoms generally decreased after the soldiers left Kuwait. Military personnel deployed to the Persian Gulf War have reported a variety of symptoms attributed to their exposures, including asthma and bronchitis, but Lange et al. (2002) and Thorn et al. (2002) did not find that exposures to oil fire smoke caused respiratory symptoms among veterans. Smith et al. (2002) found that, despite some limitations in the study, the data they analyzed did not indicate that Gulf War veterans have an increased risk of postwar morbidity from exposure to Kuwaiti oil well-fire smoke. However, there may well be differences in exposure and pollutants emitted between the widespread, uncontrolled Kuwaiti oil field fires over land and the DWH event fires involving controlled burns over water.

There would be some residual air quality impacts after the well is capped or "killed." As most of the oil would have been burned, evaporated, or weathered over time, air quality would return to pre-oil spill conditions. While impacts on air quality are expected to be localized and temporary, adverse effects that may occur from the exposure of humans and wildlife to air pollutants could have long-term consequences (BOEMRE 2011a).

4.4.4.1.4 Impact Conclusions.

Routine Operations. Routine operations in the GOM would result in levels of NO_2, SO_2, PM_{10}, and $PM_{2.5}$ well within the NAAQS at onshore locations. The incremental concentrations of NO_2, SO_2, and PM_{10} would be well within the maximum allowable PSD increments. No significant impacts from CO would be anticipated. Emissions estimates for all activities (OCS and non-OCS) show that OCS activities would contribute less than 2% of the total O_3 in areas with levels at times above the standard levels. It would not be expected that emissions from the proposed action would have a measurable impact on acid deposition or visibility. Given the small percentage contributions of routine Program operations to global GHG emissions, their potential impact on climate change would be small. Therefore, impacts to air quality from routine operations associated with the Program in the GOM are expected to be minor.

Expected Accidental Events and Spills. Spill impacts at a given location would depend on the size, location, and duration of the spill and meteorological conditions such as wind speed and direction. Evaporation of small accidental oil spills would cause small localized increases in VOCs. Most of the emissions would occur within a few hours of the spill and would decrease thereafter. Large spills (≥1,000 gal) would result in VOC increases over a larger area and a longer period of time. Most of the VOCs considered hazardous by USEPA are reduced by 99% within 12 hr after a spill. Heavier compounds take longer to evaporate, and therefore air concentrations may not peak until 24 hr after the spill. VOC concentrations in the immediate vicinity of the spill could be high during the first day but concentrations of criteria pollutants would remain within the NAAQS. Over time, air quality would return to pre-spill conditions. Therefore, impacts from small spills would be minor. Impacts from large spills could be moderate in the immediate vicinity of the spill for a short time after the spill, but would be minor after about 12 hr. Air quality impacts from a small or large diesel spill would be less than from an oil spill, and thus would be minor.

In situ burning of spilled crude or diesel would generate emissions of NO_2, SO_2, CO, PM_{10}, and $PM_{2.5}$. In general, particulates would not exceed 150 $\mu g/m^3$ beyond about 5 km (3 mi) downwind of an *in situ* burn. After the burn, air quality would return to pre-burn conditions. Thus, the air quality impacts of *in situ* burns of small spills (<1,000 bbl) would be minor. Air quality impacts of *in situ* burns of large spills could be moderate, but would rapidly return to minor after the burn ceased.

An accidental release of H_2S to the atmosphere could present a serious hazard to platform workers and persons close to the platform. OCS operators involved with sour gas production must have an H_2S Contingency Plan containing measures to prevent serious injury or death to workers. Most sour gas facilities have H_2S concentrations that would result in H_2S levels above the OSHA ceiling level within the dimensions of a typical platform. With the Contingency Plan mitigating impacts, accidental releases of H_2S would cause minor to moderate air impacts.

An Unexpected Catastrophic Discharge Event. In the event of an unexpected CDE, the greatest impacts on air quality would occur during the initial explosion of gas and oil and during the spill response and cleanup. Impacts could continue for days during the initial event and for months during the spill response and cleanup. Despite the length of time that could be involved, emissions from a CDE would be temporary and, over time, air quality in the GOM would return to pre-event conditions.

If *in situ* burning is used during the response to a CDE, carcinogenic dioxins and furans could be formed. These chemicals can bioaccumulate in the food chain. Studies performed during the DWH event indicated that levels of these chemicals were about the same as levels from residential wood stoves and forest fires, so that bioaccumulation is not expected to be a problem. Although dioxins were created during DWH burns, reports found that workers, onshore residents, and residents consuming fish had incremental lifetime cancer risks well below USEPA's target risk level. Although there may be differences between exposure and pollutants emitted between the uncontrolled Kuwaiti oil field fires over land and the controlled DWH burns over water, one study concluded that symptoms reported by soldiers and associated with proximity to the Kuwaiti fires decrease after leaving Kuwait. Other studies concluded that exposure to oil fire smoke did not cause respiratory symptoms among veterans and that there was no increase in morbidity from exposure to smoke from Kuwaiti oil well fires.

There would be some residual air quality impacts after the well was capped. Over time, air quality would return to pre-event conditions. While impacts on air quality are expected to be temporary, adverse effects may occur from the exposure of humans and wildlife to air pollutants that could have long-term consequences.

Overall, the air quality impacts of an unexpected CDE, including *in situ* burning, in the GOM could be moderate during the initial release and during the spill response and cleanup, but would become minor after the well was capped.

4.4.4.2 Alaska – Cook Inlet

The OCS facilities located off the coast of Alaska within the Cook Inlet would be under the jurisdiction of the USEPA, which regulates air emissions as prescribed in 40 CFR Part 55. For facilities located within 40 km (25 mi) of a State's seaward boundary, the regulations are the same as would be applicable if the emission source were located in the corresponding onshore area, and would include State and local requirements for emission controls, emission limitations, offsets, permitting, monitoring, testing, and reporting. For facilities located more than 40 km (25 mi) from a State's seaward boundary, the USEPA air quality regulations apply, for new sources, PSD regulations, and Title V permits. PSD applies to sources that could potentially emit more than either 100 tpy or 250 tons per year (tpy) of a criteria pollutant or precursor. Title V applies to sources that could potentially emit more than 100 tpy of any regulated non-GHG pollutant. In 75 FR 31514, the USEPA promulgated the Greenhouse Gas Tailoring Rule, bringing emissions of GHGs under the PSD and Title V requirements. New source GHG thresholds for PSD are 75,000 tpy CO_2e for sources already subject to PSD for another pollutant and 100,000 tpy CO_2e for other new sources.[18] For Title V, the thresholds are 100,000 tpy CO_2e and 100 tpy on a mass basis. Which threshold applies to a particular source, how the potential emissions are calculated, and what controls are required if the applicable threshold is exceeded are all issues determined in discussions with regulators during the air permit application and approval process.

[18] There is an additional requirement that the source's GHG emissions also meet the 100/250 tpy non-GHG threshold based on mass (total GHG emissions without considering the global warming potential of individual gases).

The USEPA has established NAAQS for six criteria pollutants — NO_2, SO_2, PM_{10} and $PM_{2.5}$, CO, Pb, and O_3 — because of their potential adverse effects on human health and welfare. The health and environmental effects of air pollutants have been summarized by the USEPA (USEPA 2011a). Ambient levels of criteria pollutants other than Pb can contribute to respiratory illnesses, especially in persons with asthma, children, and the elderly, and PM and CO can also aggravate cardiovascular diseases.

Ozone Formation. O_3 in the atmosphere is formed by photochemical reactions involving primarily NO_x and VOCs. It is formed most readily in the summer season, with high temperatures, lower wind speeds, intense solar radiation, and an absence of precipitation; high-O_3 episodes are typically associated with slow-moving, high-pressure systems characterized by light winds and shallow boundary layers (NRC 1992). Conditions in Alaska are seldom favorable for significant O_3 formation, primarily due to low ambient temperature and lack of sufficient emissions of VOC to initiate the chemical reaction that forms ozone in the presence of sunlight. At Kodiak, for example, the highest monthly mean daily maximum of 61.0°F occurs in August, when the highest temperature is 86°F (NCDC 2011a). However, measurements taken at several locations have found moderate levels of ozone in Alaska, about 34% and 54% of the 1-hr (revoked in 2005) and 8-hr NAAQS, based on data from Wainwright and Point Lay for 2009 and 2010 and about 61% and 67% of the NAAQS for data taken at five locations on the North Slope for various periods between 1999 and 2007 (USEPA 2010d, 2011s).

Acid Deposition and Visibility. Gaseous pollutants undergo various chemical reactions in the atmosphere to form small particles, which remain airborne for extended periods of time. NO_x compounds react with ammonia and moisture to form ammonium nitrate particles, which contribute to $PM_{2.5}$ concentrations. SO_2 combines with moisture to form tiny sulfate particles, which may also contribute to adverse health effects. In addition, gaseous NO_x and SO_2 can dissolve into tiny suspended water droplets that form clouds. These acidic chemicals eventually return to the ground in either wet (e.g., rain, snow) or dry (e.g., gases, particles) forms, commonly referred to as acid deposition or acid rain (USEPA 2011b). Dry deposition and wet deposition are equally important. The deposition often takes place hundreds of miles from the source. Acid deposition can damage forests and crops, change the makeup of soil, and in some cases may make lakes and streams acidic and unsuitable for fish. Deposition of nitrogen from NO_x emissions also contributes to nitrogen load in water bodies, especially estuaries and near-coastal ecosystems. Acid deposition accelerates the decay of building materials and paints, including those of irreplaceable monuments, statues, sculptures, and other cultural resources. Particulate matter, including sulfate and nitrate particles and organic aerosols that form part of photochemical smog, reduces atmospheric visibility. Atmospheric pollutants adversely affect visibility in many national parks and monuments, as well as wilderness areas (USEPA 2011b).

The most important source of visibility degradation is from $PM_{2.5}$ in the 0.1- to 1-μm size range, which covers the range of visible light (0.4–0.7 μm) (Malm 1999). These particles are directly emitted into the atmosphere through fuel burning. However, other sources arise through the chemical transformation of NO_2, SO_2, and VOCs into nitrates, sulfates, and carbonaceous particles. Existing visibility in Alaska is generally good because of the absence of large emission sources.

4.4.4.2.1 Impacts of Routine Operations. The Cook Inlet OCS experiences open-water conditions throughout the year, except in small northern portions of the planning area from January to March (MMS 2003a).

Under the proposed action, construction and operation of up to 12 exploration and delineation wells, up to 114 development and production wells, up to 241 km (150 mi) of new offshore pipeline, up to 169 km (105 mi) of new onshore pipeline, and up to 1 new pipeline landfall would be required before adverse air quality impacts would occur in Cook Inlet. These activities would generate emissions from stationary sources at the drilling/well sites and from support vessels and aircraft over the 40-year period of the Program (Table 4.4.1-3). There could be up to 3 vessel trips/week and 3 helicopter trips/week under the proposed action.

Emissions. The type and relative amounts of air pollutants generated by offshore operations vary according to the phase of activity. There are three principal phases of OCS operations: exploration, development, and production. Activities affecting air quality include seismic surveys; drilling activities; platform construction and emplacement; pipeline laying and burial operations; platform operations; flaring; fugitive emissions; support vessel and helicopter operations; and evaporation of VOCs during transfers and spills. Principal emissions of concern are the criteria pollutants and their precursors: NO_x, SO_2, PM_{10}, and $PM_{2.5}$, CO, and VOCs.

Releases of toxic chemicals could be a concern around oil spills and *in situ* burning and especially during accidental releases of H_2S at platforms. Other sources of pollutants related to OCS operations are accidents such as losses of well control and oil spills. Spill emissions consist primarily of VOCs, while fires and *in situ* burning produce criteria pollutants along with hazardous air pollutants.

The 50-year total air emissions from the proposed action in the Cook Inlet were estimated using the most recent available exploration and development scenarios for 2012–2017, as shown in Table 4.4.4-3. These emissions were estimated by BOEM (Wolvovsky 2012), using emission factors from the Offshore Environmental Cost Model (Industrial Economics, Inc. et al. 2011).

Oil and gas activity emissions from the Program for the Cook Inlet are relatively small in comparison to those other planning areas. In terms of absolute amount, the main emissions would be NO_x followed by CO and VOCs, with lesser amounts of SO_x, PM_{10} and $PM_{2.5}$ in order of descending emissions. Emissions from the Program would initially be lower in the first few years as exploratory wells were drilled and platforms started producing oil and gas. During the last half of the 50-yr Program, emissions would decrease as production decreased and some platforms were removed (MMS 2007d).

Impacts on Criteria Pollutants Other Than Ozone. Air quality modeling for NO_2, SO_2, and PM_{10} were conducted for a lease sale in the Cook Inlet Planning Area (MMS 2003a). Potential air quality impacts were estimated by using the Offshore and Coastal Dispersion model for both exploratory drilling and a production facility. Potential emission sources were placed so as to maximize potential air quality impacts on the Tuxedni Wilderness Area (WA), which is a PSD Class I area in the Cook Inlet. The highest predicted NO_2 concentration in the Tuxedni WA was 0.27 $\mu g/m^3$, about 11% of PSD Class I maximum allowable increment of 2.5 $\mu g/m^3$. For

TABLE 4.4.4-3 Estimated 50-year Total Air Emissions from OCS Activities in the Cook Inlet Planning Area, Proposed 2012-2017 Leasing Program

	Emissions (10^3 tons)					
Activity	NO_x	SO_x	PM_{10}	$PM_{2.5}$	CO	VOC
Development/production wells	0.80–2.18[a]	0.16–0.44	0.06–0.15	0.06–0.15	0.14–0.39	0.00–0.01
Drilling exploration/delineation wells	0.08–0.23	0.02–0.05	0.01–0.02	0.01–0.02	0.01–0.04	0.00–0.00
Helicopters	0.01–0.04	0.00–0.01	0.00–0.01	0.00–0.01	0.16–0.52	0.03–0.10
Pipe-laying vessels	0.33–1.99	0.06–0.34	0.01–0.08	0.01–0.08	0.07–0.41	0.01–0.08
Platform construction	0.01–0.02	0.00–0.00	0.00–0.00	0.00–0.00	0.00–0.00	0.00–0.00
Platform production	0.90–2.87	0.01–0.04	0.01–0.03	0.01–0.03	0.99–3.16	0.81–2.57
Platform removal	0.01–0.02	0.00–0.00	0.00–0.00	0.00–0.00	0.00–0.00	0.00–0.00
Support vessels	1.63–5.16	0.22–0.7	0.03–0.09	0.03–0.09	0.15–0.49	0.03–0.09
Survey vessels	0.02–0.06	0.00–0.01	0.00–0.00	0.00–0.00	0.00–0.01	0.00–0.00
Total	3.79–12.57	0.47–1.58	0.11–0.37	0.11–0.37	1.54–5.76	0.89–2.85

[a] The range of values reflects the low and high end of the exploration and development scenarios for the Program.

Sources: Industrial Economics, Inc. et al. 2012; Wolvovsky 2012.

SO_2, the highest predicted annual average, maximum 24-hr, and maximum 3-hr average concentrations in the Tuxedni WA were 0.02, 0.58, and 2.7 μg/m^3, respectively, for which PSD Class I incremental limits are 2, 5, and 25 μg/m^3. For PM_{10}, the highest annual average and 24-hr average concentrations in Tuxedni WA were predicted to be 0.02 and 0.51 μg/m^3, for which PSD Class I incremental limits are 4 and 8 μg/m^3. The highest onshore pollutant concentrations were lower than or comparable to those in the Tuxedni WA and thus less than the NAAQS and the PSD Class II incremental limits.

Comparing Impacts to PSD Increments

Several points should be considered when air quality impacts are compared to PSD increments. First, the PSD program applies to individual sources, not programs. Emissions from an individual source such as a platform or set of platforms could differ from the emissions being modeled in a particular study. Second, increment tracking is a cumulative process that sets a maximum allowable increase above a baseline concentration. It is unlikely that a permitting agency would permit a single source to consume the entire increment. Last, PSD applies only to major sources, generally sources with the potential to emit more than 250 tons/yr, except the 100 tons/yr threshold for 28 source categories. OCS oil and gas production activities are subject to a 250 tons/yr threshold. Regardless of the *actual* emissions, a source's potential emissions could exceed the 250 tons/yr threshold. Determining *potential* emissions and available PSD increment allowances require consultation with the cognizant regulators.

If applicable under the PSD or Title V regulations, each project in the Program would apply the best available control technology according to USEPA and State regulations, and pollutant concentrations would have to meet the PSD incremental limits. Existing pollutant concentrations in the Cook Inlet are well within the NAAQS (MMS 2003a). The small additional concentrations from the Program would not be expected to result in levels that equal or exceed the NAAQS.

Impacts on Ozone. As noted above, although ozone does form in Alaska, conditions are seldom favorable for significant O_3 formation because of the low ambient temperature and the lack of sufficient emissions of VOC to initiate the chemical reaction with NO_x and sunshine required to form ozone. Thus a significant increase in O_3 concentrations onshore is not likely to result from oil and gas activities associated with the proposed action. OCS activities would also be relatively small and separated from each other, diminishing the combined effects from these activities and greatly increasing atmospheric dispersion of pollutants before they reach shore. The proposed activities would not be expected to cause any exceedances of the O_3 standard (MMS 2008b).

Impacts on Visibility. A number of visibility screening runs were performed using the VISCREEN model to evaluate potential effects of oil and gas activities on visibility in the Tuxedni WA (MMS 2003a). For an exploration project located 12 km (7.5 mi) distant from the Tuxedni WA, the model results exceed the screening criteria when the wind blows directly from the facility to the Tuxedni WA, under the worst-case meteorological conditions with a wind speed of 1 m/s (2.2 mph) and stable atmosphere. If the screening criteria are exceeded, it indicates the possibility that a plume generated by the emissions would be visible by an observer within Tuxedni WA. However, it does not provide a measure of any general visibility effects in the area, such as regional haze. It is estimated that this scenario would occur less than 1% of the time. For distances larger than 50 km (31 mi), the screening criteria were not exceeded. Under average meteorological conditions, it is estimated that a plume would not be visible.

Given that oil and gas sources are relatively small and would be scattered over a large area, it is not expected that they would have a measureable impact on visibility. However, a more refined analysis might be needed during the permitting process to more precisely evaluate any effects of oil and gas activities on visibility.

Greenhouse Gas Emissions and Climate Change. Estimates were made of the 50-year total GHG emissions of CO_2, CH_4, and N_2O for all projected activities associated with the Program (Wolvovsky 2012). Emission estimates for the various activities were largely based on emission factors from the Offshore Environmental Cost Model (Industrial Economics, Inc. et al. 2011). Air emissions resulting from the Program were estimated by considering the exploration and development scenarios presented in Table 4.4.1-3. Emissions are given in terms of (Tg) of CO_2e, where 1 Tg is 10^{12} g (10^6 metric tons). This measure takes into account a Global Warming Potential (GWP) factor that accounts for the relative effectiveness of a gas to contribute to global warming with respect to the same amount of CO_2. In these calculations, CH_4 is given a GWP of 21, while N_2O is given a GWP of 310.

Table 4.4.4-4 lists the total calculated emissions (25-year totals for the low scenario and 30-year totals for the high scenario) of CO_2, CH_4, and N_2O from activities associated with the Program and compares them with current (2009) U.S. GHG emissions from all sources (USEPA 2011l). The projected CO_2 emissions from the Program are about 0.00038–0.00095% of all current CO_2 emissions in the United States. The Program CH_4 and N_2O emissions are up to about 0.00170% and 0.00011%, respectively, of their current respective emissions in the United States. If CO_2, CH_4, and N_2O emissions are combined, the Program emissions are about 0.00039–0.00099% of the nationwide total of these three GHG emissions and about 0.00038%–0.00097% of the nationwide emissions of all GHGs. The estimated total global GHG emissions in 2005 were approximately 38,726 Tg CO_2e (74 FR 66539). The estimated Program GHG emissions are about 0.000065–0.00017% of the total global GHG emissions.

As noted in Section 3.3, GHG emissions are one of the causes of climate change. Climate change is a global phenomenon and predicting climate change impacts requires consideration of large-scale or even worldwide GHG emissions, not just emissions at a local level. Climate change predictive capability (modeling) lacks the ability to estimate the impact of GHGs from a particular source or sources such as oil and gas activities associated with the Program. What their impact, if any, would be is determined not only by the emissions from the oil and gas activities themselves, but also by the GHG emissions of other sources throughout the world and whether these other emissions are expected to increase or decrease. In addition, since some GHG gases, such as CO_2, may persist in the atmosphere for up to a century, the potential impacts of any source may extend well beyond the active lifetime of the source or program. This said, given the small percentage contributions of oil and gas activities in Cook Inlet to global GHG emissions, the potential impact on climate change would probably be small. Section 3.3 provides some baseline considerations for climate change and Section 4.4.3 and Sections 4.4.6 through 4.4-15 discuss potential impacts on specific impact areas.

TABLE 4.4.4-4 Projected Greenhouse Gas Emissions from Oil and Gas Activities in the Cook Inlet Planning Area, 2012-2017 Leasing Program[a]

Pollutant	2012-2017 Program[b] (Tg CO_2e)	2012-2017 Cook Inlet (Tg CO_2e)[c]	Total 2009 U.S. Emissions from All Sources (Tg CO_2e)	2012-2017 Cook Inlet as Percentage of Total 2009 U.S. Emissions
CO_2	58.3–117.27	0.52–1.57	5,505.2	0.00038–0.00095
CH_4	15.4–29.67	0.11–0.35	686.3	0.00064–0.00170
N_2O	0.47–0.95	0.005–0.010	295.6	0.00007–0.00011
$CO_2 + CH_4 + N_2O$	74.18–147.89	0.63–1.93	6,487.1	0.00039–0.00099
All GHGs[d]	74.18–147.89	0.63–1.93	6,633.2	0.00038–0.00097

[a] Emissions in the table represent 25-year totals for the low scenario and 30-year totals for the high scenario, except the third column, which presents total 2009 U.S. emissions.

[b] Sum of the GHGs from Cook Inlet, GOM, and the Beaufort Sea and Chukchi Sea Planning Areas in this table and Tables 4.4.4-2 and 4.4.4-6.

[c] One Tg is equal to 10^{12} g, or 10^6 metric tons. The CO_2e for a gas is derived by multiplying the mass of the gas by the associated GWP, which accounts for the relative effectiveness of a gas to contribute to global warming with respect to the same amount CO_2. In these calculations, CH_4 is given a GWP of 21, while N_2O is given a GWP of 310.

[d] Total U.S. GHG emissions also include hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride emissions. Estimates of emissions from the Program were not made for these compounds, but they are assumed to be very small.

Sources: Industrial Economics, Inc. et al. 2012; USEPA 2011l; Wolvovsky 2012.

4.4.4.2.2 Impacts of Expected Accidental Events and Spills. Under the proposed action, the number and types of spills assumed to occur in Cook Inlet include up to one large spill (≥1,000 bbl) from either a pipeline or platform and between 8 and 18 small spills (<1,000 bbl) over the 40-year period of the Program (Table 4.4.2-1). Evaporation of oil from these spills and emissions from spill response and cleanup activities including *in situ* burning, if used, have the potential to affect air quality in Cook Inlet.

Spills and In Situ Burning. Small accidental oil spills would cause small, localized increases in concentrations of VOCs because of evaporation of the surface oil. Most of the emissions would occur within a few hours of the spill and would decrease rapidly after that period. Large spills would exhibit similar behavior but would affect a somewhat larger area and cause elevated pollutant concentrations that would persist for a longer period of time. The impacts at a given location would depend on the size, location, and duration of the spill and meteorological conditions such as wind speed and direction. Hanna and Drivas (1993) modeled the emissions of various hydrocarbon compounds from a large spill. A number of these compounds, including BTEX and hexane, are classified by the USEPA as hazardous air pollutants. Many of these contaminants may be carcinogenic to humans and/or animals. The results showed that these compounds evaporate almost completely within a few hours after the spill occurs. Ambient concentrations peak within the first several hours after the spills starts and are reduced by two orders of magnitude after about 12 hr. The heavier compounds take longer to evaporate and may not peak until about 24 hr after spill occurrence. Total ambient VOC concentrations are high in the immediate vicinity of an oil spill, but concentrations are much reduced after the first day (MMS 2007d). Spreading of the spilled oil and action by winds, waves, and currents would further disperse VOC concentrations to extremely low levels over a relatively larger area. Concentrations of criteria pollutants would remain well within NAAQS (MMS 2008b). Over time, air quality would return to pre-spill conditions. There is no information about any possible effect from the inhalation of air contaminants by subsistence animals, but this effect would be expected to be much less than any contamination by contact with hazardous compounds in the water. These effects on subsistence are described in Section IV.B.3.k of MMS (2007d).

In situ burning is a potential technique for cleanup and disposal of spilled oil. *In situ* burning of a spill results in emissions of NO_2, SO_2, CO, and PM_{10} and generates a plume of black smoke. Fingas et al. (1995, 2011) describes the results of a monitoring program of a burn experiment at sea. The program involved extensive ambient measurements during two experiments in which approximately 300 bbl of crude oil was burned. It found that during the burn, CO, SO_2, and NO_2 were measured only at background levels and were frequently below detection levels. Ambient levels of VOCs were high within about 100 m (328 ft) of the fire but much lower than those associated with a nonburning spill. PAHs were largely burned by the fire and were lower in the soot than in the oil. Particulates at sea level were of concern only up to 150 m (492 ft) downwind. Measured concentrations of PAHs were low. It appeared that a major portion of these compounds was consumed in the burn. Effects of *in situ* burning for spilled diesel fuel would be similar to those associated with a crude oil spill (MMS 2008b). The appearance of a black plume from *in situ* burning around a subsistence hunting area could have an adverse effect on subsistence hunting practices because of the creation of a perception that wildlife has been contaminated. Subsistence hunters may avoid areas where such incidents have occurred.

A major component of the pollution from a fire would be soot. Soot would cling to plants near the fire but would tend to clump and wash off vegetation in subsequent rains. Potential contamination of shoreline and onshore vegetation would be limited, because oil and gas activities under the proposed action would be at least 15 km (9.3 mi) offshore, with the exception of any oil- or gas-transport pipelines (MMS 2008b).

Smoke from burning crude oil would contain PAHs. Benzo(a)pyrene, which often is used as an indicator of the presence of carcinogenic varieties of PAHs, is present in crude oil smoke in very small amounts, but in quantities approximately three times larger than in unburned oil (Evans 1988). Investigators have found that, overall, the oily residue in smoke plumes from crude oil is mutagenic, although not highly so. McGrattan et al. (1995) modeled smoke plumes associated with *in situ* burning. The results showed that the surface concentrations of particulate matter did not exceed the health criterion of 150 $\mu g/m^3$ beyond about 5 km (3 mi) downwind of an *in situ* burn. This appears to be supported by field experiments conducted off Newfoundland and in Alaska (MMS 2007d). This should be considered conservative because this health standard is based on a 24-hr average concentration rather than a 1-hr average concentration.

After the burn, air quality would rapidly return to pre-burn conditions.

Air quality impacts from accidental oil spills in open water during the proposed action would be similar to those described above. However, albeit limited to a small northern area and short duration (January to March), a spill in Cook Inlet during broken ice or melting ice conditions could result in more concentrated emissions over a smaller area than would be the case under open-water conditions because the ice would act to reduce spreading of the oil compared to the spreading of a spill in open water. An oil spill on solid sea ice would spread relatively slowly compared to a spill in open water. The more volatile components of the oil would evaporate rather rapidly, but the heavier compounds would linger on the surface. The effects on air quality would result in more concentrated emissions over a smaller area than would be the case for a spill in open water.

Hydrogen Sulfide. An accidental release of H_2S at a platform and its associated impacts on platform workers and persons in close proximity to a platform are discussed in detail in Section 4.4.4.1. Potential impacts at or around the platform would be similar in the Cook Inlet.

4.4.4.2.3 Impacts of an Unexpected Catastrophic Discharge Event. In the Cook Inlet Planning Area, an unexpected low-probability CDE is assumed to range in size from 75,000 and 125,000 bbl, with a duration of 50–80 days (Table 4.4.2-2). Evaporation of oil from these spills and emissions from spill response and cleanup activities including *in situ* burning, if used, have the potential to result in minor to moderate impacts to air quality in Cook Inlet.

A CDE in South Central Alaska could emit regulated pollutants into the atmosphere. This may cause air quality impacts during some phases of the event. The greatest impacts on air quality conditions would occur during the initial explosion of gas and oil and during the spill response and cleanup, particularly if the event occurs during the winter. Impacts could continue for days during the initial event and could continue for months during spill response and clean up. Therefore, while the impacts may be large during these two phases, overall, the emissions from a CDE would be temporary and, over time, air quality in south central Alaska would return to pre-event conditions (BOEMRE 2011j).

The air impacts of any *in situ* burning associated with a CDE in Cook Inlet would be similar to those open-water impacts discussed in Section 4.4.4.1. Potential impacts from a large spill on the ice are discussed in the "Spills and *In Situ* Burning" subsection above.

There would be some residual air quality impacts after the well is capped or "killed." As most of the oil would have been burned, evaporated, or weathered over time, air quality would return to pre-oil spill conditions. While impacts on air quality are expected to be localized and temporary, adverse effects that may occur from the exposure of humans and wildlife to air pollutants could have long-term consequences (BOEMRE 2011a).

4.4.4.2.4 Impact Conclusions.

Routine Operations. Routine operations in Cook Inlet would result in levels of NO_2, SO_2, PM_{10}, and $PM_{2.5}$ within the NAAQS at onshore locations. Modeling conducted for NO_2, SO_2, and PM_{10} for a lease sale in Cook Inlet showed concentrations below the Class I PSD increments in the Tuxedni WA and below the NAAQS and PSD Class II increments at onshore locations. The small additional concentrations from the Program would not be expected to exceed the NAAQS. Conditions are seldom favorable for significant O_3 formation in Alaska, and the proposed activities would not be expected to cause exceedances of the O_3 standard. Given that oil and gas sources are relatively small and scattered over a large area, it is not expected that they would have a measurable impact on visibility. Given the small percentage contributions of routine Program operations to global GHG emissions, their potential impact on climate change would be small. Therefore, impacts to air quality from routine operations associated with the Program in Cook Inlet are expected to be minor.

Expected Accidental Events and Spills. Spill impacts at a given location would depend on the size, location, and duration of the spill and meteorological conditions such as wind speed and direction. Evaporation of small accidental oil spills would cause small localized increases in VOCs. Most of the emissions would occur within a few hours of the spill and would decrease thereafter. Large spills (≥1,000 gal) would result in VOC increases over a larger area and a longer period of time. Most of the VOCs considered hazardous by USEPA are reduced by 99% within 12 hr after a spill. Heavier compounds take longer to evaporate, and therefore air concentrations may not peak until 24 hr after the spill. VOC concentrations in the immediate vicinity of the spill could be high during the first day, but concentrations of criteria pollutants would remain within the NAAQS. Over time, air quality would return to pre-spill conditions. Therefore, impacts from small spills would be minor. Impacts from large spills could be moderate in the immediate vicinity of the spill for a short time after the spill but would be minor after about 12 hr.

In situ burning of spilled crude or diesel would generate emissions of NO_2, SO_2, CO, PM_{10}, and $PM_{2.5}$. In general, particulates would not exceed the 150 $\mu g/m^3$ beyond about 5 km (3 mi) downwind of an *in situ* burn. After the burn, air quality would return to pre-burn conditions. Thus, the air quality impacts of *in situ* burns of small spills (<1,000 bbl) would be minor. Air quality impacts of *in situ* burns of large spills could be moderate, but would rapidly return to minor after the burn ceased.

An accidental release of H_2S to the atmosphere could present a serious hazard to platform workers and persons close to the platform. OCS operators involved with sour gas production must have an H_2S Contingency Plan containing measures to prevent serious injury or death to workers. Most sour gas facilities have H_2S concentrations that would result in H_2S levels above the OSHA ceiling level within the dimensions of a typical platform. With the Contingency Plan mitigating impacts, accidental releases of H_2S would cause minor to moderate air impacts.

An Unexpected Catastrophic Discharge Event. In the event of an unexpected CDE, the greatest impacts on air quality would occur during the initial release and during the spill response and cleanup. Impacts could continue for days during the initial event and for months during the spill response and cleanup. Despite the length of time that could be involved, emissions from a CDE would be temporary and, over time, air quality in Cook Inlet would return to pre-event conditions.

If *in situ* burning is used during the response to a CDE, carcinogenic dioxins and furans could be formed. These chemicals can bioaccumulate in the food chain. Studies performed during the DWH event indicated that levels of these chemicals were about the same as levels from residential wood stoves and forest fires so that bioaccumulation is not expected to be a problem. Although dioxins were created during DWH burns, reports found that workers, onshore residents, and residents consuming fish had incremental lifetime cancer risks well below USEPA's target risk level. Although there may be differences between exposure and pollutants emitted between the uncontrolled Kuwaiti oil field fires over land and the controlled DWH burns over water, one study concluded that symptoms reported by soldiers and associated with proximity to the Kuwaiti fires decreased after leaving Kuwait. Other studies concluded that exposure to oil fire smoke did not cause respiratory symptoms among veterans and that there was no increase in morbidity from exposure to smoke from Kuwaiti oil well fires.

There would be some residual air quality impacts after the well was capped. Over time, air quality would return to pre-event conditions. While impacts on air quality are expected to be temporary, adverse effects may occur from the exposure of humans and wildlife to air pollutants that could have long-term consequences.

Overall, the air quality impacts of an unexpected CDE, including *in situ* burning, in Cook Inlet could be moderate during the initial explosion of gas and oil and during the spill response and cleanup but would become minor after the well was capped.

4.4.4.3 Alaska – Arctic

With the exception of icebreakers, which are a major emission source in the Arctic that is not present in the GOM, general air emission sources and potential impacts on ambient air quality associated with OCS oil and gas activities are covered in detail in Section 4.4.4.1 for the GOM. Air quality impacts for both the Beaufort and the Chukchi Seas are similar and are discussed together. Differences are noted where appropriate.

With the enactment of the Clean Air Act Amendments of 1990 (CAA), control of air emissions from rigs, drillships, and platforms on the Arctic OCS was the responsibility of the USEPA (CAA Section 328). Amendments to CAA Section 328 were enacted on December 23, 2011, through the Consolidated Appropriations Act, 2012 (Pub. L. 112-74. December 23, 2011. Amendment to Section 430 Section 10101 of the Omnibus Budget Reconciliation Act of 1993 [30 USC 28f], Section 432, Air Emissions from Outer Continental Shelf Activities). The signing of Pub. L. 112-74 transferred authority from the USEPA to the Department of Interior (USDOI) for air emissions on the Beaufort Sea and Chukchi Sea OCS adjacent to the North Slope Borough of Alaska. The new jurisdiction is authorized under Section 5(a)(8) of the OCS Lands Act (OCSLA) and is regulated pursuant to the USDOI Pollution Prevention and Control rule at 30 CFR Part 550 Subpart C (USDOI Air Quality Regulatory Program). The Arctic OCS is defined to include the Beaufort Sea and Chukchi Sea OCS Planning Areas that are adjacent to the North Slope Borough of Alaska. The other Alaska OCS Planning Areas, including the Cook Inlet, remain under USEPA jurisdiction and emissions are regulated pursuant to 40 CFR Part 55.

All Federal actions on the Alaska OCS, including the Arctic OCS, proposed to occur within 4.8 km (3 mi) of shore remain subject to air quality regulations of the Alaska Department of Environmental Conservation (ADEC) and may require State air quality permits. For proposed exploration plans (EPs) or development or production plans (DPPs) located more than 4.8 km (3 mi) offshore on the Arctic OCS, emissions are regulated by the BOEM Alaska Region (AOCSR) under the USDOI Air Quality Regulatory Program. Under the program, the AOCSR does not issue air quality permits, as was required under USEPA rules; rather, the AOCSR Office of the Environment conducts an analytical evaluation of the air quality analysis contained in any EP or DPP proposed for the Arctic OCS for compliance with program. Emissions projected for a facility proposed for an EP or DPP that exceed exemption thresholds calculated under 30 CFR 550.303(d) would be required to conduct an air quality impact analysis (dispersion analysis) for comparison to the USEPA Significance Levels (SLs)[40 CFR 51.165(b)(2)]. Should the air quality analysis show that pollutant concentrations would exceed one or more of the SLs, the application of Best Available Control Technology (BACT) would be required. If the action proposes a permanent facility, for instance a DPP, additional analysis would be required to demonstrate whether the application of BACT would result in compliance with the USEPA Maximum Allowable Increases (MAIs) [40 CFR 52.2(c)]. Additional controls are required until the MAIs are met. The air quality analysis contained in a proposed EP or DPP must demonstrate compliance with the USDOI Air Quality Regulatory Program before the EP or DPP could be approved by the AOCSR Office of Leasing and Plans. Any required application of BACT or other emission controls would be enforced by the AOCSR Bureau of Safety and Environmental Enforcement (BSEE).

Emissions of greenhouse gases (GHGs) also occur as a result of the operation of engines aboard marine vessels and other vehicles and equipment proposed for the Alaska OCS. For the Arctic OCS, GHG emissions are no longer reported within the USEPA Title V or Prevention of Significant Deterioration (PSD) air quality permitting process. Rather, depending on the type of oil and gas activity, the operator is independently responsible for reporting projected emissions of GHG to the USEPA as specified in the 40 CFR Part 98 Subparts A, C, and W. No function of the USDOI Air Quality Regulatory Program provides for the reporting of GHG.

Likewise, under the program, there is no requirement to report or obtain a permit for hazardous air pollutants (HAPs) pursuant to Section 112 of the Clean Air Act. Therefore, it is the responsibility of the project proponent to independently consult with the Federal and State EPA authorities regarding requirements to report HAPs.

The USEPA has established NAAQS for six criteria pollutants — NO_2, SO_2, PM_{10} and $PM_{2.5}$, CO, Pb, and O_3 — because of their potential adverse effects on human health and welfare. The health and environmental effects of air pollutants have been summarized by the USEPA (USEPA 2011a). Ambient levels of criteria pollutants other than Pb can contribute to respiratory illnesses, especially in persons with asthma, children, and the elderly, and PM and CO can also aggravate cardiovascular diseases.

Ozone Formation. O_3 in the atmosphere is formed by photochemical reactions involving primarily NO_x and VOCs. It is formed most readily in the summer season, with high temperatures, lower wind speeds, intense solar radiation, and an absence of precipitation; high-O_3 episodes are typically associated with slow-moving, high-pressure systems characterized by light winds and shallow boundary layers (NRC 1992). Conditions in Alaska are seldom favorable for significant O_3 formation, primarily due to low ambient temperature. At Barrow, for example, the highest monthly mean daily maximum of 45.9°F occurs in July, when the highest temperature is 79°F (NCDC 2011b). However, measurements taken at several locations have found moderate levels of ozone in Alaska, about 34% and 54% of the 1-hr (revoked in 2005) and 8-hr NAAQS based on data from Wainwright and Point Lay for 2009 and 2010, and about 61% and 67% of the NAAQS for data taken at five locations on the North Slope for various periods between 1999 and 2007 (USEPA 2010d, 2011s).

Acid Deposition and Visibility. Gaseous pollutants undergo various chemical reactions in the atmosphere to form small particles, which remain airborne for extended periods of time. NO_x compounds react with ammonia and moisture to form ammonium nitrate particles, which contribute to $PM_{2.5}$ concentrations. SO_2 combines with moisture to form tiny sulfate particles, which may also contribute to adverse health effects. In addition, gaseous NO_x and SO_2 can dissolve into cloud water. These acidic chemicals eventually return to the ground in either wet (e.g., rain, snow) or dry (e.g., gases, particles) forms, commonly referred to as acid deposition or acid rain (USEPA 2011b). Dry deposition is just as important as wet deposition. The deposition often takes place hundreds of miles from the source. Acid deposition can damage forests and crops, change the makeup of soil, and in some cases may make lakes and streams acidic and unsuitable for fish. Deposition of nitrogen from NO_x emissions also contributes to nitrogen load in water bodies, especially estuaries and near-coastal ecosystems. Acid deposition accelerates the decay of building materials and paints, including those of irreplaceable monuments, statues, sculptures, and other cultural resources. Particulate matter, including sulfate and nitrate particles and organic aerosols that form part of photochemical smog, reduces atmospheric visibility. Atmospheric pollutants adversely affect visibility in many of national parks and monuments, and in wilderness areas (USEPA 2011b).

The most important cause of visibility degradation is from $PM_{2.5}$ in the 0.1- to 1-μm size range, which covers the range of visible light (0.4–0.7 μm) (Malm 1999). These particles are directly emitted into the atmosphere through fuel burning. However, other sources arise through chemical transformation of NO_2, SO_2, and VOCs into nitrates, sulfates, and carbonaceous particles. Existing visibility in Alaska is generally good because of the absence of large emission sources. However, the phenomenon of Arctic haze, which occurs in Arctic Alaska during the winter and spring, is caused primarily by long-range transport of pollutants from industrial Eurasia (Rahn 1982).

Arctic Haze. Arctic haze causes a reduction in visibility and often appears in distinct bands at different heights. The haze is seasonal, appearing first in late fall around November, and peaking in the spring. The haze originates from anthropogenic sources outside the Arctic. The most severe episodes occur when stable high pressure systems produce clear, calm weather and can reduce visibility (~30.6 km [~19 mi]) in spite of the otherwise clear weather. Coal burning appears to be the principle source of haze particles. Haze particles consists of sulfate (up to 90%), soot, and sometimes dust, most of which originate in Eurasia and are picked up by the Arctic air mass that moves northward over the North Pole in winter. The cold, dry air in the polar regions allows particles to remain airborne for weeks, thus permitting the contaminants to spread over the Arctic and into North America. Arctic haze reduces visibility, but the levels of sulfur compounds in haze are lower than those found in heavily polluted cities (AMAP 1997).

4.4.4.3.1 Impacts of Routine Operations. OCS operations in the Arctic Ocean are unique in a number of ways because of the sea ice that is present much of the year. In waters 5–10 m (16–33 ft) deep, exploratory wells may be drilled from an ice or gravel island (MMS 2003e). Construction of an ice island would need to take place in winter (November–January), and material and personnel would be carried to the site by vehicles operating on an ice road. In water 10–20 m (33–66 ft) deep, movable platforms attached to the seafloor may be used for exploration. Drilling operations from these platforms are usually conducted during open-water season from July through October. Ice islands are not projected for the Chukchi Sea, because activities there would not occur close to shore. In deeper waters, drillships or floating platforms would be used, and drilling would be limited less than 4 months during the summer. Material and supplies would be ferried using barges or supply boats. In addition, icebreakers would operate in the vicinity of the drilling rig and vessels to control incursions of sea ice. Because of the Arctic conditions, the pace of development is slower as activities are limited to certain rather narrow time frames. Air emission rates tend to be higher because activities are more concentrated and additional vessels such as icebreakers may be needed. In shallow waters, production may take place from gravel islands, while in deeper waters production facilities would be installed on large gravity-base platforms. As in the case of exploration, a gravel island would be constructed during winter. The modules for production facilities would be installed during the ice-free period using barges, tugboats, and supply vessels (MMS 2007d).

Under the proposed action, construction and operation of up to 36 exploration wells, up to 400 production wells, up to 92 subsea wells, up to 652 km (405 mi) of new offshore pipeline, and up to 129 km (80 mi) of new onshore pipeline would be required before adverse air quality impacts would occur in Arctic Alaska. These activities would generate emissions from stationary sources at the drilling/well sites and from support vessels and aircraft over the 50-year period of the Program (Table 4.4.1-4). There could be up to 27 vessel trips/wk and 27 helicopter trips/wk under the proposed action.

Emissions. The type and relative amounts of air pollutants generated by offshore operations vary according to the phase of activity. There are three principal phases of OCS operations: exploration, development, and production. Activities affecting air quality include seismic surveys; drilling activities; platform construction and emplacement; pipeline laying and burial operations; platform operations; flaring; fugitive emissions; support vessel and helicopter operations; and evaporation of VOCs during transfers and spills.

Releases of toxic chemicals could be a concern around spills and during *in situ* burning and especially during accidental releases of H_2S at platforms. Other sources of pollutants related to OCS operations are accidents such as losses of well control and oil spills. Spill emissions consist primarily of VOCs, while fires and *in situ* burning produce criteria pollutants along with hazardous air pollutants.

The 50-year air emissions from the proposed action for the Beaufort Sea and the Chukchi Sea were estimated by using the most recent available exploration and development scenarios for 2012–2017 as shown in Table 4.4.4-5; pipe-laying vessels, platform construction, and platform removal activities include emissions from icebreakers. These emissions were estimated by BOEM (Wolvovsky 2012), using emission factors from the Offshore Environmental Cost Model (Industrial Economics, Inc. et al. 2011).

In terms of absolute amount, the largest emissions would be NO_x, followed by CO, with lesser amounts of SO_x, VOCs, PM_{10}, and $PM_{2.5}$. Under the low scenario, the largest source of NO_x is the drilling of exploration and delineation wells; under the high scenario, the largest NO_x source is support vessels. Under both scenarios, the drilling of exploration and delineation wells is the largest source of SO_x, PM_{10}, and $PM_{2.5}$. Oil tankers cruising, loading, and unloading in Alaska are projected to be the largest source of CO and VOC emissions associated with oil and gas activities in the Arctic. However, much of the tanker emissions would be at some distance from the lease areas. For sources located in or near the lease areas, platform production would be the largest source of CO and VOC emissions. Emissions from the Program would initially be lower in the first few years as exploratory wells were drilled and platforms started producing oil and gas. During the last half of the Program, emissions would decrease as production decreased and some platforms were removed (MMS 2007d).

Impacts on Criteria Pollutants Other Than Ozone. Air quality modeling using the Offshore and Coastal Dispersion Model (OCD) has been performed in past studies to assess impacts from planned lease sales in the Beaufort Sea (MMS 1996a). The highest predicted onshore annual average NO_2 concentrations were in the range of 0.5–1.5 $\mu g/m^3$, which is well below the PSD Class II maximum allowable increment of 25 $\mu g/m^3$. Concentrations of SO_2 and PM_{10} were not modeled; however, when the results are scaled according to the respective emission rates, the levels would be below the PSD Class II maximum allowable increments.

An examination of the air quality modeling analysis performed for the Northstar facility and proposed Liberty development project in the Beaufort Sea provides a measure of the expected impacts over water near an OCS production facility on a gravel island in the Beaufort Sea. The highest predicted concentrations for NO_2, SO_2, and PM_{10} for the Northstar and Liberty projects occurred within 200 m (656 ft) of the facility boundary and were close to but still lower than PSD Class II maximum allowable increments (MMS 2002c). The highest onshore concentrations were considerably lower. The combined facility concentrations for Liberty plus background were well within NAAQS (between 2 and 30% of the standards).

Results of OCD modeling for development from a proposed lease sale in the Chukchi Sea indicated that the highest annual average NO_2 concentration was 1.29 $\mu g/m^3$, which is about 5% of PSD Class II maximum allowable increment of 25 $\mu g/m^3$ (MMS 1991). No modeling was performed for SO_2 and PM_{10}, but concentrations should be well within the PSD Class II increments considering that NO_x emissions are an order of magnitude higher than SO_2 and PM_{10} emissions.

TABLE 4.4.4-5 Estimated 50-Year Total Air Emissions from OCS Activities in the Arctic (Beaufort and Chukchi Seas) Planning Area, Proposed 2012-2017 Leasing Program

	Emissions[a] (10^3 tons)					
Activity	NO_x	SO_x	PM_{10}	$PM_{2.5}$	CO	VOC
Development/Production Wells	2.44–9.4[b]	0.5–1.92	0.17–0.64	0.17–0.64	0.01–0.05	0.44–1.67
Drilling Exploration/Delineation Wells	5.93–17.79	1.54–4.61	0.27–0.80	0.24–0.73	0.00–0.01	0.26–0.77
Helicopters	0.04–0.21	0.01–0.05	0.01–0.04	0.01–0.04	0.43–2.56	0.09–0.5
Pipe-laying Vessels	0.73–5.37	0.12–0.91	0.03–0.2	0.03–0.2	0.15–1.11	0.03–0.2
Platform Construction	1.85–8.33	0.43–1.96	0.07–0.33	0.07–0.3	0.06–0.26	0.06–0.29
Platform Production	2.39–14.07	0.03–0.19	0.02–0.13	0.02–0.13	2.63–15.5	2.14–12.61
Platform Removal	1.85–8.33	0.43–1.96	0.07–0.33	0.07–0.3	0.06–0.26	0.06–0.29
Support Vessels	4.3–25.34	0.58–3.41	0.07–0.44	0.07–0.44	0.41–2.41	0.07–0.44
Survey Vessels	0.05–0.32	0.01–0.04	0.00–0.00	0.00–0.00	0.00–0.03	0.00–0.00
Total	19.49–89.16	3.65–15.04	0.71–2.92	0.68–2.8	3.77–22.2	3.15–16.79

[a] Activity in the Beaufort and Chukchi Seas will be confined to the ice-free portions of the year and emissions will occur predominantly during this period.

[b] The range of values reflects the low and high end of the exploration and development scenarios for the Program.

Source: Industrial Economics, Inc. et al. 2012; Wolvovsky 2012.

Results of PSD permit modeling for Beaufort Sea exploration drilling by Shell's Frontier Discoverer drillship and its Associated Fleet, including icebreakers, were below the PSD Class II increments and below the NAAQS levels (USEPA 2010d). Similar modeling for Beaufort Sea and Chukchi Sea exploration drilling by the *Noble Discoverer* drillship indicated no violations of Alaska SAAQS or NAAQS, including the 1-hr NO_2 and SO_2 standards beyond 500 m (1,640 ft) of the drillship and at all onshore locations. The analysis included the formation of secondary $PM_{2.5}$ (USEPA 2011s).

These activities in the Arctic Alaska are not anticipated to affect Class I areas in Alaska, which are several hundred miles away.

The major onshore source of industrial emissions in the Arctic Alaska, the Prudhoe Bay-Kuparuk-Endicott oil-production complex, was the subject of monitoring programs during 1986–1987 and from 1990 through 1996. Five monitoring sites were selected; three were considered subject to maximum air pollutant concentrations, and two were considered more representative of the air quality of the general Prudhoe Bay area. All the values meet Federal and State ambient air quality standards. These results indicate that ambient pollutant concentrations from oil and gas activities, even for sites subject to maximum concentrations, are likely to meet the ambient air quality standards (MMS 2008b).

The Program would result in a rather slow rate of development involving a small number of facilities that would be spread over a wide area. Each project would apply the best available control technology according to USEPA and State regulations, and pollutant concentrations would have to meet the PSD incremental limits. Existing pollutant concentrations in coastal Alaska are well within the NAAQS. The small additional concentrations from the Program would result in levels that are still well within the NAAQS.

Impacts on Ozone. As noted above, although ozone does form in Alaska, conditions are seldom favorable for significant O_3 formation. Precursor NO_x and VOC emissions are relatively small, and a significant increase in O_3 concentrations onshore is not likely to result from oil and gas activity scenarios associated with the proposed action. Although sunshine is present in the Beaufort Sea program area most of each day during summer, temperatures remain relatively low. The highest 8-hr average ozone concentrations would be well below the NAAQS of 0.075 ppm. Because the projected O_3 precursor emissions from any of the proposed activities are considerably lower than the existing emissions from the Prudhoe Bay-Kuparuk-Endicott complex, the proposed activities would not be expected to cause any violations of the O_3 standard (MMS 2008b).

Impacts on Visibility. For the proposed Liberty Project in the Beaufort Sea, British Petroleum (Exploration) Alaska (BPXA) ran the VISCREEN model, which calculates the potential impact of a plume of specified emissions for specific transport and dispersion conditions (MMS 2002c). It found noticeable effects on a limited number of days, ones that had the most restrictive meteorological conditions, but no effects at all during average meteorological conditions. This model tends to overestimate impacts, and it is not known to what extent OCS sources contribute to the predicted visibility reductions. The OCS sources are relatively small and would be scattered over a large area. It is not expected that they would have a measureable impact on visibility. Overall, the impacts from the proposed action would be expected to be small or negligible (MMS 2007d).

Greenhouse Gas Emissions and Climate Change. Estimates were made of the 50-year total GHG emissions of CO_2, CH_4, and N_2O for all projected activities associated with the Program (Wolvovsky 2012). Emission estimates for the various activities were largely based on emission factors from the Offshore Environmental Cost Model (Industrial Economics, Inc. et al. 2011). Air emissions resulting from the Program were estimated by considering the exploration and development scenarios presented in Table 4.4.1-4. Emissions are given in terms of (Tg) of CO_2e, where 1 Tg is 10^{12} g (10^6 metric tons). This measure takes into account a GWP factor, which accounts for the relative effectiveness of a gas to contribute to global warming with respect to the same amount CO_2. In these calculations, CH_4 is given a GWP of 21, while N_2O is given a GWP of 310.

Table 4.4.4-6 lists the total calculated emissions (30-year totals for the low scenario and 43-year totals for the high scenario) of CO_2, CH_4, and N_2O from activities associated with the Program and compares them with current (2009) U.S. GHG emissions from all sources (USEPA 2011l). The projected CO_2 emissions from the Program are about 0.0012–0.0038% of all current CO_2 emissions in the United States. The projected CH_4 and N_2O emissions from the Program are up to about 0.0058% and 0.0002%, respectively, of all their current respective emissions in the United States. If CO_2, CH_4, and N_2O emissions are combined, the Program emissions are about 0.0012–0.0038% and 0.0012–0.0037% of the nationwide total of three GHG emissions and of all GHG emissions, respectively. The estimated total global GHG emissions in 2005 were approximately 38,726 Tg CO_2e (74 FR 66539). The estimated Program GHG emissions are about 0.00020–0.00064% of the total global GHG emissions.

As noted in Section 3.3, GHG emissions are one of the causes of climate change. Climate change is a global phenomenon and predicting climate change impacts requires consideration of large scale or even worldwide GHG emissions, not just emissions at a local level. Climate change predictive capability (modeling) lacks the ability to estimate the impact of GHGs from a particular source or sources such as oil and gas activities associated with the Program. What their impact, if any, would be is determined not only by the emissions from the oil and gas activities themselves, but also by the GHG emissions of other sources throughout the world and whether these other emissions are expected to increase or decrease. In addition, since some GHG gases, such as CO_2, may persist in the atmosphere for up to a century, the potential impacts of any source may extend well beyond the active lifetime of the source or program. This said, given the small percentage contributions of oil and gas activities in Arctic region to global GHG emissions, the potential impact on climate change would probably be small. Section 3.3 provides some baseline considerations for climate change and Section 4.4.3 and Sections 4.4.6 through 4.4-15 discuss potential impacts to specific impact areas.

4.4.4.3.2 Impacts of Expected Accidental Events and Spills. Under the proposed action, the number and types of spills assumed to occur in Arctic Alaska include up to 3 large spills (≥1,000 bbl) from pipelines or platforms and between 60 and 225 small spills (<1,000 bbl) over the 50-year period of the Program (Table 4.4.2-1). Evaporation of oil from these spills and

TABLE 4.4.4-6 Projected Greenhouse Gas Emissions from Oil and Gas Activities in the Arctic (Beaufort and Chukchi Seas) Planning Area, 2012-2017 Leasing Program[a]

Pollutant	2012-2017 Program[b] (Tg CO_2e)	2012-2017 Beaufort and Chukchi Seas (Tg CO_2e)[c]	Total 2009 U.S. Emissions from All Sources (Tg CO_2e)	2012-2017 Beaufort and Chukchi Seas as Percentage of Total 2009 U.S. Emissions
CO_2	58.3–117.27	2.06–8.91	5,505.2	0.0012–0.0038
CH_4	15.4–29.67	0.29–1.72	686.3	0.0014–0.0058
N_2O	0.47–0.95	0.01–0.03	295.6	0.0001–0.0002
CO_2 + CH_4 + N_2O	74.18–147.89	2.36–10.66	6,487.1	0.0012–0.0038
All GHGs[d]	74.18–147.89	2.36–10.66	6,633.2	0.0012–0.0037

[a] Emissions in the table represent 30-year totals for the low scenario and 43-year totals for the high scenario, except the third column, which presents total 2009 U.S. emissions.

[b] Sum of the GHGs from Beaufort and Chukchi Seas, GOM, and the Cook Inlet Planning Areas in this table and Tables 4.4.4-2 and 4.4.4-4.

[c] One Tg is equal to 10^{12} g or 10^6 metric tons. The CO_2e for a gas is derived by multiplying the mass of the gas by the associated GWP, which accounts for the relative effectiveness of a gas to contribute to global warming with respect to the same amount CO_2. In these calculations, CH_4 is given a GWP of 21, while N2O is given a GWP of 310.

[d] Total U.S. GHG emissions also include hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride emissions. Estimates of emissions from the Program were not made for these compounds, but they are assumed to be very small.

Sources: Industrial Economics, Inc. et al. 2012; USEPA 2011l; Wolvovsky 2012.

emissions from spill response and cleanup activities including *in situ* burning, if used, have the potential to affect air quality in the Arctic Alaska.

Spills and In Situ Burning. Small accidental oil spills would cause small, localized increases in concentrations of VOCs because of evaporation of the spill. Most of the emissions would occur within a few hours of the spill and would decrease rapidly after that period. Large spills would exhibit similar behavior but would affect a somewhat larger area and cause elevated pollutant concentrations to persist somewhat longer. The impacts at a given location would depend on the size, location, and duration of the spill and meteorological conditions such as wind speed and direction. Hanna and Drivas (1993) modeled the emissions of various hydrocarbon compounds from a large spill. A number of these compounds, including BTEX and hexane, are classified by the USEPA as hazardous air pollutants. Many of these contaminants may be carcinogenic to humans and/or animals. The results showed that these compounds evaporate rapidly within a few hours after the spill occurs. Ambient concentrations peak within the first several hours after the spills starts and are reduced by two orders of magnitude after about 12 hr. The heavier compounds take longer to evaporate and may not peak until about 24 hr after spill occurrence. Total ambient VOC concentrations are high in the immediate vicinity of an oil spill, but concentrations are much reduced after the first day (MMS 2007d). Spreading of the spilled oil and action by winds, waves, and currents would further disperse VOC concentrations to extremely low levels over a relatively larger area. Concentrations of criteria pollutants would remain well within NAAQS (MMS 2008b). Over time, air quality would return to pre-spill conditions. There is no information about any possible effect from the inhalation of air contaminants by subsistence animals, but this effect would be expected to be much less than any contamination by contact with hazardous compounds in the water. These effects on subsistence are described in Section IV.B.3.k of MMS (2007d).

In situ burning is a potential technique for cleanup and disposal of spilled oil. *In situ* burning of a spill results in emissions of NO_2, SO_2, CO, and PM_{10} and generates a plume of black smoke. Fingas et al. (1995, 2011) describes the results of a monitoring program of a burn experiment at sea. The program involved extensive ambient measurements during two experiments in which approximately 300 bbl of crude oil was burned. It found that during the burn, CO, SO_2, and NO_2 were measured only at background levels and were frequently below detection levels. Ambient levels of VOCs were high within about 100 m (328 ft) of the fire, but were much lower than those associated with a nonburning spill. PAHs were largely burned by the fire and were lower in the soot than in the oil. Particulates at sea level were of concern only up to 150 m (492 ft) downwind. Measured concentrations of PAHs were low. It appeared that a major portion of these compounds was consumed in the burn. The appearance of a black plume from *in situ* burning around a subsistence hunting area could have an adverse effect on subsistence hunting practices because of the creation of a perception that wildlife has been contaminated. Subsistence hunters may avoid areas where such incidents have occurred.

A major component of the pollution from a fire would be soot. Soot would cling to plants near the fire but would tend to clump and wash off vegetation in subsequent rains. Potential contamination of shoreline and onshore vegetation would be limited, because oil and gas activities under the proposed action would be at least 15 km (9.3 mi) offshore, with the exception of any oil- or gas-transport pipelines (MMS 2008b).

Smoke from burning crude oil would contain PAHs. Benzo(a)pyrene, which often is used as an indicator of the presence of carcinogenic varieties of PAHs, is present in crude oil smoke in very small amounts, but in quantities approximately three times larger than in unburned oil (Evans 1988). Investigators have found that, overall, the oily residue in smoke plumes from crude oil is mutagenic, although not highly so. McGrattan et al. (1995) modeled smoke plumes associated with *in situ* burning. The results showed that the surface concentrations of particulate matter did not exceed the health criterion of 150 $\mu g/m^3$ beyond about 5 km (3 mi) downwind of an *in situ* burn. This appears to be supported by field experiments conducted off Newfoundland and in Alaska (MMS 2007d). This is quite conservative as this health standard is based on a 24-hr average concentration rather than a 1-hr average concentration. After the burn, air quality would return to pre-burn conditions.

Air quality impacts from accidental oil spills in open water during the proposed action would be similar to those described above. However, a spill in the Arctic during broken ice or melting ice conditions could result in more concentrated emissions over a smaller area than would be the case under open-water conditions because the ice would act to reduce spreading of the oil compared to the spreading of a spill in open water. The sea-surface spreading of an oil spill on solid sea ice would be relatively slow compared to a spill in open water. The more volatile components of the oil would evaporate rather rapidly, but the heavier compounds would linger on the surface. The effects on air quality would result in more concentrated emissions over a smaller area than would be the case for a spill in open water.

Hydrogen Sulfide. An accidental release of H_2S at a platform and its associated impacts on platform workers and persons in close proximity to a platform are discussed in detail in Section 4.4.4.1 for the GOM. Potential impacts at or around the platform would be similar in Arctic Alaska.

4.4.4.3.3 Impacts of an Unexpected Catastrophic Discharge Event. In the Arctic, an unexpected, low-probability CDE event is assumed to range in size from 1,700,000 and 3,900,000 bbl with a duration of 60–300 days in the Beaufort Planning Area, and from 1,400,000 and 2,100,000 bbl with a duration of 40–75 days in the Chukchi Planning Area (Table 4.4.2-2). Evaporation of oil from these spills and emissions from spill response and cleanup activities including *in situ* burning, if used, have the potential to result in minor to moderate impacts to air quality in Arctic Alaska.

A CDE in Arctic Alaska could emit regulated pollutants into the atmosphere. This may impact air quality during some phases of the event. The greatest impacts on air quality conditions would occur during the initial explosion of gas and oil and during spill response and clean up, particularly if the event occurs during the winter. Impacts could continue for days during the initial event and could continue for months during spill response and clean up. Therefore, while the impacts may be large during these two phases, overall, the emissions from a CDE would be temporary and, over time, air quality in Arctic Alaska would return to pre-event conditions (BOEMRE 2011j).

There would be some residual air quality impacts after the well is capped or "killed." As most of the oil would have been burned, evaporated, or weathered over time, air quality would return to pre-oil spill conditions. While impacts on air quality are expected to be localized and temporary, adverse effects that may occur from the exposure of humans and wildlife to air pollutants could have long-term consequences (BOEMRE 2011a).

The air impacts of any *in situ* burning associated with a CDE in the Arctic would be similar to impacts discussed in Section 4.4.4.1. Potential impacts from a large spill on ice are discussed in the "Spills and *In Situ* Burning" subsection above.

4.4.4.3.4 Impact Conclusions.

Routine Operations. Routine Program operations in Arctic Alaska would result in levels of NO_2, SO_2, PM_{10}, and $PM_{2.5}$ well within the NAAQS at onshore locations. Existing pollutant concentrations in coastal Alaska are well within the NAAQS, and the small additional concentrations from the Program would result in levels that are still well within the NAAQS. Conditions are seldom favorable for significant O_3 formation in Alaska, and the proposed activities would not be expected to cause any violations of the O_3 standard. In addition, routine operations are not expected to have a measurable impact on visibility. Given the small percentage contributions of routine Program operations to global GHG emissions, their potential impact on climate change would be small. Therefore, impacts to air quality from routine operations associated with the Program in Arctic Alaska are expected to be minor.

Expected Accidental Events and Spills. Spill impacts at a given location would depend on the size, location, and duration of the spill and meteorological conditions such as wind speed and direction. Evaporation of small accidental oil spills would cause small localized increases in VOCs. Large spills (≥1,000 gal) would result in VOC increases over a larger area and a longer period of time. Most of the VOCs considered hazardous by USEPA are reduced by 99% within 12 hr after a spill. Heavier compounds take longer to evaporate, and therefore air concentrations may not peak until 24 hr after the spill. VOC concentrations in the immediate vicinity of the spill could be high during the first day but concentrations of criteria pollutants would remain within the NAAQS. Over time, air quality would return to pre-spill conditions. Therefore, impacts from small spills would be minor. Impacts from large spills could be moderate in the immediate vicinity of the spill for a short time after the spill but would be minor after about 12 hr.

In situ burning of spilled crude or diesel would generate emissions of NO_2, SO_2, CO, PM_{10}, and $PM_{2.5}$. In general, particulates would not exceed the 150 $\mu g/m^3$ beyond about 5 km (3 mi) downwind of an *in situ* burn. After the burn, air quality would return to pre-burn conditions. Thus, the air quality impacts of *in situ* burns of small spills (<1,000 bbl) would be minor. Air quality impacts of *in situ* burns of large spills could be moderate, but would rapidly return to minor after the burn ceased.

An accidental release of H_2S to the atmosphere could present a serious hazard to platform workers and persons close to the platform. OCS operators involved with sour gas production must have an H_2S Contingency Plan containing measures to prevent serious injury or death to workers. Most sour gas facilities have H_2S concentrations that would result in H_2S levels above the OSHA ceiling level within the dimensions of a typical platform. With the Contingency Plan mitigating impacts, accidental releases of H_2S would cause minor to moderate air impacts.

Spills on ice could result in more concentrated emissions over a smaller area than would be the case for spills in open water, as discussed above. The impacts for small spills would still be minor, and impacts from large spills could be moderate in the immediate vicinity of the spill for a short time after the spill but would be minor after some time, probably exceeding 12 hr.

An Unexpected Catastrophic Discharge Event. During an unexpected CDE, the greatest impacts on air quality would occur during the initial explosion of gas and oil and during the spill response and cleanup. Impacts could continue for days during the initial event and for months during the spill response and cleanup. Despite the length of time that could be involved, emissions from a CDE would be temporary and, over time, air quality in Arctic Alaska would return to pre-event conditions.

If *in situ* burning is used during the response to a CDE, carcinogenic dioxins and furans could be formed. These chemicals can bioaccumulate in the food chain. Studies performed during the DWH event indicated that levels of these chemicals were about the same as levels from residential wood stoves and forest fires, so that bioaccumulation is not expected to be a problem. Although dioxins were created during DWH burns, reports found that workers, onshore residents, and residents consuming fish had incremental lifetime cancer risks well below USEPA's target risk level. Although there may be differences between exposure and pollutants emitted between the uncontrolled Kuwaiti oil field fires over land and the controlled DWH burns over water, one study has concluded that symptoms reported by soldiers and associated with proximity to the Kuwaiti fires decreases after leaving Kuwait. Other studies concluded that exposure to oil fire smoke did not cause respiratory symptoms among veterans and that there was no increase in morbidity from exposure to smoke from Kuwaiti oil well fires.

There would be some residual air quality impacts after the well was capped. Over time, air quality would return to pre-event conditions. While impacts on air quality are expected to be temporary, adverse effects may occur from the exposure of humans and wildlife to air pollutants that could have long-term consequences.

Overall, the air quality impacts of an unexpected CDE, including *in situ* burning, in Arctic Alaska could be moderate during the initial explosion of gas and oil and during the spill response and cleanup but would become minor after the well was capped.

4.4.5 Potential Impacts on the Acoustic Environment

This section identifies impact producing factors and potentially impacted resources (such as marine mammals). Details on impacted resources (such as marine mammals and sea turtles) are provided in the specific resource sections of Chapter 4.

BOEM has screened seismic, deep-tow sonar, electromagnetic survey, geological and geological sampling, remote sensing, and marine magnetic survey activities for potential impacts on marine mammals; sea turtles; fishes; commercial, personal, and recreational fisheries; coastal and marine birds; benthic communities; cultural resources; subsistence uses of natural resources; military uses; and recreational and commercial diving in the GOM (BOEMRE 2010b), but did not cover other routine operations such as construction, drilling, explosives, and support vessels and aircraft. The study reviewed EAs, EISs, and relevant literature pertinent to OCS activities and identified resources such as marine mammals for impact analysis. A preliminary screening using resource-specific significance criteria based on accepted threshold levels was conducted to identify those G&G seismic survey activities and resources with potential for non-negligible impacts. Various technologies were evaluated for each type of activity, and impacts from airgun noise, sonar noise, vessel traffic, towed streamers, and aircraft traffic were considered. Only seismic surveys were determined to have potential adverse impacts on marine mammals, sea turtles, fishes, and commercial and recreational fisheries. The other survey activities screened were determined to have negligible or no measurable acoustic impacts. These results should also be relevant to the Arctic region and south central Alaska and include potential for impacts to personal-use and subsistence fisheries and taking of marine mammals.

Table 4.4.1-1 details impact producing factors for routine activities associated with oil and gas activities and the project phases in which they can occur. Noise associated with offshore OCS oil and gas activities results from exploration activities, construction of onshore and offshore facilities and pipelines involving activities such as pile driving, trenching, earth moving, and building, the operation of fixed structures such as offshore platforms and drilling rigs, maintenance, aircraft and service-vessel traffic including icebreakers, and platform removal, and results in changed ambient noise conditions during those activities.

During exploration, noise is generated by operating airgun arrays, drilling, and support vessels and aircraft. During the development phase, noise is generated by drilling, ship and aircraft traffic, pipeline trenching, platform and other offshore construction, and onshore construction. During production operations, noise is generated by maintenance activities, ship and aircraft traffic, and various production activities and associated equipment such as pumps. During production, airgun–supported deep penetration 4D seismic operations that incorporate changes in reservoirs over time, if used, will also cause noise. Workover rigs also conduct drilling activity during the production phase, albeit with lesser noise levels than original drilling. Decommissioning noise is generated by explosive and nonexplosive structure removal, and supporting ship and aircraft traffic.

Noise generated from these activities can be transmitted through both air and water and may be extended or transient, and pulsed or constant. Offshore drilling and production involves various activities that produce a composite underwater noise field. As described in Section 3.6, the intensity level and frequency of the noise emissions are highly variable, both between and among the various industry sources. Noise from proposed OCS activities may affect resources. Whether a sound is or is not detected by marine organisms will depend both on the acoustic properties of the source (spectral characteristics, intensity, and transmission patterns) and sensitivity of the hearing system in the marine organism. Anthropogenic noise can cause physical damage to or death of an exposed animal; intense levels can damage hearing, and, if particularly loud or novel, may induce disruptive behavior and cause stress-related responses, such as endocrine responses (MMS 2006a, 2008a).

Accidental events with the potential for affecting ambient noise conditions include oil spills involving transport and support vessels and tankers, loss of well control, and spill response activities. Oils spills can occur both offshore and at coastal facilities and have occurred in coastal waters at shoreline storage, processing, or transport facilities.

Improperly balanced well pressures that result in sudden, uncontrolled releases of fluids from a wellhead or wellbore are referred to as loss of well control. Loss of well control can occur during exploratory drilling, development drilling, production, completion, or workover operations. In the event of a loss of well control, the eruption of gases and fluids may generate significant pressure waves and noise. During a loss of well control, the pressure waves and noise generated by the eruption of gases and fluids might be significant enough to harass or injure marine mammals, depending on the proximity of the animal to the site of the loss of well control (MMS 2006a).

Accident response and support activities, including support aircraft and vessels, involved in mitigating loss of well control and spills affect ambient noise conditions. For smaller spills, response actions (and associated changes in ambient noise) in open water would be expected to be localized and of relatively short duration. In the event of a large spill or a catastrophic spill event covering a greater ocean area and contacting the shore or moving into coastal and inland wetlands, longer term response activities including seismic surveys, skimmers, and other mechanical equipment, would affect ambient noise conditions over a wider area and for a longer time than would response activities for small spills. The nature, magnitude, and duration of noise-related impacts depends on the magnitude, frequency, location, and date of accidents, characteristics of spilled oil, spill-response capabilities and timing, and various meteorological and hydrological factors (MMS 2006a, 2007d). For spills, accident response and cleanup activities, including intentional hazing, would be the primary sources of acoustic impacts.

4.4.5.1 Gulf of Mexico

Impacts of Routine Operations. Routine activities that affect ambient noise conditions in some portions of the GOM include seismic surveys, drilling noise, ship and aircraft noise, offshore and onshore construction, operational activities, and decommissioning (see Section 3.6.1 for details on the noise levels and frequencies associated with routine operational activities).

Under the proposed action, seismic surveys would be conducted to identify locations for up to 2,100 exploration wells (Table 4.4.1-1). Noise from these seismic surveys and the associated survey and support vessels would affect the acoustic environment. Airgun noise can be detected up to 100 km (62 mi) from the source, so, under appropriate conditions (see Section 3.6.1.4.4), the affected area can be extensive, but the greatest changes to ambient noise levels would occur at locations closer to the airgun. Effects could include behavioral and physical effects on marine mammals and sea turtles. Impacts of seismic surveys on marine mammals and sea turtles are presented in Sections 4.4.7.1 and 4.4.7.4, respectively. In addition to the noise, the high-pressure pulse and associated particle motion in the near field is a concern for fish. Potential impacts on fish are discussed in Section 4.4.7.3. Commercial and recreational fishing could be affected if behavioral changes in target species (MMS 2007d) occur as a result of exposure to seismic surveys (see Section 4.4.11). These impacts would continue for the duration of the survey, and the affected area would move along with the survey and support vessels. Because these activities would be short term, potential impacts on ecological resources would be short-term.

Under the proposed action, construction and installation of exploration and delineation wells (up to 2,100), development and production wells (up to 2,600), platforms (up to 450), FPSOs (up to 2), and offshore pipelines (up to 12,000 km [7,500 mi]) will result in increases in noise levels in the vicinity of these construction activities. With the exception of pipeline trenching, construction and installation activities would generate noise from stationary noise sources at the drilling/well sites and from support vessels and aircraft.

Noise from pile driving, construction of offshore platforms and pipelines and noise from the associated support vessels and aircraft would cause noise that would disturb marine mammals (Section 4.4.7.1) and sea turtles (Section 4.4.7.4) in the vicinity of the construction activity and may cause fish to leave the construction area (see Section 4.4.7.3). Pipeline trenching and onshore construction could cause behavioral effects in birds, especially if the noises occur near nesting colonies during nesting periods (see Section 4.4.7.2). Marine species in nearby waters could also be affected. These effects would persist for the duration of the activity, could persist for weeks after the end of the activity, and would be strongest at the construction site or along the line of the trenching activity or routes of the vessels or aircraft. Multiple construction projects in the same vicinity could have increased noise impacts.

Additional noise-related impacts could be caused by dredging operations. Noise from dredging generally reaches background levels within 25 km (16 mi), but can extend even farther and thus can affect a fairly wide area.

Under the proposed action, drilling noise during exploration and production would be relatively constant for the duration of the drilling. Drilling noise generally would be less than ambient background levels beyond 30 km (19 mi) from the drill site (see Section 3.6.1.4) and would be strongest near the well. Noise levels would increase if several wells were located in proximity to one another. The principal noise concern in the GOM is the potential to affect marine mammals, sea turtles, and fish (see Sections 4.4.7.1, 4.4.7.4, and 4.4.7.3, respectively).

In addition to drilling noise, machinery on platforms also generates noise during operation. Such noise could be continuous or transient and variable in intensity, depending on the nature and role of the machinery. Underwater noise would be relatively low intensity because the noise sources are on decks well above the surface of the water and because of the small surface area of the legs in contact with the water, but it could affect marine mammals (see Section 3.6.1.4.3).

Under the proposed action, vessel traffic (up to 600 trips per week for up to 45 platforms) and helicopter traffic (up to 5,500 trips per week) will result in increases in noise levels along the traffic routes and at the platforms during construction and operation. Sound generated by these activities will be transient at any one location, may be variable in intensity (MMS 2006a), and may affect marine mammals, sea turtles, and birds (see discussions in Section 4.4.7). Noise from vessel traffic generally reaches background levels within 10 km (6 mi) of the source, but may be detectable at very large distances in deep water. Flights over land would also affect terrestrial mammals (see Section 4.4.7.1). How far sounds travel from vessels is highly variable, depending on environmental conditions and the type of vessel. However, noise would be transient along the traffic path but would recur as long as trips continue. Frequent overflights could produce longer term consequences (MMS 2007d, 2008a).

Noise from decommissioning could result from dismantlement of above-platform structures and the use of underwater explosive or mechanical means to collapse or sever the platform. Marine mammals, sea turtles, and fish could be affected by the noise and shock wave, especially that associated with the use of explosives (see Sections 4.4.6 and 4.4.7). Nonexplosive impacts from dismantling activities and support vessels and aircraft would continue for the duration of the activity and be localized around the facility being decommissioned. Noise and the pressure pulse from explosive detonation would be short term, but the pressure pulse could cause serious impacts on nearby marine mammals (MMS 2007d, 2008a) (also see Section 4.4.7.1). Explosive detonation impacts would be strongest near the detonation site.

Impacts of Expected Accidental Events and Spills. Under the proposed action, the number and types of spills assumed to occur in the GOM Planning Area include up to 7 large spills (≥1,000 bbl) from both pipeline and platforms, and as many as 470 small spills (<1,000 bbl) and up to one tanker spill of up to 3,100 bbl (Table 4.4.2-1). Noise from emergency and spill-response activities and support vessels and aircraft has the potential to disturb marine mammals, sea turtles, fish, and birds. For small spills, noise generated from response actions in open water would be expected to be localized and of relatively short duration. In the event of a large spill covering a greater ocean area and contacting the shore or moving into coastal and inland wetlands, longer term response activities, including seismic surveys, skimmers, and other mechanical equipment, over a wider area would be required and associated noise would occur over a wider area. Noise from response equipment and support vessels and aircraft could disturb marine mammals, sea turtles, fish, and birds in the vicinity of the response action, temporarily for small spills and for longer periods for large spills (see the biota-specific discussion in Section 4.4.7). Noise along the trajectories of support vessels and aircraft would be transient and localized along the trajectory but would recur for the duration of the spill response. Response activities for onshore spills or offshore spills that reached the land would have similar impacts but would also affect terrestrial species (MMS 2006a, 2007d). The pressure wave and noise generated from an incident involving a loss of well control could affect marine mammals and could be large enough to harass or injure them if they were close enough to the site of the event (MMS 2006a).

Impacts of an Unexpected Catastrophic Discharge Event. For the purposes of analysis, a CDE in the GOM is assumed to range in size from 900,000 to 7,200,000 bbl (Table 4.4.2-2). Sources of noise and impacts would be similar to, but probably larger than, those above for expected events. Accident response and support activities, including support aircraft and vessel activity, have the potential to cause noise impacts. These impacts would occur both at the site of the response activity and along the trajectories of support vessels and aircraft and would affect marine mammals, sea turtles, fish, and birds. Noise along support vessel and aircraft routes would be transient and localized along the route but would recur for the duration of the response. The ensonified area would depend on the size of the CDE and the extent of the response area. The impacts could cover large area, as was the case for the DWH event, and be more sustained over a longer time depending on the volume, location, duration, and weather conditions during the CDE and the response and cleanup activities. Impacts could continue for days during the initial event and for months during spill response and cleanup.

Impact Conclusions.

Routine Operations. Noise impacts under the proposed action would be unavoidable. Routine activities that affect ambient noise conditions in the GOM include seismic surveys, drilling, ship and aircraft traffic, onshore and offshore construction, operational activities, and decommissioning. Noise would affect marine mammals, sea turtles, fish, and birds. Terrestrial mammals would be affected by noise produced during onshore construction and aircraft overflights. The magnitude of the impact would vary with the type of resource affected, the timing of the noise-generating activity, the distance over which the noise is detectable, and the spatial relationship between the noise-generating activity and the affected resource. Short-term transient noises would generally have different impacts than continuous, long-term noise. Seismic survey noise would be short-term. Drilling noise would continue for the duration of the activity and could be detectable over a fairly wide area. Ship and aircraft traffic would produce transient noise along the routes followed. Construction activities would tend to be limited to the vicinity of the activity except for dredging and pile driving, which can be detected over fairly wide areas. Operational noises would be low-level and localized but would continue over the lifetime of the activity. Impacts on ambient noise levels from these activities are expected to be minor.

Decommissioning activities would be similar to construction activities and would be expected to have minor impacts on ambient noise levels except for the use of explosives. If used, explosive noise would be short-term but the pressure pulse could cause serious impacts to nearby marine mammals. Impacts from use of explosives could thus be minor to moderate.

Expected Accidental Events and Spills. Seismic surveys, skimmers, mechanical equipment, and support vessels and aircraft are among the noise sources associated with cleanup and response activities. Noise from these sources would persist for the duration of the response activities. At the conclusion of the activities, ambient noise would return to pre-spill levels. Noise from response activities could affect terrestrial and marine mammals, sea turtles, fish, and birds. Noise from responses to small spills would be short-term and localized except for the transient noise along the trajectories of support vessels and aircraft. Noise from response activities for large spills would probably take place over a longer time and cover a greater area, generally producing greater impacts than noise from response activities for small spills. Noise impacts from response activities for small and large spills are expected to be minor. If the event involves a major loss of well control, the associated pressure wave could harass or injure nearby marine mammals. Thus, the impacts could be minor to moderate.

An Unexpected Catastrophic Discharge Event. Seismic surveys, skimmers, mechanical equipment, and support vessels and aircraft are among the noise sources associated with response and cleanup activities for an unexpected CDE. Noise from these response activities could continue for days during the initial event and for months during spill response and cleanup. When these activities cease, ambient noise would return to pre-spill levels. Noise from response activities could affect terrestrial and marine mammals, sea turtles, fish, and birds. Noise would be transient along the trajectories of support vessels and aircraft but would persist for the possibly extended duration of cleanup and response activities. If the event involves a major loss of well control, the associated pressure wave could harass or injure nearby marine mammals. Noise impacts from response activities for an unexpected CDE are expected to be minor to moderate.

4.4.5.2 Alaska – Cook Inlet

The impact producing factors for noise that may be expected for the Cook Inlet Planning Area under the proposed action include seismic surveys, ship and aircraft traffic, drilling and trenching, offshore construction, and production operations. There would be no onshore new construction involving pipeline landfalls, shore bases, processing facilities, or waste facilities and no platform removals in the Cook Inlet Planning Area under the proposed action (see Table 4.4.1-3).

Impacts of Routine Operations. Routine activities that could potentially cause changes in ambient noise levels in Cook Inlet include seismic surveys, drilling noise, ship and aircraft noise, offshore construction, and operational activities. See Section 3.6.1.4 for details on the noise levels and frequencies associated with routine operational activities.

Under the proposed action, seismic surveys would be conducted to identify locations for up to 12 exploration and delineation wells (Table 4.4.1-3). Airgun noise can be detected up to 100 km (62 mi) from the source and beyond under appropriate conditions (see Section 3.6.1.4.4), so the affected area can be extensive, although changes in ambient noise levels would be greatest at locations closest to the airgun. Noise from these seismic surveys and the associated survey and support vessels would alter the acoustic environment and affect ecological resources in the planning area. Effects could include physical and behavioral changes in marine mammals and fish and disturbance of birds. See Section 4.4.7 for discussions of noise impacts on ecological resources of the planning area. Targeted species for commercial, personal-use, subsistence, and recreational fishing could also be affected (MMS 2007d). These impacts would continue for the duration of the survey, and the affected area would move along with the survey and support vessels.

Noise from construction of as many as 3 offshore platforms, up to 114 development and production wells, 241 km (150 mi) of offshore pipeline, and 169 km (105 mi) of onshore pipeline, as well as noise from the associated support vessels and aircraft, could disturb marine mammals (see Section 4.4.7.1) as well as birds (see Section 4.4.7.2) in the vicinity of the construction activity. Construction activity may cause fish to leave the construction area (see Section 4.4.7.3). These effects would persist for the duration of the activity and could persist for weeks after the end of the activity and would be strongest at the construction site or along the line of any required offshore trenching activity. Multiple construction projects occurring simultaneously in the same vicinity or over multiple years would have increased noise impacts. Any effects would persist for the duration of the construction and be strongest near the construction site.

Under the proposed action, pile driving drilling noise during exploration, development, and production would be relatively constant for the duration of the drilling. Drilling noise generally would be less than ambient background levels beyond 30 km (19 mi) from the drill site (see Section 3.6.1.4.3) and would be strongest near the well. Noise levels would increase if several wells were operating simultaneously in close proximity to one another. The noise could have impacts on mammals, fish, and birds in Cook Inlet as discussed in Section 4.4.7. Noise and vessel traffic associated with oil and gas activities in offshore areas adjacent to boundaries of the

Lake Clark National Park and Preserve, the Katmai National Park and Preserve, and State wildlife refuges and ranges bordering Cook Inlet could temporarily disturb some wildlife and negatively affect recreational values for park users (Section 4.4.12) (MMS 2007d).

In addition to drilling noise, machinery on platforms generates noise during operation. Such noise could be continuous or transient and variable in intensity depending on the nature and the role of the machinery. Underwater noise would be relatively weak because of the small surface area in contact with the water, but it could affect marine mammals (MMS 2006a). Because there would be no more than three platforms developed as a result of leasing under the Proposed Action Alternative, noise impacts from platform operation are anticipated to localized.

Under the proposed action, vessel traffic (up to three trips per week) and helicopter traffic (up to three trips per week) will result in increases in noise levels along the traffic routes and at platforms during construction and operation. Sound generated by these activities is transient and variable in intensity; it may affect mammals, fish, and birds, as discussed in Section 4.4.7. Noise from vessel traffic generally reaches background levels within 10 km (6 mi) of the source, but may be detectable at very great distances in deep water. Flights over land would also affect terrestrial mammals (see Section 4.4.7.1). The noise would be transient along the traffic path but would recur as long as trips continue. Frequent overflights could produce longer term consequences (MMS 2007d, 2008a).

Although Cook Inlet is generally more than 90% ice free and the Federal waters of Cook Inlet are not seasonally icebound, any icebreaker activity may increase as a result of the proposed action and could result in increased disturbance of marine mammals. Icebreakers operate in support of exploration including seismic survey, construction, and operation activities. Icebreakers do not operate during the open-water season. Icebreaking vessels produce louder, but also more variable, sounds than those associated with other vessels of similar power and size. Icebreaker noise can be substantial out to at least 5 km (3 mi) and may be detectable from more than 50 km (31 mi) away. Icebreaker noise would add to the impacts discussed above for the particular activity they were supporting, but any increases would not occur during the open-water season. Impacts would be transient along the path of the icebreaker and would be strongest near the path.

There is currently no subsistence whaling in Cook inlet, but there is some potential for noise-induced alterations in marine mammal behavior. Local residents have consistently indicated that whales and other marine mammals are very sensitive to noise and that they have been disturbed from their normal patterns of behavior by past seismic and drilling activities (Section 4.4.13). Lease stipulations have minimized such problems in the recent past, so noise and disturbance effects are expected to be effectively mitigated (MMS 2006a). See Sections 4.4.10.2.1 and 4.4.13.2.1 for discussions of noise impacts on land use and subsistence harvests, respectively.

Impacts of Expected Accidental Events and Spills. Under the proposed action, the number and types of spills assumed to occur in the Cook Inlet Planning Area include up to one large spill (≥1,000 bbl) from either a pipeline or a platform and as many as 18 small (<1,000 bbl) spills (Table 4.4.2-1). Noise from emergency and spill-response activities and support vessels and aircraft has the potential to disturb marine mammals, fish, and birds. For small spills, noise generated from response actions in open water would be expected to be localized and of relatively short duration. In the event of a large spill covering a greater ocean area and contacting the shore or moving into coastal and inland wetlands, longer term response activities over a wider area would be required and associated noise would occur over a wider area. Noise from response equipment and activities including seismic surveys, skimmers, and other mechanical equipment and support vessels and aircraft could affect marine mammals, fish, and birds in the vicinity of the response action, temporarily for small spills and for longer periods for large spills (see biota-specific discussions in Section 4.4.7). Noise along the routes of support vessels and aircraft would be transient and localized along the route but would recur for the duration of the response. Response activities for onshore spills or offshore spills that reached coastal areas would have similar acoustic impacts on nearby marine mammals and birds and would also affect terrestrial species (MMS 2006a, 2007d). The pressure wave and noise generated from an incident involving a loss of well control could affect marine mammals and could be large enough to harass or injure them if they were close enough to the site of the event (MMS 2006a).

Impacts of an Unexpected Catastrophic Discharge Event. An unexpected CDE in the Cook Inlet Planning Area is assumed to range in size from 75,000 to 125,000 bbl (Table 4.4.2-2). Sources of noise and impacts would be similar to, but probably larger than, those above for expected events. Accident response and support activities, including support aircraft and vessel activities, have the potential to cause noise impacts. These impacts would occur both at the site of the response activity and along the trajectories of support vessels and aircraft and would affect marine mammals, fish, and birds. Noise along support vessel and aircraft routes would be transient and localized along the route but would recur for the duration of the response. The ensonified area would depend on the size of the CDE and the extent of the response area. The impacts could cover a large area, as was the case for the DWH event, and be more sustained over a longer time depending on the volume, location, duration, and weather conditions during the CDE and the response and cleanup activities. Impacts could continue for days during the initial event and for months during spill response and cleanup.

Impact Conclusions.

Routine Operations. Noise impacts under the proposed action would be unavoidable. Routine activities that affect ambient noise conditions in Cook Inlet include seismic surveys, drilling, ship and aircraft traffic, icebreakers, onshore and offshore construction, operational activities, and decommissioning. Noise would affect marine mammals, fish, and birds. Terrestrial mammals would be affected by onshore construction and aircraft overflights. The magnitude of the impact would vary with the type of resource affected, the timing of the noise-generating activity, the distance over which the noise is detectable, and the spatial relationship between the noise-generating activity and the affected resource. Short-term transient noises would generally have different impacts than continuous, long-term noise. Seismic survey noise would be short-term. Drilling noise would continue for the duration of the activity and could be detectable over a fairly wide area. Ship and aircraft traffic would produce transient noise along the routes followed. Noise from icebreakers, if used, would be seasonal, louder and more variable than noise for other vessels, and detectable over a fairly wide area. Construction activities would tend to be limited to the vicinity of the activity, except for dredging and pile driving, which can be detected over fairly wide areas. Operational noises would be low-level and localized but would continue over the lifetime of the activity. Impacts on ambient noise levels from these activities are expected to be minor.

Decommissioning activities would be similar to construction activities and would be expected to have minor impacts on ambient noise levels except for the use of explosives. If used, explosive noise would be short–term but the pressure pulse could cause serious impacts to nearby marine mammals. Impacts from use of explosives could thus be minor to moderate.

Expected Accidental Events and Spills. Seismic surveys, skimmers, mechanical equipment, and support vessels and aircraft are among the noise sources associated with cleanup and response activities. Noise from these sources would persist for the duration of the response activities. At the conclusion of the activities, ambient noise would return to pre-spill levels. Noise from response activities could affect terrestrial and marine mammals, fish, and birds. Noise from responses to small spills would be short-term and localized except for the transient noise along the trajectories of support vessels and aircraft. Noise from response activities for large spills would probably take place over a longer time and cover a greater area, generally producing greater impacts than noise from response activities for small spills. Noise impacts from response activities for small and large spills are expected to be minor. If the event involves a major loss of well control, the associated pressure wave could harass or injure nearby marine mammals. Thus, the impacts could be minor to moderate.

An Unexpected Catastrophic Discharge Event. Seismic surveys, skimmers, mechanical equipment, and support vessels and aircraft are among the noise sources associated with response and cleanup activities for an unexpected CDE. Noise from these response activities could continue for days during the initial event and for months during spill response and cleanup. When these activities cease, ambient noise would return to pre-spill levels. Noise from response activities could affect terrestrial and marine mammals, fish, and birds. Noise would be transient along the trajectories of support vessels and aircraft but would persist for the possibly extended duration of cleanup and response activities. If the event involves a major loss of well control, the associated pressure wave could harass or injure nearby marine mammals. Noise impacts from response activities for an unexpected CDE are expected to be minor to moderate.

4.4.5.3 Alaska – Arctic

The impact-producing factors for noise that may be expected in Arctic Alaska under the proposed action include seismic surveys, ship and aircraft traffic, drilling and trenching, offshore construction, construction of onshore pipeline, and production operations. There would be no onshore construction involving pipeline landfalls or shore bases and no platform removals in Arctic Alaska under the proposed action (see Table 4.4.1-4).

Impacts of Routine Operations. Routine activities that will affect ambient noise conditions in the Beaufort Sea and Chukchi Sea Planning Areas include seismic surveys, drilling noise, ship and aircraft noise, icebreaker noise, offshore construction, onshore pipeline construction, and operational activities. See Section 3.6.1.4 for details on the noise levels and frequencies associated with routine operational activities.

Under the proposed action, seismic surveys would be conducted to identify locations for up to 36 exploration wells (16 in the Beaufort Sea Planning area and 20 in the Chukchi Sea Planning Area). Airgun noise can be detected up to 100 km (62 mi) from the source and beyond under appropriate conditions (see Section 3.6.1.4.4), so the affected area can be extensive, although changes in ambient noise levels would be greatest at locations closest to the airgun. Noise from these seismic surveys and the associated survey and support vessels would alter the acoustic environment and affect ecological resources in the planning area. Effects would include physical and behavioral changes and disturbance in marine mammals and fish. Marine and coastal birds could also be affected. See Section 4.4.7 for discussions of noise impacts on ecological resources of the two planning areas. The potential for affecting ecological resources would continue for the duration of the survey activities.

Under the proposed action, construction and installation of exploratory and production wells (up to 36 and 400, respectively), platforms (up to 9), onshore pipelines (up to 129 km [80 mi]), offshore pipelines (up to 652 km [405 mi]), and subsea wells (up to 92 [up to 10 in the Beaufort Sea Planning Area and up to 81 in the Chukchi Sea Planning Area]) will result in increases in noise levels in the vicinity of these construction activities. With the exception of pipeline trenching, construction and installation activities would generate noise from stationary noise sources at the drilling/well sites and from support vessels and aircraft.

Noise from pile driving, construction of offshore platforms and pipelines, support vessel and aircraft traffic, and gravel placement activities could disturb normal behaviors in marine mammals, birds, and fish in the vicinity of the construction activities (see Section 4.4.7). These effects would persist for the duration of the activity and would be strongest at the construction site(s) or along the line of any required trenching activity. Multiple construction projects occurring simultaneously in the same vicinity or over multiple years would have increased noise impacts.

Construction of up to 129 km (80 mi) of onshore pipeline on areas adjacent to the Beaufort Sea would cause noise that would disturb terrestrial mammals (see Section 4.4.7.1). Impacts would depend on the season and proximity to critical habitat and would persist for the duration of the construction activity. Affected areas would move as the active construction area progressed along the pipeline route. Marine mammals, birds, and fish in nearby waters could be affected. Given that there would be no new pipeline landfalls and no new shore bases constructed, little or no additional onshore construction is anticipated under the proposed action, any noise-related impacts would be limited to relatively few terrestrial mammals and birds. Any effects would persist for the duration of the construction and be strongest near the construction site. Additional noise-related impacts could be caused by gravel excavation activities.

Under the proposed action, drilling noise would be relatively constant during exploration phase drilling and during development and production phase drilling. Drilling noise generally would be less than ambient background levels beyond 30 km (19 mi) from the drill site (see Section 3.6.1.4.3) and strongest near the well. Noise levels would increase if several wells were located in close proximity to one another. The drilling noise could affect marine mammals, birds, and fish (see the biota-specific discussion in Section 4.4.7).

In addition to drilling noise, machinery on platforms generates noise during operation. Such noise could be continuous or transient and variable in intensity depending on the nature and the role of the machinery. Underwater noise would be relatively weak because of the small surface area in contact with the water, but it could affect marine mammals (MMS 2006a).

Under the proposed action, vessel traffic (up to 27 trips per week) and helicopter traffic (up to 27 trips per week) will result in increases in noise levels along the traffic routes and at the platforms during construction and operation. Vessel traffic in Arctic Alaska occurs primarily in the summer (MMS 2007d). Sound generated by these activities is transient and variable in intensity and may affect terrestrial and marine mammals, marine and coastal birds, and fish, as discussed in Section 4.4.7. Noise from vessel traffic generally reaches background levels within 10 km (6 mi) of the source, but may be detectable at very large distances in deep water. Flights over land would also affect terrestrial mammals (see Section 4.4.7.1). The noise would be transient along the traffic path but would recur as long as trips continue. Frequent overflights could produce longer term consequences (MMS 2007d, 2008a).

Icebreaker activity in the Beaufort Sea and Chukchi Sea areas could increase under the proposed action if needed to support exploration, construction, and operation activities. In addition to icebreaking activities when there is ice cover, icebreakers also engage in ice management activities during the summer. Icebreakers do not operate during the open-water season. Icebreaking vessels produce louder, but also more variable, sounds than those associated with other vessels of similar power and size. Icebreaker noise can be substantial out to at least 5 km (3 mi) and may be detectable from more than 50 km (31 mi) away (see Section 3.6). Icebreaker noise would add to the impacts discussed above for the particular activity they were supporting. Impacts would be transient along the path of the icebreaker and would be strongest near the path.

Noise during staging activities for exploration, development, and production would likely occur in areas with existing infrastructure, such as Deadhorse, and cause little direct impact on local native communities. Noise from vessel and aircraft traffic, seismic surveys, and icebreakers could also disturb marine mammals, birds, and fish and thus potentially affect subsistence harvests and resources. Lease stipulations have minimized such problems in the recent past, so noise and disturbance effects are expected to be effectively mitigated (MMS 2008b).

Impacts of Expected Accidental Events and Spills. Under the proposed action, the number and types of spills assumed to occur in the Arctic region include up to 3 large spills (≥1,000 bbl) from pipelines and platforms and between 60 and 225 small (<1,000 bbl) spills over the 50-yr period of the Program (Table 4.4.2-1). Noise from emergency and spill-response activities and support vessels and aircraft has the potential to disturb marine mammals, fish, and birds. For small spills, noise generated from response actions in open water would be expected to be localized and of relatively short duration. In the event of large spills covering a greater ocean area and contacting the shore or moving into coastal and inland wetlands, longer term response activities over a wider area would be required and the associated noise would occur over a wider area. Noise from response equipment and activities including seismic surveys, skimmers, and other mechanical equipment and support vessels and aircraft could disturb marine mammals, birds, and fish, as well as invertebrate prey species in the vicinity of the response action; the impact would be temporary for small spills and of longer duration for large spills (see biota-specific discussions in Section 4.4.7). Noise along the routes of support vessels and aircraft would be transient and localized but would recur for the duration of the spill response. Response activities for onshore spills or offshore spills that reached the land could have similar impacts but would also affect terrestrial species (MMS 2006a, 2007d). The pressure wave and noise generated from an incident involving a loss of well control could affect marine mammals and could be large enough to harass or injure them if they were close enough to the site of the event (MMS 2006a).

Impacts of an Unexpected Catastrophic Discharge Event. In the Arctic planning areas, an unexpected CDE is assumed to range in size between 1,700,000 and 3,900,000 bbl in the Beaufort Planning Area, and between 400,000 and 2,100,000 bbl in the Chukchi Planning Area (Table 4.4.2-2). Sources of noise and impacts would be similar to, but probably larger than, those above for expected events. Accident response and support activities, including support aircraft and vessel activities, have the potential to cause noise impacts. These impacts would occur both at the site of the response activity and along the trajectories of support vessels and aircraft and would affect marine mammals, fish, and birds. Noise along support vessel and aircraft routes would be transient and localized along the route but would recur for the duration of the response. The ensonified area would depend on the size of the CDE and the extent of the response area. The impacts could cover a large area, as was the case for the DWH event, and be more sustained over a longer time depending on the volume, location, duration, and weather conditions during the CDE and the response and cleanup activities. Impacts could continue for days during the initial event and for months during spill response and cleanup.

Impact Conclusions.

Routine Operations. Noise impacts under the proposed action would be unavoidable. Routine activities that affect ambient noise conditions in Arctic Alaska include seismic surveys, drilling, ship and aircraft traffic, icebreakers, onshore and offshore construction, operational activities, and decommissioning. Noise would affect marine mammals, fish, and birds. Terrestrial mammals would be affected by onshore construction and aircraft overflights. The magnitude of the impact would vary with the type of resource affected, the timing of the noise-generating activity, the distance over which the noise is detectable, and the spatial relationship between the noise-generating activity and the affected resource. Short-term transient noises would generally have different impacts than continuous, long-term noise. Seismic survey noise would be short-term. Drilling noise would continue for the duration of the activity and could be detectable over a fairly wide area. Ship and aircraft traffic would produce transient noise along the routes followed. Noise from icebreakers would be seasonal, louder and more variable than noise for other vessels, and detectable over a fairly wide area. Construction activities would tend to be limited to the vicinity of the activity, except for dredging and pile driving, which can be detected over fairly wide areas. Operational noises would be low-level and localized but would continue over the lifetime of the activity. Impacts on ambient noise levels from these activities are expected to be minor.

Decommissioning activities would be similar to construction activities and would be expected to have minor impacts on ambient noise levels except for the use of explosives. If used, explosive noise would be short-term but the pressure pulse could cause serious impacts to nearby marine mammals. Impacts from use of explosives could thus be minor to moderate.

Expected Accidental Events and Spills. Seismic surveys, skimmers, mechanical equipment, support vessels and aircraft, and icebeakers, if used, are among the noise sources associated with cleanup and response activities. Noise from these sources would persist for the duration of the response activities. At the conclusion of the activities, ambient noise would return to pre-spill levels. Noise from response activities could affect terrestrial and marine mammals, fish, and birds. Noise from responses to small spills would be short-term and localized except for the transient noise along the trajectories of support vessels and aircraft. Noise from response activities for large spills would probably take place over a longer time and cover a greater area, generally producing greater impacts than noise from response activities for small spills. Noise impacts from response activities for small and large spills are expected to be minor. If the event involves a major loss of well control, the associated pressure wave could harass or injure nearby marine mammals. Thus, the impacts could be minor to moderate.

An Unexpected Catastrophic Discharge Event. Seismic surveys, skimmers, mechanical equipment, support vessels and aircraft, and icebreakers, if used, are among the noise sources associated with response and cleanup activities for an unexpected CDE. Noise from these response activities could continue for days during the initial event and for months during spill response and cleanup. When these activities cease, ambient noise would return to pre-spill levels. Noise from response activities could affect terrestrial and marine mammals, fish, and birds. Noise would be transient along the trajectories of support vessels and aircraft but would persist for the possibly extended duration of cleanup and response activities. If the event involves a major loss of well control, the associated pressure wave could harass or injure nearby marine mammals. Noise impacts from response activities for an unexpected CDE are expected to be minor to moderate.

4.4.6 Potential Impacts on Marine and Coastal Habitats

4.4.6.1 Coastal and Estuarine Habitats

4.4.6.1.1 Gulf of Mexico (GOM). Coastal and estuarine habitats could be directly or indirectly affected by a number of factors associated with oil and gas activities (Table 4.4.6-1). These factors include vessel traffic, maintenance dredging of navigational canals, construction and operation of onshore facilities, installation and maintenance of pipelines, expansion of ports and docks, and operation of offshore oil and gas facilities. The potential for impacts would be largely influenced by site-specific factors, such as the habitat types and distribution in the

TABLE 4.4.6-1 Impacting Factors for Coastal and Estuarine Habitats in the Gulf of Mexico

	Habitat Type		
Oil and Gas Impacting Factors[a]	Barrier Landforms	Wetlands	Seagrasses
Vessel traffic (all phases)	X	X	X
Navigation channel maintenance dredging (operations)	X	X	X
Pipeline emplacement (construction)	X	X	X
Construction of onshore facilities (construction)		X	X
Expansion of onshore facilities (construction)	X	X	X
Use of existing facilities (operations)	X	X	X
Expansion of ports and docks (construction)	X	X	X
Disposal of OCS-related wastes (all phases)		X	X
Accidental spills (all phases)	X	X	X

[a] X = Potential impacts on the resource attributable to the impacting factor.

vicinity of oil and gas activities. Many of the activities associated with oil and gas, such as platform construction, would occur in offshore waters, with minimal impacts on coastal habitats other than for potential accidents.

Impacts of Routine Operations.

Barrier Landforms. The potential effects on coastal barrier islands, beaches, and dunes from routine operations would primarily be associated with indirect effects from maintenance dredging and vessel traffic. Impacts of pipeline landfalls and use or expansion of coastal facilities could also occur.

Maintenance dredging of navigation channels in barrier inlets and bar channels can remove sediments from the longshore sediment drift. Maintained channels intercept and capture sediments, and dredged materials are often discharged to ocean dump sites. Dredging may contribute to the reduction of sediment deposition and affect the stability of downdrift barrier landforms (MMS 2007c). Reductions in sediment supply could subsequently contribute to small local losses of adjacent downdrift barrier beach habitat, with impacts over a broader area where the sediment supply is low, such as along the Louisiana coastal barrier islands in the Central Planning Area (CPA). However, dredged sediments are used in beach restoration projects where feasible (MMS 2008a). The installation of erosion control structures, such as jetties, for OCS-related facilities built near barrier shorelines may also accumulate sediments and induce erosion of downdrift areas (MMS 2007c). Although it is not considered likely, there is a possibility that, in some locations, dredging may result in the resuspension and transport of sediments that may contain residual oil from the DWH event.

Service vessel traffic to exploration and production wells could contribute to erosion of barrier beaches. Approximately 300 to 600 vessel trips per week would occur in the GOM under the proposed action. Waves generated by service vessels can erode unprotected shorelines and areas that currently experience barrier beach losses from ongoing shoreline degradation, particularly the coastal areas of Louisiana; vessel traffic can contribute to the accelerated erosion of sediments along beaches through increased wave activity. Erosion from vessel activity along unarmored navigation channels has resulted in channel widening in the Western Planning Area (WPA) and CPA and land loss in some areas. However, restoration and stabilization of channel margins have been effective in minimizing channel widening. Wave activity could be minimized by maintaining reduced vessel speeds in the vicinity of barrier islands.

The proposed action would include approximately less than 12 new pipeline landfalls in the GOM region. Impacts on barrier landforms would likely be avoided during pipeline construction by the use of modern construction techniques, such as directional (trenchless) boring, under barrier islands and beaches (MMS 2008a). These construction methods avoid or minimize impacts on the barrier systems (Wicker et al. 1989). If nonintrusive techniques were not used, impacts on beach and dune communities from ground-disturbing activities during pipeline construction could occur, with the potential for accelerated beach erosion and island breaching. The presence of pipelines, even after decommissioning, in some areas of the GOM may potentially result in the reduction or elimination of suitable sediment sources used for beach renourishment and restoration projects, because of the necessity of pipeline avoidance. Loss of sediment sources could potentially restrict restoration activities in some areas. In addition, at restoration sites, pipeline safety buffers can reduce the number and extent of areas available for restoration, and pipeline surveys divert funds that would otherwise be available for such restoration. However, as noted above, fewer than 12 new pipeline landfalls would be constructed under the proposed action. Pipeline disturbance widths are generally small with modern placement methods, and the rights-of-way should be less than 200 m (218 yd) in width. Operators are interested in protecting pipelines from coastal erosion, so a synergy could be developed with coastal restoration projects. Because of demand for OCS material for coastal restoration, BOEM is trying to cluster pipelines and to keep pipelines away from known marine mineral resources (BOEM 2012a; USDOI 2009).

Up to 12 new natural gas processing facilities and 4 to 6 new pipe yards would be constructed. No new facilities would be expected to be constructed on barrier beaches or associated dunes; however, impacts on other coastal upland habitats would likely occur. Habitat losses would be minimized if facilities were located in previously disturbed areas. Expansion of existing facilities located on barrier beaches or dunes would result in losses of those habitats. The continued use of facilities that have become located in the barrier beach and dune zone because of ongoing shoreline recession may result in accelerated erosion of those habitats.

Wetlands. The potential effects on wetlands from routine operations would primarily be associated with direct impacts from pipeline emplacement and maintenance and navigation channel maintenance dredging, as well as indirect impacts from decreased water quality (such as from disposal of OCS-related wastes), altered hydrology, and vessel traffic. Impacts from ground-disturbing activities during construction or expansion of support facilities, such as processing facilities and pipeline yards, could also occur.

The construction of pipelines through coastal wetlands could result in direct losses of marsh habitat, depending on avoidance of wetlands in pipeline route selection and the emplacement technique used. The use of directional boring under wetlands during pipeline construction would likely avoid or minimize impacts on wetlands. Trenching for pipeline emplacement would result in direct impacts on marsh habitat from excavation. Long-term reduction in vegetation productivity above and adjacent to the pipeline, including areas backfilled, would likely occur, with potential losses of wetland habitat, depending on factors such as the success of backfilling, time of year, and duration of construction (Turner et al. 1994; MMS 2007c).

Maintenance dredging of navigation channels would contribute to increased flushing and draining of interior marsh areas by tides and storms, which could result in shifts in species composition, habitat deterioration, erosion, and wetland loss (LCWCRTF 1998, 2003). Channels alter the hydrology of coastal marshes by affecting the amount, timing, and pathways of water flow (Day et al. 2000a). Hydrologic alterations can result in changes in salinity and inundation, causing a dieback of marsh vegetation and a subsequent loss of substrate and conversion to open water (LCWCRTF 2001; Day et al. 2000a). Saltwater intrusion into brackish and freshwater wetlands further inland could result in mortality of salt-intolerant species and loss of some wetland types such as cypress swamp, or transition of wetland types such as freshwater marsh to brackish and saltmarsh or open water (MMS 2007c). The deposition of dredged material onto adjacent disposal banks could potentially result in a small localized contribution to ongoing impacts of disposal banks, such as preventing the effective draining of some adjacent areas, resulting in higher water levels or more prolonged tidal inundation, or restricting the movement of water, along with sediments and nutrients, into other marsh areas (Day et al. 2000a). Impacts on marsh habitats from navigation channels would be expected to be mitigated by the beneficial use of dredged material (MMS 2008a), through the application of dredged material onto marsh surfaces to increase substrate elevations for marsh restoration or creation. Small areas of marsh would likely be lost during dredging by the occasional inadvertent deposition of dredged material, as well as created by material deposition into shallow water (MMS 2007c).

Service vessel traffic to exploration and production wells would contribute to erosion of marsh habitat. Wetland losses would likely occur along unarmored navigation channels because of the widening that would result from the continued erosion of adjacent marsh substrates due to waves generated by vessel traffic (LCWCRTF 2003). Erosion from vessel activity along navigation channels has resulted in channel widening in the WPA and CPA and land loss in some areas. However, restoration and stabilization of channel margins have been effective in minimizing channel widening. Erosion of wetlands would not occur along armored channels, which are frequently used by OCS-related vessel traffic.

The construction or expansion of facilities near the coastline, including the potential expansion of port facilities, could potentially result in the direct loss of wetlands from the placement of fill material during building construction, as well as the construction of pipelines, access roads, and transmission corridors. However, construction in wetlands is discouraged by State and Federal permitting agencies. Section 404 of the Clean Water Act regulates the discharge of dredge or fill material into U.S. waters, including wetlands. Impacts on jurisdictional wetlands (those under the regulatory jurisdiction of the CWA, Section 404) would require permitting from USACE. In addition, Executive Order 11990, "Protection of Wetlands" (42 FR 26961, May 24, 1977), requires all Federal agencies to minimize the destruction, loss, or degradation of wetlands, both jurisdictional and nonjurisdictional, and to preserve and enhance the natural and beneficial values of wetlands. Indirect impacts of construction could include habitat fragmentation, altered hydrology from changes in surface drainage patterns or isolation of wetland areas from water sources, conversion to upland communities or open water, sedimentation and turbidity, and introduction of contaminants in stormwater runoff. Resulting changes in affected wetlands could include a reduction in biodiversity and the establishment and predominance of invasive plant species. Impacts on wetlands from construction could be minimized by maintaining buffers around wetlands and by using best management practices for erosion and sedimentation control. As noted above, construction in wetlands is managed and regulated by the appropriate State agencies and the USACE. It is assumed that standard mitigation measures would be applied to any construction project associated with the Program.

Impacts on wetlands near constructed facilities might also result from other factors, such as disposal of wastes at upland disposal sites, which could introduce contaminants into wetlands. Contaminants from land storage or disposal sites might migrate into groundwater or could be present in stormwater runoff that could flow into wetlands. Contaminants might also be released to surface water in service vessel discharges, which might affect wetlands. State requirements would be enforced to prevent and address potential occurrences. Impacts on wetlands would be minimized by implementing water quality practices.

Seagrasses. The potential effects on seagrass communities from routine operations would primarily be associated with effects from vessel traffic, pipeline emplacement, and maintenance dredging. Impacts from use or expansion of coastal facilities could also occur.

Coastal seagrass communities might be damaged by vessel traffic outside established traffic routes, which could result in long-term scars on seagrass beds (MMS 2003d). The recovery rate would be greater for larger scars and low-density vegetation. Seagrass communities might also be affected by trenching for pipeline installation, which could bury adjacent seagrasses and deposit lighter sediments onto leaves of more distant seagrasses. Turbidity from pipeline emplacement, maintenance dredging of navigation canals, or vessel traffic might adversely affect seagrass communities by decreasing seagrass cover and productivity, and changing species composition, as a result of reduced light levels (MMS 2007c). It is assumed that the USACE and State agency requirements regarding the mitigation of turbidity impacts on submerged vegetation from pipeline emplacement and maintenance dredging of navigation channels would be followed. Salinity changes resulting from dredging can also result in changes in species composition of seagrass communities. Because activities associated with the Program would be located adjacent to coastlines with substantial seagrass resources in the U.S. GOM, the Program would be expected to have potential effects on the overall condition of seagrass communities in the GOM. Localized impacts on small areas of seagrass could occur in coastal areas west of Florida including the extensive, deepwater seagrass resources of the west Florida shelf.

Impacts of Expected Accidental Events and Spills. The potential effects on coastal and estuarine habitats from accidents would primarily be associated with impacts from spills of oil and other petroleum hydrocarbons, such as fuel oil or diesel fuel, and subsequent cleanup efforts. Large (≥1,000 bbl) and small (<1,000 bbl) oil spills could occur as a result of tanker and barge spills, pipeline spills, or platform spills. This analysis assumes 2–5 pipeline spills of 1,700 bbl, 1–2 platform spills of 5,100 bbl, 1 tanker spill of 3,100 bbl, 35–70 small spills (>50–1,000 bbl), and 200–400 small spills up to 50 bbl. Spills from vessels should be minimized by compliance with USCG requirements for spill prevention and control. Section 4.4.2 provides details of spill assumptions. Oil or other spilled materials might be transported to barrier landforms and wetland habitats by currents or tides. The amount of oil deposited on coastal habitats would depend on various factors, such as spill volume, distance from shoreline, ambient conditions, degree of weathering, and effectiveness of response actions. Large spills would potentially result in heavy or widespread deposits of oil. The majority of spills would be less than 50 bbl and would likely result in light, mostly localized oiling, or would fail to reach a shoreline. Small spills >50 to <1,000 bbl, while not likely to result in widespread shoreline oiling, could be expected to result in moderate deposits.

Beaches could be affected by oil spills, and the direct mortality of biota could result. Spilled oil that reaches barrier beaches might be restricted to beach surfaces, or it could penetrate into subsurface layers. Permeable substrates, generally associated with larger sand grain sizes, and holes created by infauna could increase oil penetration, especially that of light oils and petroleum products (NOAA 2000). Oil may become buried under sediments by wave action. Although beach and foredune areas are often sparsely vegetated, impacts on vegetation might occur if oil was carried to higher elevations by storm waves and tides. Oiled beach sediments could weaken dune and other beach vegetation, resulting in accelerated erosion. Because of the changes in barrier beach and dune profiles as a result of hurricanes, such as Katrina and Rita, habitat between the shoreline and beach ridge may be more vulnerable to impacts of spills (MMS 2008a).

Impacts on coastal marsh vegetation from oil spills could range from a short-term reduction in photosynthesis to extensive mortality and subsequent loss of marsh habitat as a result of substrate erosion and conversion to open water (Hoff 1995; Proffitt 1998). Small spills less than 50 bbl would likely result in short-term impacts, while large spills could incur both short-term and long-term impacts depending on habitat type and location and the effectiveness of spill containment and cleanup activities.

Vegetation that dies back could recover, even following the death of all existing leaves. Long-term impacts could include reduced stem density, biomass, and growth (Proffitt 1998). Mangroves might decrease canopy cover or die over a period of weeks to months (Hensel et al. 2002; Hayes et al. 1992). Other effects of spills could include a change in plant community composition or the displacement of sensitive species by more tolerant species. In locations where soil microbial communities were affected, effects might be long term, and wetland recovery might be slowed. The degree of impacts on wetlands from spills are related to the oil type and degree of weathering, amount of oil, duration of exposure, season, plant species, percentage of plant surface oiled, substrate type, and oil penetration (Hayes et al. 1992; Hoff 1995; Proffitt 1998; Hensel et al. 2002). Higher mortality and poorer recovery of vegetation generally result from spills of lighter petroleum products (such as diesel fuel), heavy deposits of oil, spills during the active growing period of a plant species, contact with sensitive plant species (especially those located in coastal fresh marsh), completely oiled plants, and deep penetration of oil and accumulation in substrates. Most spills in deepwater areas would require an extended period of time to reach a shoreline or marsh and would undergo natural degradation and dispersion, which, in addition to expected containment actions, would reduce potential impacts. A large spill in shallow water, for example, a tanker spill of 3,100 bbl, could result in relatively unweathered oil reaching extensive areas of coastal wetlands and subsequent loss of marsh habitat. Because of the changes in barrier island profiles as a result of hurricanes Katrina, Rita, and Ivan, there is a greater potential for oil spill impacts on coastal marshes (MMS 2008a).

Impacts on seagrass communities would generally be short term, resulting from contact with oil dispersed in the water column, from reduced light and oxygen levels due to the sustained presence of an oil slick in protected areas, or from reduced populations of epiphyte grazers (MMS 2007c). Recovery would generally occur in about 1 yr. Long-term losses of seagrass habitat would not be expected to occur from a spill unless unusually low tides result in direct contact of seagrass leaf surfaces with an oil slick.

Although any residual oil that might remain on barrier beaches following cleanup could be largely removed in highly exposed locations through wave action, oil could remain in the shallow subsurface for extended periods of time. In some locations, oil might become buried by new sand deposition (NOAA 2000). Natural degradation and persistence of oil on beaches are influenced by the type of oil spilled, the amount present, sand grain size, the degree of penetration into the subsurface, the exposure to the weathering action of waves, and sand movement onto and off the shore. Spilled oil might be entirely absent from affected beaches within a year or less, or it might persist for many years (Dahlin et al. 1994; Hayes et al. 1992; Petrae 1995; Irvine 2000). On sheltered beaches, heavy oiling left for long periods could form an asphalt pavement relatively resistant to weathering (Hayes et al. 1992). Spilled oil remaining in wetlands after cleanup degrades naturally by weathering processes and biodegradation caused by microbial communities in the soil. Full recovery of coastal wetlands might occur in less than 1 yr or might require more than 5 yr, depending on site and spill characteristics (Hoff 1995). Oil might degrade very slowly in saturated soils under mangroves; more than 30 yr could be required for mangroves to recover (Hensel et al. 2002). Oil could remain in some coastal substrates for decades, even if it was cleaned from the surface. Heavy deposits of oil in sheltered areas or in the supratidal zone could form asphalt pavements resistant to degradation (Hoff 1995).

Spill cleanup operations might adversely affect barrier beaches and dunes if large volumes of contaminated substrates were removed. Such removal could affect beach stability, resulting in accelerated shoreline erosion, especially in areas of sand deficit, such as along the Louisiana coastline in the CPA. However, sand removal is generally minimized during spill cleanup (MMS 2007c). Foot traffic during cleanup might mix surface oil into the subsurface, where it might persist for a longer time. Spill cleanup actions might damage coastal wetlands through trampling of vegetation, incorporation of oil deeper into substrates, increased erosion, and inadvertent removal of plants or sediments, all of which could have long-term effects (Hoff 1995; Proffitt 1998; NOAA 2000). These actions could result in plant mortality and delay or prevent recovery. In locations where spill cleanup would include the excavation and removal of contaminated soils and biota, increased erosion and lowered substrate elevation could result in marsh loss by conversion to open water, unless new sediments were applied. Effective low-impact cleanup actions could include bioremediation, low-pressure flushing, or use of chemical cleaners (Mendelssohn and Lin 2003; Hoff 1995; Proffitt 1998).

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes an unexpected CDE with an assumed volume of 0.9–7.2 million bbl and duration of 30–90 days (Table 4.4.2-2). The amount of oil deposited on coastal habitats would depend on various factors, such as spill volume, distance from shoreline, ambient conditions, degree of weathering, and effectiveness of response actions. Although oiling in most areas on barrier islands and beaches is expected to be light, a CDE would potentially result in heavy or widespread deposits of oil and would have a greater likelihood for extensive areas of shoreline affected and heavy deposits of oil in multiple locations. For example, the DWH event, which released 4.9 million bbl of oil, affected more than 1,046 km (650 mi) of the GOM coastal habitat, from the Mississippi River Delta to the Florida panhandle. More than 209 km (130 mi) of coastal habitat were moderately to heavily oiled, including a substantial number of Louisiana beaches (see Section 3.7.1.1.5).

An extended-duration CDE could potentially impact over 1,600 km (1,000 mi) of shoreline. Because of the length of shoreline that could potentially be oiled and the sensitivity of GOM coastal habitats, a high-volume, extended-duration CDE could cause extensive habitat degradation. Loss of vegetation could lead to loss of marsh habitat as a result of substrate erosion and conversion to open water.

While storms may remove oil from shores and strong winds would accelerate the process of dispersal and weathering, storm surges may carry oil into the coastline and inland as far as the surge reaches. Hurricanes have degraded many coastal beaches, marshes, and barrier islands in the GOM, making them more susceptible to a CDE. The toxicity of oil reaching beaches and coastal wetlands from a deepwater CDE should be greatly reduced due to weathering and response activities, thereby minimizing the chances of irreversible damage to the impacted areas. A CDE in shallower waters near shore may have greater impacts because of a shorter period of weathering and dispersion prior to shoreline contact. A spill from a CDE could oil a few to several hundreds of acres of wetlands depending on the depth of inland penetration (Burdeau and Collins 2010). Effects would vary from moderate to heavy oiling. In most cases, the beach face would receive most of the oil; however, in areas where the marsh is immediately adjacent to the beach face or embayments, or in the case of small to severe storms, marshes would also be oiled. Light oiling in wetlands may cause diebacks for one growing season or less, depending on the oil concentration and the season during which contact occurs. However, depending on its duration and magnitude, a CDE could result in high concentrations of oil that would cause long-term effects to wetland vegetation, including some plant mortality and loss of land.

Impact Conclusions.

Routine Operations. Routine Program activities in the GOM would result in minor to moderate localized impacts. Although routine operations in the GOM could have impacts on coastal barrier beaches and dunes, primarily as a result of pipeline construction, maintenance dredging of inlets and channels, and vessel traffic, modern methods of pipeline construction could result in minimal beach erosion. Studies have shown few effects of pipeline landfalls and navigation channels on barrier beach stability.

Routine operations in the GOM could have direct impacts on wetlands as a result of direct losses of habitat from construction activities, pipeline landfalls, and channel dredging, and indirect impacts as a result of altered hydrology caused by channel dredging. Construction impacts, while unavoidable, would be mitigated by State and Federal regulations governing construction in wetland areas.

Expected Accidental Events and Spills. Impacts of a spill on coastal habitats in the GOM could range from negligible to minor for small spills 50 bbl or less, negligible to moderate for small spills >50 to <1,000 bbl, and moderate to major for large spills (≥1,000 bbl), if recovery from the effects of a spill does not occur and exposure results in habitat loss. Spills of oil or other materials could potentially affect both the surface and subsurface of beach and dune substrates in the GOM. Oiled beach sediments could weaken dune and other beach vegetation, resulting in accelerated erosion. Impacts on coastal marsh vegetation from oil spills could range from a short-term reduction in photosynthesis to extensive mortality and subsequent loss of marsh habitat as a result of substrate erosion and conversion to open water. Cleanup operations themselves could also affect wetlands. The effects of spills will depend on the specific habitat affected; the size, location, duration, and timing of the spill; and on the effectiveness of spill containment and cleanup activities. Small spills would likely result in short-term minor impacts, while large spills could incur both short-term and long-term moderate to major impacts, depending on habitat type and location and effectiveness of spill containment and cleanup activities.

An Unexpected Catastrophic Discharge Event. A CDE with an assumed volume of 0.9–7.2 million bbl in the GOM would be associated with a loss of well control. Oil might be transported from offshore areas to coastal wetlands by currents or tides. The amount of oil deposited on coastal habitats would depend on various factors, such as spill volume, distance from shoreline, ambient conditions, degree of weathering, and effectiveness of response actions. A CDE would potentially result in heavy or widespread deposits of oil and would have a greater likelihood for extensive areas of shoreline being affected and heavy deposits of oil in multiple locations. The degree of effects and length of recovery depend on a number of factors such as the type of oil, extent of biota exposure, substrate type, degree of sediment contamination, time of year, temperature, and species sensitivity. Impacts of a CDE on coastal habitats in the GOM could range from moderate to major.

4.4.6.1.2 Alaska Region – Cook Inlet.

Impacts of Routine Operations. The potential effects on coastal habitats from routine operations would primarily be associated with direct impacts from ground-disturbing activities during pipeline construction as well as indirect impacts from service vessels and the operation of existing facilities (see Table 4.4.6-2).

TABLE 4.4.6-2 Impacting Factors for Coastal and Estuarine Habitats in the Alaska Region – Cook Inlet

	Habitat Type		
Oil and Gas Impacting Factors[a]	Cook Inlet Coastal Habitats	Arctic Barrier Landforms	Arctic Wetlands
Vessel traffic (all phases)	X	X	X
Construction of onshore pipelines (construction)	X		X
Use of existing facilities (operations)	X		X
Disposal of OCS-related wastes (all phases)	X		X
Accidental spills (all phases)	X	X	X

[a] X = Potential impacts on the resource attributable to the impacting factor.

Up to one new pipeline landfall would be constructed in the Cook Inlet Planning Area. Pipeline installation would include trench excavation through intertidal and shallow subtidal areas. Installation could directly disturb tidal marshes, beaches, rocky shores, or other coastal habitats, depending on the location of the landfall. A few acres of habitat would likely be altered at each landfall site, and some intertidal and shallow subtidal organisms would be displaced (MMS 2003b). Intertidal and shallow subtidal vegetation could be indirectly impacted by excavation for pipeline installation. Areas adjacent to the trench may be covered by excavated sediments, and organisms could be affected by sedimentation and turbidity associated with the disturbance of bottom sediments during trench excavation and backfilling. Impacts could be reduced by implementing measures to restrict the dispersal of sediments.

Approximately 80–169 km (50–105 mi) of new onshore pipeline would be constructed. Pipelines would deliver oil to existing refineries in Nikiski and natural gas to transmission facilities in the Kenai area, both on the eastern side of Cook Inlet. Indirect effects could include habitat fragmentation, reduced infiltration and increased surface runoff from soil compaction on the construction site, altered hydrology including increased or reduced inundation or saturation of substrates, sedimentation and turbidity, deposition of fugitive dust, and introduction of contaminants in stormwater runoff. Impacts to local streams could affect coastal wetlands. Impacts could result in changes in plant community structure, reduction in plant biodiversity, and the establishment and dominance of invasive plant species. However, activities that may potentially impact wetlands are regulated by State agencies and the USACE. Standard mitigation measures would be applied to any construction project associated with these activities. For example, construction-related impacts could be minimized by maintaining buffers around wetlands and implementing best management practices for erosion and sediment control. Although wetlands along the pipeline route could be affected by construction, impacts could be reduced if pipelines were located in existing utility or transportation system rights-of-way, when possible, and if natural drainage patterns were maintained. Section 404 of the Clean Water Act regulates the discharge of dredge or fill material into U.S. waters, including wetlands. Impacts on jurisdictional wetlands (those under the regulatory jurisdiction of the CWA, Section 404) would require permitting from USACE. In addition, Executive Order 11990, "Protection of

Wetlands" (42 FR 26961, May 24, 1977), requires all Federal agencies to minimize the destruction, loss, or degradation of wetlands, both jurisdictional and nonjurisdictional, and to preserve and enhance the natural and beneficial values of wetlands. Indirect impacts to coastal habitats from sedimentation originating along the pipeline route could be reduced by minimizing crossings of anadromous fish streams and consolidating pipeline crossings with other utility and road crossings.

Construction of a pipeline gravel service road, haul road, and access roads would replace habitat with unvegetated surfaces or result in altered habitat having few species in common with nearby undisturbed habitats. Habitat may also be disturbed by the establishment of work camps. Resulting changes in affected wetlands could include a reduction in biodiversity, replacement of one wetland type for another (such as by dewatering or ponding), conversion to upland communities, or conversion of vegetated wetlands to open water.

No new shore bases, processing facilities, or waste disposal facilities would be constructed. Existing shore bases, gas processing facilities, and waste disposal facilities would be used for all new oil and gas activities in the planning area. Operation of existing facilities could have local indirect effects on wetland vegetation from exhaust emissions or atmospheric releases from processing facilities. Contaminants could be introduced into wetlands from the use of existing waste storage or disposal sites, if contaminants migrate into groundwater or enter stormwater that flows into wetlands. Service vessels would make one to three trips per week for each of the one to three new platforms in the planning area. Discharges from service vessels that support drilling platforms may contain materials that adversely affect coastal wetlands or other intertidal or shallow subtidal habitats. Wetland impacts could be avoided or minimized by implementing practices that eliminate or minimize impacts on water quality.

Impacts of Expected Accidental Events and Spills. The potential impacts on coastal habitats from accidents would primarily be associated with impacts from spills of oil or other petroleum hydrocarbons, such as fuel oil or diesel fuel, and the methods used for spill cleanup. Large (≥1,000 bbl) and small (<1,000 bbl) oil spills could occur as a result of pipeline spills or platform spills. This analysis assumes 1 large spill of 1,700 bbl from a pipeline or 5,100 bbl from a platform, as well as 1–3 small spills >50to <1,000 bbl, and 7–15 small spills up to 50 bbl. Currents and tides within Cook Inlet could transport oil or other materials to coastal habitats. The Cook Inlet Planning Area is unlike any other OCS Planning Area in that it is almost entirely surrounded by coastal habitat. Therefore, there is a very high likelihood that spills in the planning area would make contact with coastal habitats. Because of the patterns of Cook Inlet surface currents, habitats along the western shoreline of the inlet and along Shelikof Strait would have the greatest likelihood of contact from spills within the planning area, while the eastern shoreline would have a lower potential for contamination from spills (MMS 2003a). Extensive winter ice can develop along the western shores of Cook Inlet, and epibiota are seasonally removed by ice scour. Along the Shelikof Strait mainland, intertidal communities are affected by glacier ice melt and are subject to turbidity and freshwater stresses (McCammon et al. 2002).

Intertidal habitats would be highly vulnerable to spills that reach the coastline, and repeated influxes of oil may contaminate intertidal surfaces with each subsequent tidal cycle. Because of the wide tidal range (more than 9 m [30 ft] in some portions of upper Cook Inlet, north of the planning area), extensive areas of shoreline habitat may be affected by a spill, especially soft bottom habitats (sands and muds), which typically have a relatively flat topography. Shallow subtidal habitats could be affected by oil that slumps from intertidal areas and accumulates below the low-tide line.

Vulnerable intertidal habitats sensitive to disturbance from oil spills extend around most of lower Cook Inlet (MMS 2003a). Highly sensitive shoreline habitats include marshes, sheltered tidal flats, and sheltered rocky shores (NOAA 1994). The vulnerability of intertidal habitats is generally rated as highest for vegetated wetlands and semipermeable substrates, such as mud, that are sheltered from wave energy and strong tidal currents. Oil contacting these habitats is less likely to be removed by waves. Cleanup activities are very difficult to conduct on soft mud substrates, such as on tidal flats (NOAA 1994, 2000).

Direct mortality of biota could result from spilled oil contacting intertidal habitats. Oil readily adheres to marsh vegetation (NOAA 1994, 2000; Hayse et al. 1992), and effects may range from a short-term reduction in photosynthesis to extensive vegetation injury or mortality. Many invertebrates are sensitive to oil exposure. Studies of the *Exxon Valdez* oil spill provide valuable information on oil spill effects and recovery. Following the *Exxon Valdez* oil spill, the abundance of many species of algae and invertebrates were reduced at affected sites (NOAA 1997b; Peterson 2000; *Exxon Valdez* Oil Spill Trustee Council 2003). In particular, the abundance and reproductive potential of *Fucus gardneri*, a common and important brown alga species, was reduced in oiled areas and remained unstable at some locations for extended periods (*Exxon Valdez* Oil Spill Trustee Council 2003, 2010a). Although adult *Fucus* appear to have some resistance to oil toxicity, earlier life stages appear to be much more sensitive (NOAA 1998). In shallow subtidal habitats, impacts were less severe, although kelp, eelgrass, and many invertebrates were adversely affected (Peterson 2000).

Spilled oil that contacts intertidal habitats can cause changes in community structure and dynamics. Toxic compounds in oil can selectively remove the more sensitive organisms, such as echinoderms and some crustaceans, while organic enrichment from oil can stimulate the growth and abundance of opportunistic infaunal invertebrates, such as some polychaetes and oligochaetes (McCammon et al. 2002). Some opportunistic species, such as species of barnacle, oligochaetes, and filamentous brown algae, colonized affected shorelines following the *Exxon Valdez* oil spill and cleanup (Peterson 2000; *Exxon Valdez* Oil Spill Trustee Council 2003). Indirect effects also included the spread of *Fucus gardneri* onto lower shoreline areas in some regions, which inhibited the return of red algae (Peterson 2000). The reduction of predators or herbivores can also result in changes in lower trophic levels for extended periods. The adverse effects of oil on intertidal organisms, such as macroalgae, clams, and mussels, can last for more than a decade (MMS 2003e; *Exxon Valdez* Oil Spill Trustee Council 2003).

Extended periods of time may be required for intertidal communities to fully recover from an oil spill. The degree of effects and length of recovery depend on a number of factors such as the type of oil, extent of biota exposure, substrate type, degree of sediment contamination, time of year, and species sensitivity (NOAA 1998; Hayse et al. 1992; Hoff 1995). Both large and small spills could result in long-term and short-term impacts, depending on the habitats affected, the duration and size of the spill, and on the effectiveness of spill containment and cleanup activities. Recovery would likely be considerably longer for large spills with extensive biota exposure and sediment contamination than for small spills, particularly those less than 50 bbl. Although the most acutely toxic components of crude oil are rapidly lost through weathering, the more persistent components have been associated with long-term pathologies such as carcinogenicity (NOAA 1997b). Full recovery of wetlands including invertebrate communities may require more than 10 years (Hoff 1995). Studies indicate that full recolonization of sheltered rocky shorelines in Cook Inlet may require 5–10 years (Highsmith et al. 2001). Although studies in Prince William Sound indicate that some organisms can recover quickly, recovery in some intertidal and shallow subtidal habitats takes more than a decade (Peterson 2000; *Exxon Valdez* Oil Spill Trustee Council 2003). More than 20 years after the *Exxon Valdez* oil spill, intertidal communities were considered to be recovering, but had not yet fully recovered from the effects of the spill (*Exxon Valdez* Oil Spill Trustee Council 2010a).

Spilled oil may penetrate into subsurface layers or may remain on the surface. Oil can remain in intertidal sediments and organisms for more than a decade and may remain a long-term source of exposure (NOAA 1997; MMS 2003e; Short et al. 2004; *Exxon Valdez* Oil Spill Trustee Council 2003). Lingering oil, in some areas only slightly weathered, persists in intertidal beach substrates at a number of locations more than 20 years after the *Exxon Valdez* oil spill (*Exxon Valdez* Oil Spill Trustee Council 2009b, 2010a, b). Coarse-grained sand beaches are more conducive to subsurface penetration than fine-grained sands (NOAA 2000), and subsequent deposition of sand may bury oil deposits. Natural removal of subsurface oil from gravel beaches is greatly reduced by surface armoring of boulders, as observed in Prince William Sound (NOAA 1997b). Although oil is not likely to adhere to the surface of mudflats, oil may be deposited if concentrations are high; penetration of the surface is unlikely except for entering burrows or crevices (NOAA 2000).

Cleanup activities may also adversely affect intertidal habitats and biota, as occurred following the *Exxon Valdez* oil spill (NOAA 1997b; McCammon et al. 2002; *Exxon Valdez* Oil Spill Trustee Council 2003). The removal of organisms from affected surfaces and washing out of fine particles from substrates likely inhibited and slowed the recovery of intertidal communities in some areas. Trampling of vegetation and other biota during cleanup activities as well as working oil deeper into sediments from foot traffic and equipment can also delay recovery from oil spills. Extensive vessel traffic during cleanup operations may increase turbidity and adversely affect organisms, such as eelgrass, in shallow subtidal communities (*Exxon Valdez* Oil Spill Trustee Council 2003).

Impacts of an Unexpected Catastrophic Discharge Event. For the Cook Inlet Planning Area, the PEIS analyzes an unexpected CDE with an assumed volume of 75,000–125,000 bbl and duration of 50–80 days (Table 4.4.2-2). Currents and tides within Cook Inlet could transport oil, and there is a very high likelihood that spills in the planning area would make contact with coastal habitats. A CDE would potentially result in heavy or widespread deposits of oil and would have a greater likelihood for extensive areas of shoreline affected and heavy deposits of oil in multiple locations. A spill under ice or in rapidly freezing or broken ice would be more difficult to clean up, and weathering would occur much more slowly. Under these conditions, oil could be transported considerable distances and contact coastal habitats during spring breakup. The degree of effects and length of recovery depend on a number of factors such as the type of oil, extent of biota exposure, substrate type, degree of sediment contamination, time of year, and species sensitivity.

Approximately 257,000 bbl of oil were spilled during the *Exxon Valdez* oil spill, considerably larger than the CDE considered here. That spill affected approximately 2,100 km (1,300 mi) of coastline, with 300 km (200 mi) heavily or moderately oiled. More than 20 years after the *Exxon Valdez* oil spill, intertidal communities were considered to be recovering, but had not yet fully recovered from the effects of the spill (*Exxon Valdez* Oil Spill Trustee Council 2010a). While a CDE would not be expected to result in the extent of shoreline oiling that occurred following the *Exxon Valdez* oil spill, contamination of coastal habitats would likely result in long-term impacts to biotic community structure and function in sensitive intertidal habitats; such habitats could take decades to recover.

Impact Conclusions.

Routine Operations. Routine Program activities in Cook Inlet would result in minor to moderate localized impacts. Routine operations in Cook Inlet could affect coastal habitats as a result of vessel traffic, as well as infrastructure maintenance and repair activities. Direct loss of habitat could occur as a result of damaging habitats during maintenance. Direct losses would be minimized through existing Federal and State environmental review and permitting procedures that would attempt to mitigate impacts through appropriate requirements. Secondary impacts on wetlands could occur from water and air quality degradation.

Expected Accidental Events and Spills. Impacts of a spill on coastal habitats could range from negligible to minor for small spills 50 bbl or less, negligible to moderate for small spills 50 to <1,000 bbl, and moderate to major for large spills (≥1,000 bbl) if recovery from the effects of a spill does not occur and exposure results in habitat loss. Because the Cook Inlet Planning Area is almost entirely surrounded by coastal habitat, it is likely that a large spill would contact these habitats. Habitats along the western shoreline have the greatest likelihood of contact based on surface currents in the inlet. Effects of a large spill may range from a short-term reduction in photosynthesis to extensive vegetation injury or mortality. Large spills could result in changes in community structure and direct loss of habitat. The effects of accidental oil spills will depend on habitats affected; the size, location, duration, and timing of the spill; and on the effectiveness of spill containment and cleanup activities.

An Unexpected Catastrophic Discharge Event. An unexpected 75,000–125,000 bbl CDE in Cook Inlet would be associated with a loss of well control or pipeline break. Oil or other spilled materials might be transported from offshore areas to coastal wetlands by currents or tides. The amount of oil deposited on coastal habitats would depend on various factors, such as spill volume, distance from shoreline, ambient conditions, degree of weathering, and effectiveness of response actions. A catastrophic discharge event would potentially result in heavy or widespread deposits of oil and would have a greater likelihood for extensive areas of shoreline being affected and heavy deposits of oil in multiple locations. The degree of effects and length of recovery depend on a number of factors such as the type of oil, extent of biota exposure, substrate type, degree of sediment contamination, time of year, temperature, and species sensitivity. Impacts to coastal habitats from a CDE would range from moderate, if recovery of habitats occurs, to major, if recovery does not occur and exposure results in habitat loss.

4.4.6.1.3 Alaska – Arctic.

Impacts of Routine Operations.

Coastal Barrier Beaches. The potential effects on coastal barrier beaches from routine operations would primarily be associated with direct impacts from ground-disturbing activities during pipeline construction and indirect effects from vessel traffic.

No new pipeline landfalls would be constructed in the Arctic region. However, 16–129 km (10–80 mi) of new onshore pipeline would be constructed for the Beaufort Sea, connecting to existing infrastructure on the Arctic Coastal Plain (ACP). Pipeline construction may affect sand beaches and dunes on the margins of lakes and rivers on the ACP, and erosion of sand beaches and dunes adjacent to pipelines could be promoted. Stabilization of dune margins could be difficult, and establishment of vegetation cover might be slow, possibly resulting in prolonged losses of dune habitat near pipeline routes.

No new shore bases, processing facilities, or waste disposal facilities would be constructed in the Arctic region. Existing shore bases, gas processing facilities, and waste disposal facilities would be used for all new oil and gas activities in the region. Operation of existing facilities could have local indirect effects on vegetation from exhaust emissions or atmospheric releases from processing facilities.

Arctic coastal habitats are exposed to strong wave and sea ice action, and the shoreline is generally unstable and prone to erosion (MMS 2002c; Viereck et al. 1992; Macdonald 1977). Service vessel traffic to exploration and production wells and barge traffic in support of shore bases could contribute to erosion along barrier beaches. Under the proposed action, up to three vessel trips per week would be made to each of the up to five new platforms along the Chukchi Sea and up to four along the Beaufort Sea. Increases in wave activity from vessel traffic could contribute to the removal of sediments along barrier beaches. Wave activity could be minimized by maintaining reduced vessel speeds in the vicinity of barrier islands.

Wetlands. The potential effects on wetlands from routine operations would primarily be associated with direct impacts from ground-disturbing activities during construction of pipelines and roads, as well as the indirect impacts from decreased water and air quality, altered hydrology, and facility maintenance. Wetland losses could result in the localized reduction or loss of wetland functions, such as fish and wildlife habitat, attenuation of flooding and shoreline erosion, and removal of substances that reduce water quality. Avoidance of wetlands during route selection for pipelines or roads might be difficult on the ACP because of the high density of wetlands. Activities that would potentially affect wetlands are regulated by State agencies and USACE. Section 404 of the Clean Water Act regulates the discharge of dredge or fill material into U.S. waters, including wetlands. Impacts on jurisdictional wetlands (those under the regulatory jurisdiction of the CWA, Section 404) would require permitting from USACE. In addition, Executive Order 11990, "Protection of Wetlands" (42 FR 26961, May 24, 1977), requires all Federal agencies to minimize the destruction, loss, or degradation of wetlands, both jurisdictional and nonjurisdictional, and to preserve and enhance the natural and beneficial values of wetlands. Standard measures would help mitigate construction-related impacts.

Although no new pipeline landfalls would be constructed in the Arctic region, 16–129 km (10–80 mi) of pipeline would be constructed onshore to transport oil from the Beaufort Sea to existing North Slope pipelines. With a 46-m (150-ft) wide construction ROW, approximately 73–584 ha (180–1,443 ac) of land would be disturbed. A number of wetland types, including wet or moist tundra habitat, lakes, ponds, or marshes (including those occurring within lakes and ponds), could be affected by pipeline construction. Construction of a pipeline gravel workpad (service roadway), haul road, and access roads would replace wetland habitat with unvegetated surfaces or result in upland habitat having few species in common with nearby undisturbed habitats. Because of the high density of wetlands on the coastal plain, wetland habitat expected to constitute a large proportion of the disturbed area would likely be lost, as occurred during the construction of the TAPS (Pamplin 1979; BLM 2002). Construction of buried pipeline segments would affect similar amounts of wetland habitat as a workpad. However, construction of aboveground pipeline segments without a workpad would result in the loss of only small areas of wetland habitat at the locations of the vertical support members. Wetland areas may also be disturbed by the establishment of work camps. Additional impacts of construction could include altered hydrology from changes in surface drainage patterns or isolation of wetland areas from water sources, such as from blocking natural surface flows. Changes in the moisture regime, natural drainage patterns, or snow-drift patterns in adjacent areas would likely result in thermokarst, with resulting changes in the species composition of plant communities (NRC 2003a). Wetland impacts associated with degraded water quality could include sedimentation and turbidity and introduction of contaminants in stormwater runoff. Resulting changes in affected wetlands could include a reduction in biodiversity, replacement of one wetland type for another (such as by dewatering or ponding), conversion to upland communities, or conversion of vegetated wetlands to open water. Wetlands adjacent to a gravel workpad would be indirectly affected by deposition of airborne dust. Additional wetland habitat may be lost through thermokarst associated with new impoundments and heavy dust accumulations (BLM 2002).

Deposition of fugitive dust can affect plant communities and alter wetland characteristics, primarily by reducing canopy cover and altering species composition (Auerbach et al. 1997; Everett 1980; Walker and Everett 1987). Impacts may include reduced growth and density of vegetation and changes in community composition to more tolerant species. Reductions in plant cover can reduce the insulation of the ground surface, leading to thawing of the underlying ice-rich permafrost (NRC 2003a). Nonvascular species, primarily mosses and lichens, are highly sensitive. The reduction or loss of sphagnum mosses, which are important components of many plant communities on the ACP, can occur in acidic tundra habitat, especially within 10 m (33 ft) of a road (Walker et al. 1987a), potentially contributing to thermokarst. Deposition of dust on snowdrifts along roads promotes earlier melting. Roads and construction/excavation equipment can also provide a means for the introduction and spread of non-native plants and noxious weeds.

The construction of access roads and transmission corridors would likely result in the direct loss of wetlands from the placement of fill material during construction. Additional wetland habitat could be disturbed by other forms of infrastructure such as employee camps, airstrips, and power stations. The construction of these facilities could eliminate wetland habitat within the immediate footprints of the facilities. While this wetland loss would be long term, the areas disturbed represent an extremely small portion of habitat that occurs on the ACP adjacent to the Arctic region. Impacts on wetlands from construction could be minimized by maintaining buffers around lakes and ponds and by using best management practices for erosion and sedimentation control.

The impacts of road construction on the North Slope are often reduced by the restriction of construction activities to the winter months when the ground is frozen and the use of ice roads rather than gravel roads. Although ice roads avoid the loss of habitat associated with gravel roads, they may affect some vegetation communities. Effects may result from delayed melting in spring, damage to plants, plant mortality, and removal of dead material from the canopy (Walker et al. 1987a). Tundra communities generally recover from such effects, however, within several years (MMS 2002c, 2003e). Drier communities, elevated microsites, and tussock tundra are more affected (Pullman et al. 2003), while moist or wet meadow communities are little affected (MMS 2007h).

Large amounts of gravel may be required for permanent road construction. On the North Slope, gravel is often extracted from the floodplains of large rivers (Pamplin 1979; BLM 2002). The excavation of gravel from these material sites and the creation of stockpile areas may affect wetland communities on river floodplains. Wetland areas may be modified by gravel excavation and other mining operations that alter stream channels. Revegetation of the affected area is expected to be relatively rapid, within a few years.

Additional factors, such as reduced air quality, might also affect wetlands because of activities associated with pipeline or platform construction. Exhaust emissions, such as from construction equipment or pump stations, or fugitive dust generated from exposed soils or roadways could have adverse effects on nearby wetland communities.

Existing shore bases, gas processing facilities, and waste disposal facilities would be used for all new oil and gas activities in the region. Operation of existing facilities could have local indirect effects on vegetation from exhaust emissions or atmospheric releases from processing facilities. Contaminants could be introduced into wetlands from the use of existing land storage or disposal sites, if contaminants migrate into groundwater or enter stormwater that flows into wetlands. Contaminants might also be released to surface waters in service vessel discharges, and might subsequently affect wetlands. Impacts on wetlands could be minimized by the implementation of air and water quality practices.

Impacts of Expected Accidental Events and Spills.

Coastal Barrier Beaches. The potential effects on coastal barrier beaches and dunes from accidents would primarily be associated with impacts from spills of oil and other petroleum hydrocarbons, such as fuel oil or diesel fuel, and subsequent cleanup efforts. Large (≥1,000 bbl) and small (<1,000 bbl) oil spills could occur as a result of pipeline spills or platform spills. This analysis assumes 1–2 large spills of 1,700 bbl from a pipeline, 1 large spill of 5,100 bbl from a platform, as well as 10–35 small spills >50 to <1,000 bbl and 50–190 small spills up to 50 bbl. Oil or other spilled materials might be transported to barrier island beaches, coastal beaches, or lagoon beaches by currents or tides. Contamination of beaches from platform spills, pipeline spills, or vessel spills could occur. Because platforms in the Chukchi Sea would be at least 40 km (25 mi) from the coastline, platform spills there would have a lower potential for contacting beaches and dunes than spills nearer the coast in the Beaufort Sea, and the point of contact may be a greater distance down the coastline due to longshore currents. Greater weathering of the lighter, more acutely toxic components of crude oil may therefore also occur prior to contact with the coastline. Beach habitat could be affected by oil spills, and the direct mortality of biota could result. Although beach and foredune areas are often sparsely vegetated, impacts on vegetation might occur if oil were carried to higher elevations by storm waves and tides.

Spilled oil that becomes stranded on beaches might occur only on the surface, or it could penetrate into subsurface layers. Permeable substrates, generally associated with larger sand grain sizes, and holes created by infauna could increase oil penetration, especially that of light oils and petroleum products. Penetration into coarse-grained sand beaches may be up to 25 cm (0.8 ft) (NOAA 1994, 2000). Light oils may penetrate peat shores; however, peat resists penetration by heavy oils (NOAA 2000).

Although any residual oil that could remain following cleanup might be largely removed in highly exposed locations through wave action, oil could remain in the shallow subsurface for extended periods of time. In some locations, oil might become buried by new sand or gravel deposition. Natural degradation and persistence of oil on beaches are influenced by the type of oil spilled, amount present, sand grain size, degree of penetration into the subsurface, exposure to weathering action of waves, and sand movement onto and off shore. Although petroleum-degrading microbial communities are present, biodegradation along Arctic coastlines would likely be slow (Prince et al. 2002; Braddock et al. 2003; Braddock et al. 2004) and is limited to only a few months per year. Spilled oil might persist for many years, with continued effects on infauna and potential recovery of infaunal communities. On sheltered beaches, heavy oiling left for long periods could form an asphalt pavement relatively resistant to weathering (Hayes et al. 1992). Lagoon shorelines include low-energy beaches where spilled oil would likely persist for many years. Spilled oil may persist for extended periods on peat shores; however, if cleaned up, it would be expected to persist for less than a decade (Owens and Michel 2003).

Spill cleanup operations might adversely affect beaches and dunes, if the removal of contaminated substrates affects beach stability and results in accelerated shoreline erosion. Vehicular and foot traffic during cleanup could mix surface oil into the subsurface, where it would likely persist for a longer time. Manual cleanup rather than use of heavy equipment would minimize the amount of substrate removed.

Wetlands. The potential effects on wetlands from accidents would primarily be associated with impacts from spills of oil and other petroleum hydrocarbons, such as fuel oil or diesel fuel, and subsequent cleanup efforts. Oil or other spilled materials might be transported from offshore areas to coastal wetlands by currents or tides, and may result from spills involving platforms, pipelines, or service vessels. Because platforms in the Chukchi Sea would be at least 40 km (25 mi) from the coastline, platform spills there would have a lower potential for contacting coastal wetlands than spills nearer the coast in the Beaufort Sea, and the point of contact may be a greater distance down the coastline due to longshore currents. Greater weathering of the lighter, more acutely toxic components of crude oil may therefore also occur prior to contact with the coastline. The potential for impacts on marshes, estuaries, and low-lying tundra would depend on wind and wave conditions, because the rates of abrasion and dispersal of stranded oil by littoral processes are generally low, due to the small tidal range along the Arctic coast. Oil may be deposited at higher elevations of marshes, tundra, and river deltas by spring tides or storm surges and would be expected to persist for long periods due to the low rates of dispersion and degradation.

Freshwater wetlands on the ACP could be affected by spills from onshore pipelines. Oil spilled on the ACP could potentially flow into a nearby stream. Vegetation along the path of the spill would be injured or killed, including wetland vegetation along the stream. Oil reaching the Arctic coastline may persist for extended periods of time and slow or reduce vegetation recovery. Wetlands in river deltas and estuaries could be affected by oil spilled in upstream areas.

Impacts on wetlands from oil spills could result in extensive injury or mortality of vegetation and invertebrates in or on the substrate. Other effects of spills could include a change in plant community composition or the displacement of sensitive species by more tolerant species. Impacts on soil microbial communities might result in long-term wetland effects, and wetland recovery would likely be slowed. Various factors influence the extent of impacts on wetlands. Impacts would depend on site-specific factors at the location and time of the spill. The degree of impacts is related to the oil type and degree of weathering, the quantity of the spill (lightly or heavily oiled substrates), duration of exposure, season, plant species, percentage of plant surface oiled, substrate type, soil moisture level, and oil penetration into the soil (Hayes et al. 1992; Hoff 1995; NOAA 1994). Higher mortality and poorer recovery of vegetation generally result from spills of lighter petroleum products (such as diesel fuel), heavy deposits of oil, spills during the growing season, contact with sensitive plant species, completely oiled plants, and deep penetration of oil and accumulation in substrates. Oil that reaches the root system would result in high levels of mortality. Vegetation regrowth and recovery are generally better where oil spills occur in flooded areas or on saturated soils, than on unsaturated soils (BLM 2002). Coastal wetlands in sheltered areas, such as bays and lagoons, which are not exposed to strong water circulation or wave activity, would be expected to retain oil longer with longer-lasting effects on biota (Culbertson et al. 2008).

Oil spills on ice or snow in winter would likely be easily cleaned up with little oil remaining; however, spills during other times may be difficult to clean up, and considerable amounts of oil may remain. Following cleanup, the spilled oil remaining degrades naturally by weathering and biodegradation by soil microbial communities. However, biodegradation would likely be slow due to generally cool temperatures and a short growing season. Full recovery of wetlands, including invertebrate communities, might require more than 10 years depending on site and spill characteristics (Hoff 1995; Culbertson et al. 2008). Oil could remain in some wetland substrates for decades, even if it was cleaned from the surface. Heavy deposits of oil in sheltered areas of coastal wetlands or in the supratidal zone could form asphalt pavements resistant to degradation (Hoff 1995; Culbertson et al. 2008).

Spill cleanup actions might damage wetlands through trampling of vegetation, incorporation of oil deeper into substrates, increased erosion, and inadvertent removal of plants or sediments, all of which could have long-term effects (NOAA 1994, 2000; Hoff 1995). These actions could result in plant mortality and delay or prevent recovery. Complete recovery of coastal wetlands disturbed by cleanup activities could take several decades. Effective low-impact cleanup actions could include bioremediation, low-pressure flushing, or use of chemical cleaners.

The NOAA Environmental Sensitivity Index (ESI) shoreline classification system classifies coastal habitats on a scale of 1 to 10, according to habitat sensitivity to spilled oil, oil-spill retention, and difficulty of cleanup (NOAA 1994). Habitats with high ESI values are given a higher priority for protection. The ESI shoreline classification for the Beaufort and Chukchi Sea coasts includes habitats with high values, such as inundated lowland tundra or salt/brackish-water marshes, both ranked 10 (MMS 2002d, Owens and Michel 2003).

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes an unexpected CDE in the Beaufort Sea with a volume of 1.7–3.9 million bbl and duration of 60–300 days, and in the Chukchi Sea with a volume of 1.4–2.2 million bbl and a duration of 40–75 days. A CDE would potentially result in heavy or widespread deposits of oil and would have a greater likelihood of affecting extensive areas of shoreline and leaving heavy deposits of oil in multiple locations. Oil or other spilled materials might be transported from offshore areas to barrier island beaches, coastal beaches, or lagoon beaches or to coastal wetlands by currents or tides, even from a discharge in the Chukchi Sea; however, the point of contact may be a greater distance down the coastline due to longshore currents. Greater weathering of the lighter, more acutely toxic components of crude oil may therefore also occur prior to contact with the coastline. However, if a CDE were to occur late in the open-water season, oil could continue to be released after the end of the season. The liquid hydrocarbons may freeze into the sea ice and remain over winter without any extensive amount of weathering. Un-weathered oil could subsequently be transported to non-spill-zone areas in the Chukchi and Beaufort Seas and be released in the spring (BOEMRE 2011).

The Arctic shoreline is characterized by small tides and moderate winds of the region, generally creating a low potential for spilled oil to reach beyond the intertidal zone (BOEMRE 2011). However, seasonal storm events could force oil into upper shoreline areas and inside delta areas (Reimnitz and Maurer 1979). Tundra and marsh areas would then be affected. Long-term effects, impacting populations for more than two years, are possible for coastal areas due to the severity of a CDE. In 1970, Reimnitz and Maurer (1979) observed the effects of tidal surges from a major storm event that inundated low-lying tundra and delta regions on the Beaufort Sea shoreline, leaving debris lines from flotsam as far as 5,000 m (16,500 ft) inland. A storm of equal or greater magnitude could force weathered oil far inward and leave residue over wide areas of tundra and river shores.

Natural degradation and the persistence of oil on beaches are influenced by the amount of oil present, sand grain size, degree of penetration into the subsurface, exposure to weathering action of waves, and sand movement onto and off shore. Spilled oil might persist on some beaches for many years, with continued effects on infaunal communities. The potential for impacts on marshes, estuaries, and low-lying tundra would depend on wind and wave conditions. The degree of impacts is related to the degree of weathering, whether substrates are lightly or heavily oiled, duration of exposure, season, plant species, percentage of plant surface oiled, substrate type, soil moisture level, and oil penetration into the soil and root systems. Oil contamination could persist for 10 years or more, during which time the oil in the sediments could be slowly released back into the environment as a result of erosion or exposure of oiled sediments and soils (BOEMRE 2011). Full recovery of wetlands, including invertebrate communities, may require more than 10 years depending on site and spill characteristics (Culbertson et al. 2008).

Impact Conclusions.

Routine Operations. Routine Program activities in the Arctic would result in minor to moderate localized impacts. Routine operations in the Arctic could affect coastal habitats as a result of pipeline construction, gravel mining on floodplains (for pipeline workpads and offshore islands), vessel traffic, and infrastructure maintenance and repair activities. These activities could result in direct loss of habitat by replacing habitat with infrastructure and by damaging habitats during maintenance. These direct losses would be minimized through existing Federal and State environmental review and permitting procedures that would attempt to mitigate impacts through appropriate siting and construction requirements. Secondary impacts on wetlands could occur from water and air quality degradation, ice roads, fugitive dust, and altered drainage caused by pipelines and roads.

Expected Accidental Events and Spills. Impacts of a spill on coastal habitats could range from negligible to minor for small spills 50 bbl or less, negligible to moderate for small spills 50 to <1,000 bbl, and moderate to major for large spills (≥1,000 bbl), if recovery from the effects of a spill does not occur and exposure results in habitat loss. Oil or other spilled materials might be transported to barrier island beaches, coastal beaches, or lagoon beaches by currents or tides. Beach habitat could be affected by oil spills, and the direct mortality of biota could result. Spilled oil that becomes stranded on beaches could penetrate into subsurface layers. Impacts on vegetation behind beaches might occur if oil were carried to higher elevations by storm waves and tides. Freshwater wetlands on the ACP could be affected by spills from onshore pipelines. Impacts on wetlands from oil spills could result in extensive injury or mortality of vegetation and invertebrates in or on the substrate. Spills could result in changes in community structure and direct loss of habitat. Vegetation regrowth and recovery are generally better where oil spills occur in flooded areas or on saturated soils, than on unsaturated soils.

An Unexpected Catastrophic Discharge Event. An unexpected 1.7–3.9 million bbl CDE in the Beaufort Sea or a 1.4–2.1 million bbl CDE in the Chukchi Sea would be associated with a loss of well control. Oil or other spilled materials might be transported from offshore areas to coastal wetlands by currents or tides. The amount of oil deposited on coastal habitats would depend on various factors, such as spill volume, distance from shoreline, ambient conditions, degree of weathering, and effectiveness of response actions. A CDE would potentially result in heavy or widespread deposits of oil and would have a greater likelihood for extensive areas of shoreline being affected and heavy deposits of oil in multiple locations. The degree of effects and length of recovery depend on a number of factors such as the type of oil, extent of biota exposure, substrate type, degree of sediment contamination, time of year, temperature, and species sensitivity. Impacts to coastal habitats from a CDE would range from moderate, if recovery of habitats occurs, to major, if recovery does not occur and exposure results in habitat loss.

4.4.6.2 Marine Benthic Habitats

4.4.6.2.1 Gulf of Mexico.

Soft Sediments.

Impacts of Routine Operations.

Exploration and Site Development. Impacting factors for the exploration and site development phase are shown in Table 4.4.6-3. The vast majority of marine benthic habitat affected by the Program would be soft sediments. Drilling wells would temporarily reduce habitat quality by generating temporary turbidity and sedimentation for some distance around the disturbed area. It is estimated that 1,000 to 2,100 exploration and delineation wells and 1,300 to 2,600 development and production wells will be drilled in the WPA and CPA. Drilling can occur from fixed platforms, floating platforms, or drillships. The installation of floating or fixed platforms would disturb soft sediment habitat where the legs or mooring structures (anchors and chains) encountered the seabed and where subsea equipment (such as reentry collars and blowout preventers) was installed. Chronic local bottom disturbance would result from subsequent movements of anchors and mooring lines associated with floating production platforms and support vessels. The actual area of seafloor affected by anchoring operations would depend upon water depth, currents, size of the vessels and anchors, and length of anchor chain. The amount of bottom affected by anchored structures would increase with water depth because of the use of larger anchors and longer anchor chains. Anchor scars were detected in a radial pattern up to 3 km (2 mi) from a well located on the GOM continental slope (Continental Shelf Associates, Inc. 2006). Drilling vessels would use either anchors or dynamic positioning to maintain station. Drilling vessels using dynamic positioning systems rather than anchors would not generate mooring impacts on the seafloor. Exploratory well platforms can be fixed or floating.

Under the proposed action, it is estimated that 200 to 450 new production platforms will be constructed, which is expected to disturb 150 to 2,500 ha (370 to 6,178 ac) of seafloor. Ninety-five percent of these new platforms will be located in water depths less than 200 m (656 ft). In deep water, floating platforms (including those associated with a FPSO system) requiring mooring structures will typically be used, while platforms in more shallow water would

TABLE 4.4.6-3 Impacting Factors by Phase and Potential Effects on Marine Benthic Habitat in the CPA and WPA of the GOM

Disturbance	Potential Effects[a]
Exploration and Site Development	
Seismic surveys	Noise; localized anchoring disturbance
Anchoring and mooring of platforms, drillships, and seismic survey vessels	Sediment scour; temporary turbidity and sedimentation; localized alteration in sediment grain size and biogeochemical functions
Drilling and production platform placement	Noise; temporary sediment resuspension and turbidity; loss of natural habitat creation of artificial reef
Drilling	Noise; small habitat loss; local alteration of sediment characteristics; temporary turbidity and sedimentation in surrounding areas
Miscellaneous discharges (deck washing; sanitary waste; vessel releases of bilge and ballast water)	Sediment contamination
Solid wastes	Sediment contamination
Discharge of drilling muds/cuttings	Sediment and water column contamination; alteration in sediment granulometry and biogeochemical functions
Pipeline trenching and placement	Noise; long-term loss and degradation of existing benthic habitat; temporary sediment resuspension and turbidity; substrate for growth
Production	
Scour from anchors and the movement of pipelines and mooring structures	Chronic, long-term disturbance of bottom sediments; turbidity
Platform production	Noise; loss of natural habitat creation of artificial reef
Produced water discharge	Sediment contamination
Miscellaneous discharges	Sediment contamination
Solid wastes and debris	Sediment contamination
Decommissioning	
Miscellaneous discharge	Sediment contamination
Solid wastes and debris	Sediment contamination
Platform removal	Explosive noise; temporary turbidity and disturbance of bottom sediments

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

likely have legs and not require mooring. Impacts from fixed and floating production platforms would be similar to those described above for the exploration phase.

Under the proposed action, it is estimated that 3,862 to 12,070 km (2,400 to 7,500 mi) of new pipeline would be placed in the CPA and WPA, resulting in disturbance to 2,000 to 11,500 ha (4,942 to 28,417 ac) of seafloor. Up to two FPSO systems could potentially be used in deep water, which would reduce the need for pipelines. In water depths less than 60 m (197 ft), pipelines must be buried; benthic organisms within the trenched corridor could be killed or injured and organisms to either side of the pipeline could be buried by sediments. Pipelines placed on the sediment surface would replace the existing soft sediments with man-made substrate that sessile invertebrates may colonize over time. Vessel anchoring during pipeline placement would also disturb soft sediment. Anchor and mooring impacts from pipeline placement vessels would be eliminated if dynamic positioning systems rather than anchors were used during pipeline placement. The recovery period for soft sediment benthic habitat disturbed by pipeline placement would depend on factors such as water depth, sediment type, and community composition. Disturbed sediments with a greater proportion of sand to mud may fill in with fine silty material, which would alter grain size and potentially inhibit the colonization by species that existed prior to the disturbance.

During the exploration and development phase, drill cuttings and drilling muds (including synthetic drilling fluids adhering to the cuttings) could contaminate and alter the grain size of sediments immediately around the wellhead and below the discharge area. Drilling wastes are regulated by the USEPA under NPDES permits and can be discharged into the ocean only if they meet USEPA toxicity and discharge rate requirements. These requirements greatly reduce the potential for sediment contamination. Drill cuttings and muds rapidly reach the sediment surface. Therefore, the discharged drilling muds and cuttings could be deposited in highly concentrated thick layers if deposited in shallow water or near the sediment surface. In the case of near-surface discharge in deep water, drilling muds would spread out in a thin veneer over a wide area. Settled muds could cause smothering of organisms, changes in sediment characteristics and biogeochemical functions, and the loss of food resources in the immediate area. The biodegradable synthetic drilling fluids attached to the drilling waste may deplete oxygen (Trannum et al. 2010) and therefore may create local sediment anoxia.

Studies at multiple sites on the Louisiana continental shelf and slope provide the most relevant information on the potential ecological effects of drilling and drilling mud discharges on soft sediment habitat. These studies found drill cuttings were detectable up to 1 km (0.6 mi) from the well site, depending on whether cuttings were discharged near the water surface or near the bottom (Continental Shelf Associates Inc. 2004a, 2006). Concentrations of barium, hydrocarbons, and synthetic drilling fluids in the sediment were patchily distributed within the sampling radius (up to 500 m [1,640 ft] from the well) but, overall, were higher than at the control sites (Continental Shelf Associates Inc. 2004a, 2006). Several other alterations in habitat were also detected, including anoxic bottom patches, elevated metal concentrations, coarser grain size (all typically less than 300 m [984 ft] from well), and anchor scars (up to 3 km [1.9 mi] from well). Within 250 m (820 ft) of the well, sediment toxicity to certain invertebrates based on bioassays was also reported at several sites, and metrics of invertebrate community health were lower and more variable (Continental Shelf Associates Inc. 2004a). However, a greater abundance of certain species of meiofauna, macrofauna, and fish compared to controls was also detected, potentially because of the organic enrichment of sediments near the well (Continental Shelf Associates Inc. 2006). The spatial extent of the biological, physical, and chemical effects cannot be precisely determined, but drilling discharges, hydrocarbons, and sediment toxicity all dropped off rapidly with distance from the well (Continental Shelf Associates Inc. 2004a, 2006). Habitat recovery time is also unknown, but evidence for biological, physical, and chemical recovery was detected after 1 yr, so full recovery may occur over several years as sediment contaminants are biodegraded and buried by natural deposition and bioturbation (Continental Shelf Associates Inc. 2004a, 2006).

Miscellaneous discharges (deck washing, sanitary waste, and vessel discharge) also have the potential to disturb soft sediment habitats. Miscellaneous discharges could contaminate sediments if discharged in relatively shallow water. However, contaminants in surface discharges would most likely be diluted to non-toxic concentrations before reaching the sediment, especially for platforms located in deep water. Many vessel and platform wastes are disposed of on land, and those that are discharged at sea must meet USEPA and/or USCG regulatory requirements that limit their environmental effects.

Noise from seismic surveys and drilling could kill or injure organisms close enough to the noise source and reduce habitat suitability because some species would avoid the area. The severity and duration of noise would vary with site and development scenario, but overall the impacts would be temporary and localized with overall minimal effects on soft sediment habitat. See Section 4.4.7 for detailed discussions of the effects of noise and different categories of biota.

<u>Production.</u> Production activities that could affect soft sediment habitat are shown in Table 4.4.6-3 and include operational noise, miscellaneous discharges, bottom disturbance from the movement of anchors and mooring structures, and the releases of process water. In addition, the platform would replace existing featureless soft sediments and serve as an artificial reef. The potential impacts of miscellaneous discharges would continue on from the exploration and development phase and are described above. Impacts on soft sediment habitats from vessel and operational noise are expected to be long term, with the impacts lasting the duration of the production phase.

Chronic bottom disturbance from the movement of anchors and chains associated with platforms and support vessels would affect soft sediment habitats as described above for the exploration and site development phase. Pipelines in water less than 60 m (197 ft) must be buried, which would reduce the potential for pipeline movement. However, pipelines could become unearthed or moved following severe storms. These disturbances would be long term and chronic and cause scour, turbidity, and sedimentation of soft sediment habitats.

The platforms and pipelines would also create novel hard substrate, and the area on and immediately around the platform would have habitat functions and biological communities very different from these in the preconstruction period. Algae and sessile invertebrates would attach to the platform and would in turn attract reef-oriented organisms. The ecological function and value of artificial reef habitat are controversial as some species may benefit while others do not. In addition, sediment grain size and the biogeochemical processes around the platform could be altered by the flux of biogenic material from the platform to the seafloor. For example, an increase in shell material and organic matter would likely result along with a transition to benthic species adapted to these conditions (Montagna et al. 2002). The replacement of soft sediment with artificial reef would exist only during the production phase, unless the platform was permitted to remain in place after decommissioning. In deep sea soft sediment, communities may form on mooring structures, but colonization would likely be slow, and mooring structures would be completely removed during decommissioning, so impacts, if any, would be temporary.

Produced water is a normal product of oil and gas extraction that contains contaminants such as polycyclic aromatic hydrocarbons (PAHs) and heavy metals and therefore represents a potential source of contamination to benthic habitats. Before being discharged into the ocean, produced water is typically treated and must meet NPDES requirements regarding discharge rate, contaminant concentration, and toxicity, thereby reducing the potential for sediment contamination. In addition, contaminants in produced water would be diluted with distance from the discharge point and are expected to reach sediments only in biologically negligible concentrations. A major study of produced water discharges across the northern GOM indicated that despite the large volume discharged, the contribution of produced water to bottom water hypoxia is minimal when compared to riverine inputs (Bierman et al. 2007). Overall, produced water did not make a significant contribution to the hypoxic zone (Rabalais 2005).

The results of the GOM Offshore Monitoring Experiment funded by BOEM provide a good summary of the long-term changes to soft sediment habitats resulting from oil and gas development (Kennicutt et al. 1995). For the study, stations at 30–50, 100, 200, 500, and 3,000 m (98–164, 328, 656, 1,640, and 9,842 ft) distances from petroleum wells were sampled in a radial pattern surrounding the platforms. Elevated sediment concentrations of sand, organic matter, hydrocarbons, and metals were generally restricted to sediments less than 200 m (656 ft) from the platforms. PAH levels in sediments were well below levels considered to be toxic to invertebrates, and no significant hydrocarbon bioaccumulation was observed in megafaunal invertebrates near platforms. However, metal levels in invertebrate tissues were higher at the study sites (Kennicutt et al. 1995). The physical and chemical changes to sediments near the platforms were enough to alter the soft sediment communities, but the effects were restricted to within 200 m (656 ft) of the platforms. Overall, the authors concluded that oil and gas development and production resulted in moderate, highly localized changes to soft sediment habitat (Montagna and Harper 1996).

<u>Decommissioning.</u> Miscellaneous discharges and solid waste releases discussed above would continue during the decommissioning phase (Table 4.4.6-3). Platform and mooring structure removal activities could result in increased turbidity, temporary suspension of bottom sediments, and explosive shock-wave impacts. Impacts from decommissioning will vary with platform removal scenario, which ranges from complete to partial removal. The impacts from the explosive removals of the platforms would be attenuated by the movement of the shock wave through the seabed, because the charges typically would be set at 5 m (16 ft) below the seafloor surface. Under the proposed action, it is assumed that a total of 150 to 275 platforms would be removed using explosives. A small area would be disturbed, compared with total seafloor area in the entire GOM. In addition, because soft-bottom benthic habitats are typically recolonized relatively quickly following disturbances, benthic communities in disturbed areas would be

expected to recover over a period of months to years without mitigation. If the platform is toppled and left in place, the remains would serve as hard bottom habitat that would replace the existing soft sediment habitat. Artificial reefs provide habitat to fish, algae, and invertebrates; however, their ecological and population effects are controversial.

Impacts of Expected Accidental Events and Spills. Accidental hydrocarbon releases in marine habitat can occur at the surface from tankers or platforms or at the seafloor from the wellhead or pipelines. Natural gas would quickly rise above the sediment surface, which would minimize its impacts on benthic habitat. Natural gas is also less persistent in the environment than oil. Evidence from the DWH event indicates that methane gas released from the well was rapidly broken down by bacterial action with little oxygen drawdown (Camilli et al. 2010; Kessler et al. 2011). Consequently, the remainder of the discussion focuses on oil spills. It is assumed that up to 8 large spills (≥1,000 bbl), up to 70 spills between 50 and 999 bbl, and up to 400 smaller spills between 1 and 50 bbl could occur during the lease period under the proposed action (Table 4.4.2-1). Impacts would generally increase with the size of the spill. Modeling indicates that oil spilled at the surface could mix by natural dispersion to a depth of 20 m (66 ft) at highly diluted concentrations (MMS 2008a). Therefore, most surface spills would likely reach the sediment at biologically negligible concentrations. Large spills have the potential to affect a greater area of benthic habitat, with the impact magnitude depending on the location of the spill, the direction of bottom currents, and the amount of oil released. Oil from accidental releases would be dispersed by currents and broken down by natural chemical and microbial processes and would rise in the water column, thereby limiting the extent of soft sediment habitat that would be affected by any given spill. The soft sediment habitat would recover without mitigation because of natural breakdown of the oil, sediment movement by currents, and reworking by benthic fauna.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes an unexpected CDE with an assumed volume of 0.9-7.2 million bbl and a duration of 30–90 days (Table 4.4.2-2). Lethal or sublethal concentrations of hydrocarbons or mixtures of hydrocarbon and dispersant (if used) could accumulate in soft sediments, reducing habitat function. As with large spills, the magnitude of the impact depends primarily on the location of the well, time of the year, and the volume released. Typically oil rises from the seafloor to the surface, forming a surface slick. However, a subsurface plume capable of traveling long distances could form if dispersants are used, or if the well releases oil at high velocity or as a mixture of oil and gas. However, even in the case of a subsurface plume, most oil would stay above the sediment. Sediment contamination could occur from the deposition of oiled sediment and organic matter (dead plankton and organic flocculants) falling from the water column. Such deposition is expected to decrease significantly with distance from the well.

Because of the widespread presence of soft-bottom habitats on the continental shelf and slope and the tendency of oil to stay suspended above the sediment, it is anticipated that impacts from oil spills would affect only a very small proportion of such habitat within the GOM. Following the DWH event, less than 6% of deepwater (>200 m) sediment samples and less than 1% of offshore and nearshore sediment samples exceeded the USEPA chronic aquatic life benchmark for PAHs and were chemically determined to be contaminated with oil from the DWH event (OSAT 2010). Oiled sediments would recover their habitat value as hydrocarbons broke down or were buried by natural processes, and communities would soon recover through larval recruitment from adjacent areas. However, recovery time would vary with local conditions and the degree of oiling. Impacts on soft sediment habitat from accidents could potentially be long term.

Oil spill-response activities such as burning, skimming, and chemical release (e.g., dispersants or coagulants) could affect benthic habitat and biota. Skimming and burning could kill pelagic live stages of benthic biota. The chemicals used during a spill response are toxic, but there is controversy about whether the combination of oil and dispersant is more toxic than oil alone (NRC 2005b; Fingas 2008; Holland-Bartels and Kolak 2011). The use of dispersant would likely reduce oiling of nearshore benthic habitat, but may increase the exposure of subtidal benthic habitat and biota to toxic fractions of oil (NRC 2005b). In shallow water, the presence of, and noise generated by, oil spill-response equipment and support vessels could temporarily disturb benthic habitat in the vicinity of the response action, potentially reducing habitat use or disturbing migration. As with the spill itself, the location and time of the year the cleanup occurs would be an important determinant of impacts on benthic habitat and biota.

Warm Water Coral Reefs and Hard-Bottom Habitat.

Impacts of Routine Operations. BOEM has several protections in place to minimize and mitigate the adverse effects of oil and gas exploration and development on coral reefs and hard-bottom habitat. It is assumed that these current protections will also be implemented during this Program. The mitigations as described in the Topographic Features Stipulation and NTL No. 2009-G39 (available at http://www.gomr.boemre.gov/homepg/regulate/regs/ntls/2009NTLs/09-G39.pdf) create avoidance and mitigation requirements for biologically sensitive hard bottom areas and topographic features in waters 300 m (984 ft) or less.

Four hard bottom or reef habitats are designated for the various protections: (1) banks offshore of Texas and Louisiana (including the Flower Garden Banks National Marine Sanctuary [FGBNMS]), (2) the Pinnacle Trend off the Louisiana-Alabama coast, (3) seagrass and low-relief live-bottom areas primarily located in the CPA and Eastern Planning Area (EPA), and (4) potentially sensitive biological features of moderate to high relief that are not protected by (1) and (2). These protections are explained in greater detail below.

***Exploration and Site Development*.**

<u>Topographic Features (banks).</u> Because FGBNMS is a national sanctuary, no oil and gas exploration or site development would be allowed there. To protect other hard-bottom topographic features, BOEM instituted a Topographic Features Stipulation that established No Activity Zones prohibiting structures, drilling rigs, pipelines, and anchoring around 22 underwater topographic features out to a specified isobaths (typically 85 m [279 ft]) (Table 4.4.6-3). The continuation of this same practice is assumed here. To limit impacts from drilling discharges, the stipulation also requires all drilling muds and cuttings be shunted to within 10 m (33 ft) of the seafloor at distances ranging from 1 to 6.4 km (0.6 to 4 mi) away from topographic features depending on their nature and biological sensitivity. This shunting protects biota by confining the effluent to a level deeper than that of the living components of a high-

relief topographic feature. For low-relief banks in the WPA, shunting drilling effluents is not required because it would put the potentially harmful drilling muds and cuttings in the same water depth range as the topographic features. In addition, NTL No. 2009-G39 prohibits bottom-disturbing activities, including the use of anchors, chains, cables, and wire ropes within 152 m (500 ft) of a No Activity Zone without first consulting NOAA. Maps of the protected banks in the WPA and CPA are available at http://www.gomr.mms.gov/homepg/lsesale/topo_features_package.pdf.

Ninety five percent of the 200 to 450 anticipated new production platforms would be located in water depths less than 200 m (656 ft), which is within the depth range at which coral reefs and live-bottom features are found. Turbidity and sedimentation from bottom disturbance and the discharge of drilling wastes can adversely affect coral in multiple ways, including mortality, decreased growth, and loss of xoozanthelle (Thompson et al. 1980; Nugues and Roberts 2003; Fabricius 2005). The protections described above would minimize the impacts from direct bottom disturbance and sediment resuspension to designated banks from anchoring, drilling, platform placement, and pipeline trenching and placement. It is possible but not likely that turbidity would affect hard-bottom habitat if bottom disturbance occurred near the boundary of a No Activity Zone. The shunting requirements should minimize the adverse effects of discharged drilling muds and cuttings, although low-relief banks in more shallow water may be adversely affected to some degree. The topographic feature stipulations have been very effective in protecting the communities associated with topographic features. For example, despite the proximity of oil and gas development activities, long-term monitoring studies do not indicate any significant detrimental impact on the coral reefs of the FGBNMS (Gittings 1998).

<u>Pinnacle Trend.</u> The Live-Bottom/Pinnacle Trend Stipulation, which currently applies to certain blocks in the CPA and EPA, requires a biological interpretation of bathymetric and geophysical surveys to determine the distribution of pinnacle features before any bottom-disturbing activities can occur. Also, NTL No. 2009-G39 currently requires consultation with NOAA before any bottom-disturbing activities (including those caused by pipelines, anchors, chains, cables, or wire ropes) planned within 30 m (100 ft) bottoms/pinnacles with vertical relief of 2.4 m (8 ft) or more. There are no specific measures requiring drilling muds and cuttings to be discharged near the seafloor, because modeling studies suggest that the discharge would be transported over the pinnacles (Continental Shelf Associates, Inc. and Texas A&M 2001). Limitations on drilling mud discharges required by NPDES permit and the fact that the pinnacle trend area is subject to high levels of natural turbidity and sedimentation should limit impacts on pinnacle features. If it is determined that the live-bottoms might be adversely affected by the proposed activity, BOEM can further require economically, environmentally, and technically feasible measures to protect the pinnacle area. These measures may include, but are not limited to, the relocation of operations and monitoring to assess the impact of the activity on the live-bottoms. See the BOEM Web site at http://www.gomr.mms.gov/homepg/regulate/environ/topoblocks.pdf for the list and http://www.gomr.mms.gov/homepg/regulate/environ/topomap.pdf for the map of the identified pinnacle trend features.

Continued implementation of the Live-Bottom/Pinnacle Trend Stipulations and the requirements in NTL No. 2009-G39 would minimize bottom disturbance within 30 m (100 ft) of the majority of known pinnacle features. Because of these protections, direct effects such as benthic habitat disturbance from drilling, platform placement, trenching, and placement of pipelines would be minimal. However, if these activities occurred in the vicinity of the pinnacles, then sedimentation and turbidity could kill or inhibit respiration, filter feeding, and photosynthesis by hard-bottom biota. Because of the lower vertical relief pinnacles, the effects of turbidity and sedimentation could be greater in their vicinity. In addition, noise from seismic surveys, construction, and drilling could injure, kill, or cause avoidance behavior in organisms within a certain distance from the noise source. Noise disturbance would be temporary and the community would recover if the initial impact did not result in major injury or mortality to organisms associated with a pinnacle trend.

Impacts from drilling discharges would be reduced by compliance with the Pinnacle Trend/Live-Bottom Stipulation, NPDES permit restrictions that limit the amounts and types of drilling discharges and the depth at which the pinnacles are located. However, studies in the pinnacle region indicated that discharges of drilling muds may reach background levels within 1,500 m (4,921 ft) of the discharge point (Shinn et al. 1993). Therefore, pinnacles could be affected by discharges occurring at the surface and outside of the 30-m (98-ft) buffer required by NTL-2009-G39. As described above, increased turbidity and sediment deposition from discharges of muds and cuttings in the vicinity of pinnacles may reduce habitat quality and ecological function. However, biota associated with live-bottom/pinnacle features are usually adapted to life in somewhat turbid conditions and are often observed coated with a sediment veneer (Continental Shelf Associates, Inc. and Texas A&M 2001). The existing bottom currents would also prevent the accumulation of large amounts of mud and cuttings. Documentation of an exploratory well adjacent to hard-bottoms in the pinnacle trend at a depth of 103 m (338 ft), 15 months after drilling, showed cuttings and other debris covering an area of approximately 0.6 ha (1.5 ac) (Shinn et al. 1993), but the hard-bottom feature was still found to support a diverse community, including gorgonians, sponges, ahermatypic stony corals, and antipatharians. If turbidity and sediment deposition did result in extensive damage, existing studies suggest that recovery could take years (Continental Shelf Associates, Inc. and Texas A&M 2001).

Pinnacles not detected may be subject to direct damage from construction activities and discharges during site exploration and development. Previously undiscovered pinnacle features are also protected by the Potentially Sensitive Biological Features component of NTL No. 2009-G39. To minimize impacts on unmapped pinnacle features, BOEM also supports investigations through its Environmental Studies Program to locate hard- and live-bottom features and to understand their ecologies (Continental Shelf Associates, Inc., and Texas A&M University 2001). BOEM updates regulations and mitigations based on the data from these studies and from the biological interpretations of geophysical surveys, which reduces the risk of accidental damage.

<u>Live-bottom (low-relief) Features (CPA and EPA) and Potentially Sensitive Biological Features.</u> NTL No. 2009-G39 and the Live-Bottom (Low-Relief) Stipulation pertains to seagrass communities and low-relief hard-bottom reef within the GOM EPA blocks in water depths of 100 m (328 ft) or less and portions of Pensacola Area Blocks and Destin Dome Area Blocks in the CPA. NTL No. 2009-G39 also covers potentially sensitive biological features, which are features of moderate to high relief (about 2.4 m [8 ft] or higher) that provide habitat but are not protected by a biological lease stipulation.

NTL No. 2009-G39 requires that no bottom-disturbing activities (including drilling, platform placement, or the use of anchors, chains, cables, or wire ropes) may cause impacts on live-bottoms (low-relief features) or potentially sensitive biological communities. It is also required that any exploration or development activity planned within 30 m (100 ft) of either must be reviewed by BOEM. If it is determined that these habitats might be adversely affected by the proposed activity, then BOEM will require measures that may include, but are not limited to, relocation of operations, shunting of all drilling fluids and cuttings to avoid live-bottom areas, and monitoring to assess the adequacy of any mitigating measures. For further information on the live-bottom (low-relief) area stipulation and the protections for potentially sensitive biological features in the GOM, see NTL No. 2009-G39.

Overall, the protections in NTL No. 2009-G39 should minimize the potential for direct disturbance to coral reefs and live-bottom habitat. However, sediment disturbance and the discharge of drilling muds and cuttings in nearby areas could result in turbidity and sedimentation around these features that could kill or inhibit respiration, filter feeding, and photosynthesis by hard-bottom biota. Because of their generally shallow depth, low-relief habitats are particularly vulnerable to turbidity and sedimentation. In addition, low-relief live-bottom areas and potentially sensitive biological features not detected would be subject to direct mechanical damage from site exploration and development activities. Thus, appropriately siting discharge locations in pre-disturbance mitigation plans would be critical in minimizing the effects of bottom disturbance and discharges. NTL No. 2009-G39 states that the developer must provide a map showing the activity, structures, and maximum area of disturbance in relation to the feature. Such mapping would minimize impacts on these habitats and minimize the chance of disturbing as-yet-unmapped features.

Overall, impacts on coral reef and live-bottom habitat from exploration and site development activities should be minimized by existing protections. However, low-relief or small, isolated, unmapped live-bottom habitat could be affected by direct mechanical damage and turbidity and sedimentation. Given the frequent natural bottom disturbance that occurs in the GOM shelf, coral reef and live-bottom communities should be resistant to some extent to the adverse physiological impacts from periodic sedimentation. Live-bottom and coral reef habitat should recover, if they are adversely affected by exploration and site development activities. Recovery could be short term to long term depending on the extent and nature of the impact, species affected, and the suitability for recolonization of the habitat affected.

Production. Impacts on hard-bottom and coral reef habitat during the production phase could result from miscellaneous discharges, the movement of vessel anchors and mooring structures, produced water discharge, and the creation of artificial reef habitat (Table 4.4.6-3). Turbidity and sedimentation generated by chronic movement of anchors could affect coral reefs and hard-bottom habitat if they were located close enough to the disturbance. Impacts on coral and hard-bottom habitat from bottom disturbance would be minimized by existing mitigation measures.

Ninety-five percent of the 200 to 450 anticipated new production platforms would be located on the continental shelf. Algae and sessile invertebrates would rapidly colonize the platform and pipelines and would also attract mobile reef-oriented organisms. Thus, platforms would provide new hard-bottom habitat for a variety of species. However, oil and gas production platforms have been implicated in promoting the establishment of new species through natural range expansion or by providing suitable habitat for introduced exotic species (Sammarco et al. 2004; Page et al. 2006; Hickerson et al. 2008). Introduced species could displace native species and in doing so alter the ecological function of existing hard-bottom and coral habitat. For example, oil and gas platforms may have expedited the establishment of several exotic species on the FGBNMS including sergeant majors (*Abudefduf saxatilis*), yellowtail snapper (*Ocyurus chrysurus*), and orange cup coral (*Tubastraea coccinea*) (Hickerson et al. 2008). It is likely that these species would have spread even without the platforms, although the platforms may have expedited the process. If floating platforms with moorings are used, organisms could colonize mooring structures. Thus the overall benthic footprint may be small depending on the design. Also, in deep sea areas, most platforms and mooring structures would likely be completely removed during decommissioning, so impacts, if any, would be temporary.

Produced water discharges could introduce petroleum hydrocarbons and metals into hard-bottom habitat. However, impacts would be minimized by discharge and toxicity limitations imposed by NPDES permits, as well as restrictions that prevent the placement of oil and gas platforms in the immediate vicinity of these habitats. In addition, the depth of many of the coral reef and hard-bottom habitats, the prevailing current speeds, and the offsets of the discharges from these habitats would substantially dilute produced waters before they could come in contact with sensitive biological communities.

Decommissioning. Coral reefs are not likely to be affected by platform removal because of existing stipulations. Hard-bottom habitat could be adversely affected by explosive platform removal (estimated 150 to 275), which could cause turbidity and sedimentation in nearby hard-bottom habitat. Deposition of suspended sediments could smother and kill the filter-feeding sessile animals that inhabit much of the hard-bottom habitat. Explosive impacts on large topographic features covered by the No Activity Zone Stipulations would be minimized because of their distance from the seafloor and the existing stipulations precluding the placement of structures on or near these communities. However, hard-bottom features located closer to production platforms may be more susceptible to damage. In the event that live-bottom areas were affected during removal of existing platforms, recovery times would vary with damage and species.

Pipelines on the surface of the seafloor that are left in place would continue to provide hard substrate of structure-oriented organisms. In addition, many of the decommissioned platforms will be converted into artificial reefs. By acting as stepping stones across the GOM, oil platforms have been implicated in the introduction of a non-native coral species (*Tubastraea coccinea*) and fishes such as sergeant majors (*Abudefduf saxatilis*) and yellowtail snapper (*Ocyurus chrysurus*) into the FGB (Hickerson et al. 2008).

Impacts of Expected Accidental Events and Spills. Accidental spills in the CPA and WPA could affect hard-bottom and coral reef habitat from south Texas to the west Florida shelf in the EPA. Accidental hydrocarbon releases in marine habitat can occur at the surface or at the seafloor. Natural gas would quickly rise above the sediment surface, which would minimize its impacts on benthic habitat, although natural gas could temporarily reduce the habitat quality of high-relief benthic features. Natural gas is also less persistent in the environment than oil. Evidence from the DWH event indicates that methane gas released from the well was rapidly broken down by bacterial action with little oxygen drawdown (Camilli et al. 2010; Kessler et al. 2011). Consequently, the remainder of the discussion focuses on oil spills.

It is assumed that up to 8 large spills (≥1,000 bbl), up to 70 spills between 50 and 999 bbl, and up to 400 smaller spills between 1 and <50 bbl could occur during the lease period under the proposed action (Table 4.4.2-1). Most spills would be small and occur at the surface from the platform or vessels or at the seafloor from pipeline leaks. Oil from surface spills can sometimes penetrate the water column by natural dispersion to documented depths of 20 m (66 ft) or more, which is within the depth range of the crests of some coral reefs and topographic features including the FGBNMS. However, at these depths, the concentrations of the various chemical components of spilled oil are typically several orders of magnitude lower than those demonstrated to have an effect on marine organisms (MMS 2008a). Therefore, it is likely that only low concentrations of oil from surface spills would reach the sensitive benthic habitats (MMS 2008a). Subsurface spills could rise and come into contact with corals and hard-bottom habitat. Offshore banks are less likely to be affected because of the No Activity Zone stipulation that would create a large buffer between the banks and oil and gas development and production activities. A buffer of only 30 m (98 ft) applies to most hard-bottom areas and therefore low-relief, hard-bottoms could be contacted by small subsurface oil spills. However, because rapid dilution would occur as spilled oil was transported by currents and rose toward the water surface, subsurface oil spills would likely have to come into contact with a topographic feature almost immediately to have detrimental effects on the associated community.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes an unexpected CDE with an assumed volume of 0.9-7.2 million bbl and a duration of 30–90 days (Table 4.4.2-2). A CDE could degrade coral reef and hard-bottom habitat if it came into contact with large quantities of oil as it moved through the water column. Hydrocarbons have been shown to have lethal and sublethal (reproduction, larval settlement, photosynthesis, and feeding) effects on corals, although no effects on corals following oil spills are also frequently reported (Loya and Rinkevich 1980; Bak 1987; Guzman et al. 1991; Dodge et al. 1995; Haapkyla et al. 2007). Water currents moving around the banks would tend to carry oil around the banks rather than directly over the features, thereby lessening the severity of the impact (Rezak et al. 1983). Corals have the capacity to recover quickly from hydrocarbon exposure. For example, Knap et al. (1985) found that when *Diploria strigosa*, a common massive brain coral at the Flower Garden Banks, was doused with oil, it rapidly exhibited sublethal effects but also recovered quickly. However, larval stages of coral are far more sensitive than adults. Therefore, the impact magnitude of a spill is partly dependent on whether the spill occurs during a period of coral spawning.

If dispersants were used or if oil released from the wellhead had a high ratio of gas, a subsurface hydrocarbon plume covering a large area could form, which would increase the potential for contact with hard-bottom and coral reef habitat. The effect of chemically dispersed oil on corals is equivocal, with some studies finding large effects of oil and dispersant mixtures on corals and others finding only minor effects (Dodge et al. 1984; Wyers et al. 1986;

Epstein et al. 2000; Haapkvla et al. 2007; Shafir et al. 2007). If used, dispersants may slow the natural breakdown of oil, resulting in persistent toxicity. In most cases, effects on sensitive biota would be sublethal, with recovery occurring within months to a few years (MMS 2002a). For lethal exposures, the community would likely recover once the area had been cleared of oil, although full recovery could take many years (Haapkvla et al. 2007). Consequently, it is anticipated that impacts of lethal concentrations of oil reaching coral reef or hard-bottom habitat would be long term but temporary.

Deepwater Corals and Chemosynthetic Communities.

Impacts of Routine Operations.

Exploration and Site Development. In the GOM, both deepwater coral and chemosynthetic communities are currently protected under NTL No. 2009-G40 (available at http://www.gomr.boemre.gov/homepg/regulate/regs/netls/2009NTLs/09-G40.pdf), which covers all high-density deepwater communities (HDDC) in depths 300 m (984 ft) or greater. Impacts on deepwater corals and chemosynthetic communities (HDDC) from exploration and site development could potentially occur during platform and pipeline placement, the discharge of drilling muds and cuttings, and miscellaneous discharges (Table 4.4.6-3). NTL No. 2009-G40 currently prohibits the discharge of drilling muds and cuttings within 610 m (2,000 ft) of HDDC. In addition, NTL No. 2009-G40 requires that all proposed seafloor disturbances (including those caused by anchors, anchor chains, wire ropes, seafloor template installation, and pipeline construction) must be maintained at a distance of at least 76 m (250 ft) from HDDC habitat. In addition, any seafloor disturbances planned within 152 m (500 ft) of a high-density deepwater coral community must be reviewed and approved by BOEM, and the developer must demonstrate that the communities will not be adversely affected by exploration or site development. It is assumed that BOEM will continue to require and implement these measures at the lease sale phase. While these requirements and procedures are believed to be effective in identifying and avoiding most HDDC, it is possible that some unmapped or lower density communities could be mechanically damaged. In addition, despite the 76-m (250-ft) buffer, turbidity and sedimentation created by ground-disturbing activities could contact HDDC habitats. Although data are limited, studies in the GOM indicate that *Lophelia* corals are generally tolerant of turbidity and sedimentation, but at high enough levels suspended sediments can have lethal and sublethal effects (Brooke et al. 2009). Sediment could clog filtering organs, thereby inhibiting food intake and increasing metabolic costs associated with sediment removal. Chronic bottom disturbance by drilling platform moorings could be particularly large in the deep ocean depending on the technology employed. Impacts from pipeline placement barges could be minimized by the use of dynamic positioning when possible. An FPSO system may be employed for deepwater wells. Under the FPSO system, oil would be transported from the well to a surface vessel and ultimately to shore. By eliminating the need for pipelines, an FPSO system would greatly reduce bottom disturbance and the chance for disturbing HDDC.

It is estimated that less than 1% of the deepwater GOM is occupied by features or areas that could support HDDC (NTL No. 2009-G40). HDDC are spread throughout the deep areas of the northern GOM (Figure 3.7.2-2 and Figure 3.7.2-3), which makes it unlikely that the damage to small areas of the bottom would threaten this resource as a whole. The BOEM Environmental

Studies Program funds research to locate and understand the ecology of chemosynthetic communities. BOEM updates regulations and mitigations based on the data from studies and from the biological interpretations of geophysical surveys, and this reduces the risk of accidental damage. If affected by exploration and site development activities, HDDC could be repopulated from nearby undisturbed areas, although the rate of recovery could be slow or nonexistent, particularly for chemosynthetic communities (MacDonald 2000). Recent studies have shown that chemosynthetic communities can be dynamic and that changes in species composition and colonization rates can operate on the order of years to decades (Lessard-Pilon et al. 2010). This suggests chemosynthetic communities could begin recovery relatively quickly if adversely affected by oil and gas activities, although full recovery would take much longer.

Miscellaneous discharges would occur at the surface and are not expected to reach HDDC. HDDC communities are also not likely to be buried or stressed by drilling muds and cuttings because NTL No. 2009-G40 prohibits their discharge within 610 m (2,000 ft) of HDDC. Also, drilling muds and cutting would typically be discharged at the surface, and the depth of most HDDC communities make it unlikely that drilling muds and cuttings would be deposited in thick layers capable of adversely affecting these habitats.

Overall, impacts on HDDC from exploration and site development activities are expected to be minimal because of the provisions in place to protect HDDC and the review required for all drilling plans in water deeper than 300 m (984 ft). The likelihood of the undetected communities is greatly reduced through continuing improvements in the use of remote sensing data and groundtruthing. However, small and unmapped HDDC may be completely or partially destroyed by bottom-disturbing activities. In such cases, recovery would likely be long term.

<u>Production.</u> Impacts on HDDC from routine operations could result from production platform placement; operational noise; miscellaneous discharges; the movement of anchors and chains, and the releases of process water (Table 4.4.6-3). In addition, the platform, pipelines, and mooring structure will create new artificial reef habitat. A general discussion of these impacts can be found in the soft sediments section above.

Impacts from bottom disturbing activities would be similar to those discussed above in the exploration and site development phase. The direct effects of production noise, platform placement, and anchor and chain damage on HDDC would be minimized by the 76-m (250-ft) buffer required between HDDC and ground-disturbing activities, although turbidity plumes resulting from those activities could reach HDDC. Impacts from produced water discharge should also be minimal, given the NPDES requirements and the distance of HDDC from the surface where produced water will likely be discharged. Cold water coral species may colonize the well, pipeline, and platform structures relatively quickly (Gass and Roberts 2006), although growth in the GOM appears to be slower than in other areas (Brooke and Young 2009). Over time, petroleum structures may become an artificial reef functioning in a manner similar to existing coral habitat. Colonization could benefit cold water corals by increasing suitable habitat and improving gene flow among populations (Macreadie et al. 2011). The artificial reef would only exist during the production phase, except in the cases where pipelines remain on the seabed and if tension leg platform templates are allowed to remain on the seabed. There is also possible decommissioning options including leaving portions of deepwater platforms in place.

There is evidence from California that oil and gas extraction reduces the natural release of hydrocarbons that support deep-sea chemosynthetic communities (Quigley et al. 1999). However, there is no evidence for this in the GOM. More research may be needed, but oil and gas operations are not likely to remove enough hydrocarbons to affect seep communities, given the volume of the overall resource. Unlike chemosynthetic communities, *Lophelia* corals do not depend on hydrocarbon seepage to meet their metabolic requirements (Becker et al. 2009) and presumably would not be affected.

Decommissioning. Explosive platform removals would not occur because floating platforms would be used in the deep sea. The removal of anchors and chains could affect nearby HDDC by suspending sediments in the water column as described above. Restrictions that prevent oil and gas extraction activities on or near HDDC would reduce the impacts of sediment disturbance. In the event that HDDC were affected during removal of existing platforms, recovery times would vary with the species affected and the extent and nature of the damage. Cold water corals are likely to recover much more rapidly than chemosynthetic communities.

Impacts of Expected Accidental Events and Spills. It is assumed that up to 8 large spills (≥1,000 bbl), up to 70 spills between 50 and 999 bbl, and up to 400 smaller spills between 1 and <50 bbl could occur during the lease period under the proposed action (Table 4.4.2-1). Impacts would typically increase with the size of the spill. Most accidental spills would be small releases at the surface that are not expected to reach waters deep enough to contact HDDC. The impact of a small pipeline leak would also be reduced by the requirement that pipelines be located 76 m (250 ft) away from HDDC habitats. For large spills, much of the impact magnitude depends on the location of the spill, the direction of bottom currents, and the amount of oil released. Oil from accidental releases would be dispersed by currents, broken down by natural chemical and microbial processes, and would rise in the water column, thereby limiting the extent of HDDC habitat that would be affected by any given spill. However, if oil were to come into contact with a HDDC, it could result in lethal or sublethal impacts (White et al. 2012). However, HDDC are widely distributed in the GOM; therefore, the impacts of any one large spill would not affect the overall resource.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes an unexpected CDE with an assumed volume of 0.9-7.2 million bbl and a duration of 30–90 days (Table 4.4.2-2). A CDE would cause high turbidity and sedimentation and the potential release of large quantities of oil. Although petroleum hydrocarbons serve as a nutrient source for symbiotic microorganisms associated with chemosynthetic communities, hydrocarbon toxicity and the partial or complete destruction of the habitat could occur if a large concentration of oil were to contact chemosynthetic communities. Similarly, oil covering deepwater corals could kill all or part of the community or cause sublethal physiological and reproductive effects. For example, a survey of a deepwater coral site following the DWH event indicated almost half of the corals at the site had been lethally or sublethally affected by exposure to oil (White et al. 2012). The site was located approximately 11 km (7 mi) to the northeast of the Macando well. The time it would take for the site to return to pre-spill conditions is not known.

Oil typically rises to the surface over the release site. However, if dispersants are used in the subsurface, or if the released oil has a significant fraction of gas or flows from the wellhead at a high velocity, a subsurface plume may form that would increase the potential for contact with a HDDC habitat. A subsurface plume 200 m (656 ft) high and 2 km (1.2 mi) wide was found at a 1,000 m (3,280 ft depth for a distance of 35 km (22 mi) from the DWH site) (Camilli et al. 2010). There is evidence that oil released from the DWH event was mixed with dispersant (Kujawinski et al. 2011). Whether there is a synergistic toxicity from dispersants and oil mixtures for chemosynthetic communities or deepwater corals is not known.

Certain organismal components of chemosynthetic HDDC are slow-growing, and if damaged, recovery would be long term (potentially hundreds of years), if they recover at all. Recent studies have shown that seep communities can be dynamic and that changes in species composition and colonization rates can operate on the order of years to decades (Lessard-Pilon et al. 2010). This suggests chemosynthetic communities could begin recovery relatively quickly if adversely affected by oil and gas activities, although full recovery would take much longer.

***Impact Conclusions*.**

Routine Operations. The primary impacts to marine benthic habitats from routine activities would be temporary and localized impacts on soft sediments from ground disturbance during drilling and pipeline and platform placement as well as the discharge of drilling muds and cuttings and produced water. Existing mitigation measures, if applied, should ameliorate most direct impacts on sensitive benthic marine habitats, including hard-bottoms, coral reefs, and HDDC. However, in some cases, activities that generate noise, turbidity, and sedimentation may affect sensitive habitats depending on their proximity to these activities. In addition, unmapped sensitive benthic habitats not covered by the stipulations may be damaged or destroyed. If sensitive benthic live-bottom and associated biota were damaged or killed, the impacts could be long-term because living benthic habitats are slow-growing and have highly specific habitat requirements. Overall, most routine activities are expected to have negligible impacts, while those activities that result in bottom disturbance may have moderate impacts to marine benthic habitat.

Expected Accidental Events and Spills. Small surface or subsurface hydrocarbon spills are not likely to result in the degradation of benthic marine habitat because small spills would be diluted by mixing in the water column. The impact of a large spill depends on several factors such as the size, duration, timing, and location of the spill and the nature of the benthic habitat contacted by the oil. Oil tends to rise in the water column, which would limit its contact with benthic habitat. There is the potential for oil released during a large spill at the surface or subsurface to reach topographic features, where it could have lethal or sublethal impacts on sensitive coral species. However, existing regulations on the placement of oil and gas infrastructure would limit impacts to high-relief banks and coral reefs. Large releases at the seafloor also affect low-relief hard-bottom and HDDCs, although the overall impacts to the resource from any one large spill would be limited, given their wide distribution. Overall, impacts from small spills would range from negligible for spill less than 50 bbl to minor for spills less than 1,000 bbl and from minor to moderate for large spills greater than 1,000 bbl.

An Unexpected Catastrophic Discharge Event. An unexpected CDE would physically disturb the seafloor around the spill site, and a subsurface plume extending a large distance from the spill could form, if dispersants are used or if the oil released is mixed with gas. As with a large spill, the impact of a CDE depends on several factors such as the size, duration, timing, and location of the spill, and the nature of the benthic habitat contacted by the oil. In the unlikely event that a CDE occurred, sensitive benthic habitats could suffer long-term loss of ecological function because of both hydrocarbon toxicity and the subsequent cleanup activities. Hydrocarbons could persist at sublethal concentrations in sediments. Over time, hydrocarbons would be broken down by natural processes, and most benthic habitats are likely to recover. Sensitive habitats (i.e., HDDC and coral reef) damaged by a spill would likely recover slowly or possibly not recover at all. Many sensitive benthic habitats are widely scattered; therefore, individual spills would be unlikely to threaten the resource as a whole. Overall, impacts to marine benthic habitat from a CDE could range from minor to moderate, depending on the habitats affected and the level of oiling experienced by those habitats. Major impacts to coral reef habitats could occur if the Flower Gardens Banks are heavily oiled and high mortality occurs.

4.4.6.2.2 Alaska – Cook Inlet.

Impacts of Routine Operations.

Exploration and Site Development. Impacting factors for the exploration and site development phase are shown in Table 4.4.6-4. Noise from seismic surveys and drilling could kill or injure organisms close enough to the noise source and reduce habitat suitability, because some species would avoid the area. The severity and duration of noise would vary with site and development scenario, but overall the impacts would be temporary and localized with overall minimal effects on benthic habitat. See Section 4.4.7 for detailed discussions of the effects of noise on different categories of biota.

Drilling exploratory wells would temporarily reduce habitat quality by generating turbidity and sedimentation for some distance around the disturbed area. It is estimated that 4 to 12 exploration wells and 42 to 114 production wells will be drilled in the Cook Inlet Planning Area. Exploration would use jack-up rigs and gravity rigs in water up to 46 m (150 ft), while drilling ships or semisubmersible or floating drilling rigs would be used in deeper water. One to three production platforms may be installed under the proposed action. Production operations will most likely be carried out from fixed platforms. The installation of floating or fixed platforms would eliminate soft sediment where the legs or mooring structures (anchors and chains) encountered the seabed and where subsea equipment (such as reentry collars and blowout preventers) was installed. Chronic local bottom disturbance could result from subsequent movements of anchors and mooring lines associated with floating drilling platforms and support vessels. However, these types of drilling rigs affect only small areas of the bottom.

Under the proposed action, it is estimated that 80 to 241 km (50 to 150 mi) of offshore pipeline may be placed in the Cook Inlet Planning Area, resulting in disturbance of up to 210 ha (519 ac) of seafloor in Cook Inlet. Pipelines would be trenched or installed and anchored on the

TABLE 4.4.6-4 Impacting Factors by Phase and Potential Effects on Marine Benthic Habitat in the Cook Inlet Planning Area

Impacting Factor	Potential Effects[a]
Exploration and Site Development	
Seismic surveys	Noise; localized anchoring disturbance
Anchoring and mooring of platforms, drillships, and seismic survey vessels	Sediment scour; temporary turbidity and sedimentation; localized alteration in sediment grain size and biogeochemical functions
Drilling and production platform placement	Noise; temporary sediment resuspension and turbidity; loss of natural habitat creation of artificial reef;
Drilling	Noise; small habitat loss; local alteration of sediment characteristics; temporary turbidity and sedimentation in surrounding areas
Miscellaneous discharges (deck washing, sanitary waste, vessel discharges)	Sediment contamination
Solid wastes	Sediment contamination
Discharge of drilling muds/cuttings	Sediment and water column contamination; alteration in sediment granulometry and biogeochemical functions
Pipeline trenching and placement	Noise; long-term loss and degradation of existing benthic habitat; temporary sediment resuspension and turbidity
Production	
Scour from anchors and the movement of pipelines and mooring structures	Chronic long-term disturbance of bottom sediments; turbidity
Platform production	Noise; loss of natural habitat creation of artificial reef
Produced water	Sediment contamination
Miscellaneous discharges	Sediment contamination
Solid wastes and debris	Sediment contamination
Decommissioning	
Miscellaneous discharge	Sediment contamination
Solid wastes and debris	Sediment contamination
Platform removal	Temporary turbidity and disturbance of bottom sediments

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

sediment surface, which would temporarily disturb a large area of benthic habitat by generating turbidity and sedimentation. Placing the pipeline on the sediment surface would result in loss of soft sediment habitat. Vessel anchoring during pipeline placement would also disturb soft sediment. It is anticipated that pipeline placement would displace benthic communities and temporarily alter grain size in areas of the seafloor with soft sediments. Cook Inlet waters are naturally high in suspended sediments, and analyses conducted for pipeline construction for previous lease sales indicated that turbidity from pipeline construction was expected to be within the natural range of turbidities for Cook Inlet (MMS 2003a).

It is assumed that drilling muds and cutting would be discharged into Cook Inlet for exploration wells only. Drilling wastes from development and production wells would be reinjected into the wells. Drill cuttings and drilling muds (including synthetic drilling fluids adhering to the cuttings) could contaminate and alter the sediments immediately around the wellhead and below the area where drilling wastes are discharged. Drill cuttings and muds rapidly reach the sediment surface and could be deposited in highly concentrated thick layers if deposited in shallow water or near the sediment surface. In the case of near-surface discharge in deep water, drilling muds would spread out in a thin veneer over a wide area. Settled muds could cause smothering of organisms, local hypoxia, changes in sediment characteristics and biogeochemical functions, and the loss of food resources in the immediate area. Although such releases could result in temporary impacts, the amount of discharge would be small compared to the more than 44 million tons of suspended sediment carried annually into Cook Inlet by runoff from area rivers (Brabets et al. 1999). The currents in lower Cook Inlet are likely strong enough to prevent the accumulation of muds and cuttings on the bottom; therefore, benthic habitats affected by drilling discharges would recover their natural grain size. In addition, the discharge of these drilling wastes is regulated by the USEPA under NPDES permits and can be discharged into the ocean only if they meet USEPA toxicity and discharge rate requirements. These requirements greatly reduce the potential for sediment contamination. A study of sediment quality in depositional areas of Shelikof Strait and Cook Inlet in 1997–1998 found that the concentrations of metals and polyaromatic hydrocarbons in sediments (1) posed no significant risk to benthic biota or fish and (2) were not linked to oil and gas development in upper Cook Inlet (MMS 2001a). Consequently, degradation of benthic habitat in Cook Inlet from drilling waste is not expected.

Other miscellaneous discharges (deck washing, sanitary waste, and vessel discharge) also have the potential to degrade benthic habitats. Miscellaneous discharges could contaminate sediments if discharged in relatively shallow water. However, considering the high flow rate of Cook Inlet, contaminants in surface discharges would most likely be diluted to non-toxic concentrations before reaching the sediment (MMS 2003a). Many vessel and platform wastes are disposed of on land, and those that are discharged at sea must meet USEPA and/or USCG regulatory requirements that limit their environmental effects.

Production. Production activities that could affect soft sediment habitat are shown in Table 4.4.6-4 and include operational noise; miscellaneous discharges; bottom disturbance from the movement of anchors and mooring structures, and releases of process water. In addition, the platform would replace existing featureless soft sediments and serve as an artificial reef. The potential impacts of miscellaneous discharges would continue on from the exploration and development phase and are described above. Impacts on soft sediment habitats from vessel and operational noise are expected to be long term, with the impacts lasting the duration of the production phase.

Chronic bottom disturbance from the movement of anchors and chains associated with support vessels would affect soft sediment habitats as described above for the exploration and site development phase. Production platforms will most likely be fixed structures, but benthic disturbance from the movement of mooring anchors is possible if floating production platforms are used. The movement of pipelines following severe storms could be a long-term chronic disturbance to benthic habitat causing scour, turbidity, and sedimentation of soft sediment habitats. However, pipelines would either be anchored securely or trenched which would minimize the potential for bottom disturbance.

The platform structure would also create novel hard substrate, and the area on and immediately around the platform may have very different habitat functions and biological communities compared to the preconstruction period. Algae and sessile invertebrates could attach to the platform and in turn attract reef-oriented organisms. Sediments grain size, benthic communities, and biogeochemical processes in sediments around the platform could be altered by the flux of biogenic material (e.g., organic matter and shell material) from the platform to the seafloor.

Produced water can contain hydrocarbons, salts, and metals at levels toxic to marine organisms. Before being discharged into the ocean, produced water is typically treated and must meet NPDES requirements regarding discharge rate, contaminant concentration, and toxicity, thereby reducing the potential for sediment contamination. Under the proposed action, it is assumed that all produced waters would be treated and reinjected into the disposal well. Therefore, no impacts on pelagic habitat are expected to result from produced water.

Decommissioning. Platform removal activities would result in loss of the platforms reef function, bottom disturbance, and a temporary increase in turbidity and sedimentation (Table 4.4.6-4). Over time, most sediments will recover their normal physical characteristics, ecological functions, and biological communities. No explosives would be used during platform removal. Pipelines installed and anchored on the seafloor would be capped and left in place, although there is the potential for chronic sediment disturbance from pipeline movement.

Impacts of Expected Accidental Events and Spills. It is assumed that 1 to 3 small spills between 50 and 999 bbl and 7 to 15 smaller spills between 1 and <50 bbl, and large spills (≥1,000 bbl) could occur under the proposed action (Table 4.4.2-1). Much of the impact magnitude depends on the location of the spill, the direction of bottom currents, and the amount of oil released. Impacts would typically increase with the size of the spill. Oil from accidental releases would be dispersed by currents, broken down by natural chemical and microbial processes, and would rise in the water column, thereby limiting the extent of benthic habitat that would be affected by any given spill. Large spills may persist long enough to drift to shore where they could contaminate benthic habitat. However, it is anticipated that only a small amount of shoreline would be affected by these spills and they would not, therefore, present a substantial risk to the overall resource. The benthic habitat would recover without mitigation because of natural breakdown of the oil, sediment movement by currents, and reworking by benthic fauna.

Oil spill-response activities such as burning, skimming, and chemical release (e.g., dispersants or coagulants) could affect benthic habitat and biota. Skimming and burning could kill pelagic live stages of benthic biota. The chemicals used during a spill response are toxic, but there is controversy about whether the combination of oil and dispersant is more toxic than oil alone (NRC 2005b; Fingas 2008; Holland-Bartels and Kolak 2011). The use of dispersant would likely reduce oiling of nearshore benthic habitat but may increase the exposure of subtidal benthic habitat and biota to toxic fractions of oil (NRC 2005b). In shallow water, the presence of, and noise generated by, oil spill-response equipment and support vessels could temporarily disturb benthic habitat in the vicinity of the response action, potentially reducing habitat use or disturbing migration. As with the spill itself, the location and time of the year the cleanup occurs would be an important determinant of impacts to benthic habitat and biota.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes an unexpected CDE with an assumed volume of 75,000 to 125,000 bbl and a duration of 50–80 days (Table 4.4.2-2). In the case of a CDE, the likelihood of oil contacting shoreline benthic habitat and biota is relatively high because the Cook Inlet Planning Area is located within a confined estuary. Oil reaching intertidal benthic habitat would likely be drawn below the sediment surface by capillary action. Subsurface oil is more persistent because it is spread throughout a matrix of sediment types and is less subject to physical weathering from sunlight and wave action (Taylor and Reimer 2008). Decades after the *Exxon Valdez* spill, highly weathered, asphalt-like or tar deposits may still be present beneath the surface of intertidal sediments of Prince William Sound, especially in the intertidal zone of low-energy, protected, unexposed bays and beaches with boulder/cobble or pebble/gravel sediments (Short et al. 2007; Taylor and Reimer 2008; *Exxon Valdez* Oil Spill Trustee Council 2010a). NOAA reported that 97 metric tons (tonnes) (107 tons) of oil may still be present in subsurface sediments in discontinuous patches, although this is only a small fraction of the >20,000 metric tons of oil initially deposited on beaches. After a initial rapid decline of 68% per year during 1991–1992, the oil is currently decreasing in concentration at a rate of 0–4% per year (NOAA 2010c; Short et al. 2007). Overall, studies of the *Exxon Valdez* spill indicate that a catastrophic spill could result in long-term degradation of benthic habitat and sublethal effects on benthic biota. As of 2010, intertidal sediments and communities are considered to still be recovering from the *Exxon Valdez* spill (*Exxon Valdez* Oil Spill Trustee Council 2010a).

Following the *Exxon Valdez* oil spill in 1989, highly elevated hydrocarbon concentrations in intertidal sediments were found at heavily oiled sites followed by an apparent migration of the oil into the shallow subtidal zone in 1991 (Wolfe et al. 1996). Oil in the intertidal and subtidal zones can affect not only lower trophic-level organisms but also higher trophic-level organisms, such as marine and coastal birds (Section 4.4.7.2.2) and fish (Section 4.4.7.3.2; Peterson et al. 2003). However, subtidal sediment may be less likely to suffer long-term contamination because oil tends to float and natural weathering, bottom scour, and depositional processes would reduce the oil concentration in the sediment. Biological impacts on subtidal biota are also typically short term (Lee and Page 1997). Oiled subtidal sediments were detected shortly after the *Exxon Valdez* spill, but not in follow-up studies conducted in 2001, and subtidal sediment concentrations of oil are much lower than concentrations in intertidal sediments (Lee and Page 1997). Subtidal habitat and communities are considered to be very likely recovered by the *Exxon Valdez* Oil Spill Trustee Council (2010a).

Broken ice occurs in the northern and western portions of lower Cook Inlet during fall and winter. If an open water spill were to occur at this time, the ice would contain the oil somewhat and reduce spreading and contacting intertidal benthic habitat. However, oil cleanup is also more difficult in broken ice conditions. Oil from spills occurring in the winter may be trapped under ice, resulting in localized, persistent degradation of habitat quality and ecosystem function.

Impact Conclusions.

Routine Operations. Most routine activities conducted during the exploration, development, and production phases would have negligible impacts on benthic habitats. Routine activities that involve in bottom disturbance could result in minor to moderate impacts on benthic habitat in the Cook Inlet Planning Area. The primary impacts would be from ground disturbance during drilling and pipeline and platform placement as well as the discharge of drilling muds and cuttings. It is assumed that drilling muds and cuttings would be discharged into Cook Inlet for exploration wells only. Drill cuttings and drilling muds (including synthetic drilling fluids adhering to the cuttings) could contaminate and alter the sediments immediately around the wellhead and below the area where drilling wastes are discharged. Recovery of seafloor habitat could range from short-term (months) to long-term (decades). Overall, negligible to moderate impacts are expected to result from routine activities.

Expected Accidental Events and Spills. Small hydrocarbon spills are likely to result in localized degradation of benthic marine habitat because oil would typically float above the seafloor and be diluted over time. Therefore, oil reaching benthic marine habitats would likely be in low concentrations. The impact of a large spill (≥1,000 bbl) depends on several factors such as the size, duration, timing, and location of the spill, and the nature of the benthic habitat contacted by the oil. Oil tends to rise in the water column which would limit its contact with benthic habitat. Overall, impacts from small spills would range from negligible for a spill less than 50 bbl to minor for spills less than 1,000 bbl and from minor to moderate for large spills greater than 1,000 bbl.

An Unexpected Catastrophic Discharge Event. The impact of an unexpected CDE depends on several factors such as the size, duration, timing, and location of the spill, and the nature of the benthic habitat contacted by the oil. The season in which the spill occurs is especially important in Alaskan waters due to seasonal ice cover that could hinder cleanup efforts. In the unlikely event that a CDE occurred, hydrocarbons reaching subtidal habitats would likely recover more quickly than intertidal sediments. Oil reaching sensitive intertidal habitats could persist at sublethal concentrations in sediments for decades. However, hydrocarbons would eventually be broken down by natural processes, and most benthic habitats are likely to recover. Overall, impacts to marine benthic habitat from a CDE could be minor to moderate, depending on the habitats affected and the level of oiling incurred by those habitats.

4.4.6.2.3 Alaska – Arctic.

Impacts of Routine Operations.

Exploration and Site Development. Impacting factors for the exploration and site development phase relevant to seafloor habitat are shown in Table 4.4.6-5. It is assumed that oil and gas development activity would be restricted to waters less than 91 m (300 ft). Exploration drilling would employ gravel islands or mobile platforms in waters between 6 to 18 m (20 and 60 ft) in depth and drillships in deeper water. Production operations will be conducted from subsea wells, gravel islands, or gravity-based platforms in water less than 12 m (40 ft) in depth,

TABLE 4.4.6-5 Impacting Factors by Phase and Potential Effects on Marine Benthic Habitat in the Beaufort and Chukchi Sea Planning Areas

Impacting Factor	Potential Effects[a]
Exploration and Site Development	
Vessel traffic	Noise
Seismic surveys	Noise; localized anchoring disturbance
Anchoring and mooring of platforms, drillships, and seismic survey vessels	Sediment scour; temporary turbidity and sedimentation; localized alteration in sediment grain size and biogeochemical functions
Drilling and subsea well and production platform placement (including artificial islands)	Noise; temporary sediment resuspension and turbidity; loss of natural habitat creation of artificial reef; loss of benthic habitat due to artificial islands
Drilling	Noise; small habitat loss; local alteration of sediment characteristics; temporary turbidity and sedimentation in surrounding areas
Miscellaneous discharges (deck washing; sanitary waste, vessel discharges)	Sediment contamination
Solid wastes	Sediment contamination
Discharges of drilling muds/cuttings	Sediment and water column contamination; alteration in sediment grain size and biogeochemical functions
Pipeline trenching and placement	Noise; long-term loss and degradation of existing benthic habitat; temporary sediment resuspension and turbidity
Production	
Scour from anchors and the movement of pipelines and mooring structures	Chronic, long-term disturbance of bottom sediments; turbidity
Platform production	Noise; loss of natural habitat creation of artificial reef
Produced water	Sediment contamination
Miscellaneous discharges	Sediment contamination
Solid wastes and debris	Sediment contamination
Decommissioning	
Miscellaneous discharge	Sediment contamination
Solid wastes and debris	Sediment contamination
Platform removal	Temporary turbidity and disturbance of bottom sediments

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

and from larger gravity-based platforms in deeper waters. It is assumed that as many as 92 subsea production wells and 9 artificial islands could be constructed during the lease period with a footprint of approximately 1.5 ha (4 ac) per platform or island. Under the proposed action, it is estimated that 89 to 652 km (55 to 405 mi) of new offshore pipeline would be placed in the Beaufort and Chukchi Sea Planning Areas, resulting in disturbance to 77 to 567 ha (190 to 1,402 ac) of seafloor.

Drilling, platform and pipeline placement, and construction and maintenance of artificial islands have the potential to reduce benthic habitat quality by disturbing the seafloor and generating noise, turbidity, and sedimentation for some distance around the disturbed area and potentially adversely affecting benthic biota. Such activities could reduce benthic habitat quality by displacing benthic organisms and interrupting the movement and dispersal of species of all life stages. Chronic bottom disturbance would result from movements of anchors associated with floating drilling vessels and support vessels. The installation of platforms would eliminate soft sediment where the platform and mooring structures (anchors and chains) encountered the seabed and where subsea equipment (such as reentry collars and blowout preventers) was installed and depending on location, habitat loss for benthic feeders could be important. The area of burial around constructed islands could increase over time because of erosion from storm action and ice gouging on island slopes. The construction of subsea wells and gravel islands would eliminate soft sediment habitat, but the total bottom area that could be disturbed would be relatively small compared to the overall area of benthic habitat available in the Beaufort and Chukchi Sea Planning Areas.

Pipelines would be buried in waters less than 50 m (156 ft) to prevent damage from ice gouges, and pipelines in deeper water would be installed and anchored on the seafloor. Pipelines installed and anchored on the seafloor would replace natural soft sediment habitat with hard-bottoms, which would alter species composition and biogeochemical habitat function. For buried pipelines, benthic organisms within the trenched corridor would be killed or injured, and organisms to either side of the pipeline would be buried by sediments. Disturbed sediments with a greater proportion of sand to mud may fill in with fine, silty material that would alter grain size and potentially inhibit the colonization by species that existed prior to the disturbance. The recovery period for soft sediment benthic habitat affected by bottom disturbance would depend on factors such as water depth, sediment type, and community composition. In the Arctic, the benthic community in these areas experiences a naturally high amount of disturbances from ice gouging, strudel scour, and severe storms, and hyposaline and highly turbid conditions occur naturally during spring breakup. Therefore, seafloor biota in the Beaufort and Chukchi Seas may be adapted to such conditions. Turbidity plumes from construction activities under the proposed action would be temporary and disturbed areas would probably be recolonized within a few years, although recovery could take more than a decade (Conlan and Kvitek 2005).

Increased water turbidity and sedimentation from ground-disturbing activities discussed above could directly affect kelp growth by burying kelps and other organisms, altering the optical properties of the water column, and limiting photosynthesis (Maffione 2000; Dunton et al. 2009). It is estimated that kelp contributes 50–56% of annual productivity in the Boulder Patch and is an important source of organic matter that supports various members of the epilithic community (Dunton 1984). Overall, measurements have indicated natural inputs of suspended sediment from runoff and erosion are large relative to any anthropogenic inputs of sediment (Trefry et al. 2004). Therefore, unless activities are located in the immediate vicinity of the Boulder Patch, the proposed action is not expected to substantially increase turbidity or sedimentation on the Boulder Patch. Planning and permitting procedures and requirements will likely be sufficient to avoid such occurrences. Under current regulations, proposed development near the Boulder Patch area requires detailed surveys to identify the boundaries of the Boulder Patch habitat, and the expected levels of impacts from proposed activities must be identified, which will likely be sufficient to minimize impacts from pipeline construction within the Boulder Patch area. However, the construction of offshore pipelines could affect kelp habitat area outside of the Boulder Patch. Recovery would be slow if kelp communities were mechanically damaged by drilling or anchor and chain scour. It is estimated that recovery of kelp growth in areas trenched for pipeline construction could occur within a decade in some cases or could be much longer depending on the proportion of hard substrate exposed after pipeline construction was completed (Konar 2006). Although habitat loss may be relatively small when compared to the large size of the Arctic Planning Areas, even small habitat loss can be significant to specific populations depending on where it occurs.

It is assumed that drilling muds and cutting would be discharged into the Beaufort and Chukchi Sea Planning Areas for exploration wells only. Drilling wastes from development and production wells would be reinjected into the wells. Drill cuttings and drilling muds (including synthetic drilling fluids adhering to the cuttings) could contaminate and alter the grain size of sediments immediately around the wellhead and below the area where these drilling wastes are discharged. Drill cuttings and muds rapidly reach the sediment surface and could be deposited in highly concentrated thick layers if deposited in shallow water or near the sediment surface. In the case of near-surface discharge in deep water, drilling muds would spread out in a thin veneer over a wide area. Settled muds could cause smothering of organisms, local hypoxia, changes in sediment characteristics and biogeochemical functions, and the loss of food resources in the immediate area. Arctic sediments are constantly changing in grain size (Neff & Associates, LLC 2010) due to natural disturbances. Thus, after they reach the sediment, discharged muds and cuttings are likely over time to be redistributed over a broad area. Although such releases could result in temporary, localized increases in sediment load and deposition, this amount of discharge would be small compared to the more than 6.35 million tons of suspended sediment carried annually into the Beaufort Sea alone by runoff from area rivers (Neff and Associates, LLC 2010). In addition, drilling muds or cuttings that are discharged into the ocean are regulated by the USEPA under NPDES permits and can be discharged into the ocean only if they meet USEPA toxicity and discharge rate requirements. These requirements greatly reduce the potential for sediment contamination. Discharges of drilling wastes in the vicinity of the Steffansson Sound Boulder Patch are regulated under NPDES Permit Number AKG280000. Consequently, there should be minimal impacts on Boulder Patch habitat from drilling wastes.

Miscellaneous discharges (deck washing, sanitary waste, and vessel discharge) also have the potential to degrade seafloor habitats. Miscellaneous discharges could contaminate sediments if discharged in relatively shallow water. However, many vessel and platform wastes are disposed of on land, and those that are discharged at sea must meet USEPA and/or USCG regulatory requirements that limit their environmental effects. In addition, stratification of the water column prevents diffusion of chemicals to bottom layers in many areas.

Noise from seismic surveys and drilling could kill or injure organisms close enough to the noise source and reduce habitat suitability as some species would avoid the area. The severity and duration of noise would vary with site and development scenarios, but the impacts would be temporary and localized with overall minimal effects on soft sediment habitat. See Section 4.4.7 for detailed discussions of the effects of noise on different categories of biota.

Production. Production activities that could affect soft sediment habitat are shown in Table 4.4.6-5. The potential impacts of miscellaneous discharges would continue on from the exploration and development phase and are described above. Impacts on soft sediment habitats from vessel and operational noise are expected to be long-term, with the impacts lasting the duration of the production phase. Chronic bottom disturbance from the movement of anchors and chains associated with support vessels would affect soft sediment habitats as described above for the exploration and site development phase. These disturbances would be long term and chronic and cause scour, turbidity, and sedimentation of soft sediment habitats.

Platforms and gravel islands would provide additional habitat for marine plants and animals (e.g., kelp and mussels) that require a hard substrate. Therefore, the overall probable effect of platform placement and island construction would be to alter local species composition. In addition, sediment grain size and biogeochemical processes around the platform would be altered by the flux of biogenic material (shell and organic matter) from the platform to the seafloor. Data from other hard-bottom habitats suggest colonization would be slow and seasonal ice cover may restrict colonization to short-lived opportunistic species. Any artificial reef function the platform does serve would exist only during the production phase, so impacts, if any, would be temporary but lasting decades. However, gravel islands would remain in place. The islands may eventually erode and form a subsea gravel bed that would provide habitat to species attracted to hard substrate.

Produced water is a normal product of oil and gas extraction that contains contaminants such as polycyclic aromatic hydrocarbons and heavy metals and therefore represents a potential source of contamination to benthic habitats. It is assumed that all produced water will be disposed of onshore or reinjected into the well rather than discharged into the ocean. If produced water is discharged into the ocean, it is typically treated and must meet NPDES requirements regarding discharge rate, contaminant concentration, and toxicity, thereby reducing the potential for sediment contamination. Consequently, no impacts from the discharge of produced water are expected.

The results of the Arctic Nearshore Impacts Monitoring in the Development Area study funded by BOEM provide a good summary of the long-term changes to benthic habitats resulting from oil and gas production in the Arctic (Neff and Associates, LLC 2010). No relationship between the location of oil and gas production and the concentration of metals and hydrocarbons in sediment and marine animals was detected. The study concluded that metals and PAHs in Beaufort Sea sediments were primarily derived from sediments delivered by rivers, not oil and gas activities.

Decommissioning. Miscellaneous and solid waste releases discussed above would continue during the decommissioning phase (Table 4.4.6-5). Platform and mooring structure removal activities would result in bottom disturbance and a temporary increase in turbidity and sedimentation. No platforms are expected to be removed using explosives. Over time, sediments will recover their normal physical characteristics, ecological functions, and biological communities.

Impacts of Expected Accidental Events and Spills. It is assumed that large spills (≥1,000 bbl), up to 35 small spills (50 to 999 bbl), and up to 190 smaller spills (>1 and <50 bbl) could occur during the lease period under the proposed action (Table 4.4.2-2). Much of the impact magnitude depends on the location of the spill, the direction of bottom currents, and the amount of oil released. Impact magnitude would typically increase with the size of the spill. Most spills would be small and would degrade benthic habitat quality at relatively local scales. Large spills would affect a wider area of benthic habitat and potentially persist in the sediment for an extended period. Oil from accidental seafloor releases would rise in the water column, thereby limiting the extent of benthic habitat that would be affected by any given spill. Oil from most surface spills is likely to reach the sediment only at biologically negligible concentrations. Benthic habitat would recover without mitigation because of natural breakdown of the oil, sediment movement by currents, and reworking by benthic fauna.

Oil spill-response activities such as burning, skimming, and chemical release (e.g., dispersants or coagulants) could affect benthic habitat and biota. Skimming and burning could kill pelagic live stages of benthic biota. The chemicals used during a spill response are toxic, but there is controversy about whether the combination of oil and dispersant is more toxic than oil alone (NRC 2005b; Fingas 2008; Holland-Bartels and Kolak 2011). The use of dispersant would likely reduce oiling of nearshore benthic habitat, but may increase the exposure of subtidal benthic habitat and biota to toxic fractions of oil (NRC 2005b). In shallow water, the presence of, and noise generated by, oil spill-response equipment and support vessels could temporarily disturb benthic habitat in the vicinity of the response action, potentially reducing habitat use or disturbing migration. As with the spill itself, the location and time of the year the cleanup occurs would be an important determinant of impacts on benthic habitat and biota.

Impacts of an Unexpected Catastrophic Discharge Event. This PEIS analyzes an unexpected CDE with an assumed volume of 1.4-2.2 million bbl and a duration of 40–75 days in the Chukchi Sea Planning Area, and a CDE in the Beaufort Sea Planning Area with an assumed volume of 1.7-3.9 million bbl and a 60-300 day duration (Table 4.4.2-2). A CDE could result in lethal or sublethal concentrations of hydrocarbons or mixtures of hydrocarbons and dispersants (if used), which could accumulate in soft sediments, reducing habitat function. The magnitude of the impact depends primarily on the location of the well, the volume released, and the speed at which the well was capped. Most oil released in a surface or seafloor spill would float above the sediment, but sediment contamination could occur from the deposition of oiled sediment and organic matter (dead plankton and organic flocculants) falling from the water column. In addition, oil could reach the shoreline and contaminate coastal benthic habitat (see Sections 4.4.6.1.3 and 4.4.6.2.2 for a detailed discussion of the impacts of oil spills on coastal habitat). The soft sediment habitat would recover without mitigation because of natural breakdown of the oil, sediment movement by currents, and reworking by benthic fauna. However, the cold temperatures of the Arctic may allow hydrocarbons to persist in the sediments longer than in temperate areas.

The magnitude of impacts on hard-bottom kelp communities from an oil spill would depend on the location and severity of the spill. Oil spills contacting the hard-bottom kelp communities (e.g., the Boulder Patch and communities in Peard Bay and Ledyard Bay) could cause both lethal and sublethal effects on marine plants and invertebrates. Sublethal effects occur at lower concentrations and include reduced growth and/or fecundity, increased physiological stress, and behavioral changes. *Laminaria solidungula*, found in the Stefansson Sound Boulder Patch, has not been studied directly, but other Laminaria species from the Canadian Beaufort Sea showed marked physiological impairment when exposed to oils of several types and concentrations (Hsiao et al. 1978). Photosynthesis would probably be reduced by the floating oil because of reduced light penetration, and if the floating oil persisted long enough, it could affect growth and reproduction of the kelp. Benthic animal communities have also been shown to have major shifts in species composition following exposure to oil (Dean and Jewett 2001). Impacts on kelp habitat from an oil spill could be long-term. *Laminaria* beds oiled by the *Exxon Valdez* spill recovered within 10 years (Dean and Jewett 2001).

If the CDE were to occur during winter, cleanup would be much more difficult because sea ice would limit access to the spill (reviewed in Holland-Bartels and Kolak 2011). Oil cleanup response plans and technologies for ice-covered spills are still evolving, and the efficacy of many proposed spill countermeasures is as yet unknown (Holland-Bartels and Kolak 2011). If the spill were to occur under ice, oil would be trapped and essentially remain unchanged until breakup occurred and the ice began to melt. Oil could float or freeze within the ice, which would limit the potential for oil to reach deeper subtidal seafloor habitat. However, oil transported under ice to nearshore areas would remain unweathered and could degrade intertidal and shallow subtidal benthic habitat throughout the winter and after the ice thaws. The effects on primary and secondary biological productivity could be severe as well, because of loss of epontic and ice-associated fish assemblages due to oil toxicity. Oil under landfast ice would be more easily accessed and cleaned, which could reduce the duration and severity of impacts.

Impact Conclusions.

Routine Operations. Routine activities conducted during the exploration, development, and production phases that involve bottom disturbance could result in minor to moderate impacts on benthic habitat in the Beaufort Sea and Chukchi Sea Planning Areas. The primary impacts would be on soft sediments from ground disturbance during drilling and pipeline and platform placement as well as the discharge of drilling muds and cuttings and produced water. Recovery of seafloor habitat could range from short-term (months) to long-term (decades). Existing mitigation measures, if applied, should ameliorate most direct impacts on sensitive benthic marine habitats, including Boulder Patch communities in the Beaufort and Chukchi Seas. However, in some cases, activities that generate noise, turbidity, and sedimentation may affect sensitive habitats, depending on their proximity to these activities. If sensitive hard-bottom habitats were damaged, the impacts could be long-term because living benthic habitats are slow-growing and have highly specific habitat requirements. Overall, activities conducted during the exploration and site development phase are expected to have negligible to moderate effects on seafloor habitat.

Expected Accidental Events and Spills. Small surface or subsurface hydrocarbon spills are not likely to result in the degradation of benthic marine habitat because hydrocarbons associated with small spills would be diluted to low concentrations as they moved through the water. The impact of a large spill depends on several factors such as the size, duration, timing, and location of the spill, and the nature of the benthic habitat contacted by the oil. Oil from accidental releases would be dispersed by currents, and broken down by natural chemical and microbial processes, and would rise in the water column, thereby limiting the extent of soft sediment habitat that would be affected by any given spill. Overall, impacts from small spills would range from negligible for spill less than 50 bbl to minor for spills less than 1,000 bbl and from minor to moderate for large spills (≥1,000 bbl).

***An Unexpected Catastrophic Discharge Event*.** An unexpected CDE would physically disturb the seafloor around the spill site, and a subsurface plume extending a large distance from the spill could form if dispersants are used or if the oil released is mixed with gas. The impact of a CDE depends on several factors such as the size, duration, timing, and location of the spill, and the nature of the benthic habitat contacted by the oil. The season in which the spill occurs is especially important in Arctic waters due to heavy seasonal ice cover that could hinder cleanup efforts. In the unlikely event that a CDE occurred, sensitive benthic habitats could suffer long-term loss of ecological function because of both hydrocarbon toxicity and the subsequent cleanup activities. Hydrocarbons could persist at sublethal concentrations in sediments for decades, and sensitive habitats (i.e., kelp beds and intertidal zones) damaged by a spill would likely recover slowly. However, hydrocarbons would be broken down by natural processes, and most benthic habitats are likely to recover. Overall, impacts to marine benthic habitat from a CDE could range from minor to moderate, depending on the habitats affected and the level of oiling experienced by those habitats. Major impacts to hard-bottom kelp habitat could occur if these areas were heavily oiled and high mortality occurs.

4.4.6.3 Marine Pelagic Habitats

4.4.6.3.1 Gulf of Mexico

Water Column.

***Impacts of Routine Operations*.**

<u>Exploration and Site Development.</u> See Section 4.4.3.1.1 for a general discussion of the impacts of exploration and site development on water quality. During the exploration and site development phase, pelagic habitat would be affected by platform and pipeline placement, drilling activity, seismic surveys, platform lighting, and aircraft and vessel traffic, and miscellaneous vessel and platform discharges (Table 4.4.6-6). Noise impacts would be greatest near the source and would temporarily reduce habitat quality (i.e., induce physiological stress, injury, or behavioral changes) for certain species whose noise tolerance is below that of the noise level generated by the exploration and development activities. See Section 4.4.7 for detailed discussions of the effects of noise on different categories of biota. Construction lighting would alter the pelagic light regime of a small area and would attract phototaxic organisms to the platform. Studies in the northern GOM suggest that platform lighting could enhance phytoplankton productivity around the platform, potentially increase prey availability, and improve the visual foraging environment for fishes (Keenan et al. 2007).

Bottom water quality would be temporarily affected by turbidity from sediment disturbance during drilling, platform placement, and pipeline trenching and placement. Turbidity from bottom-disturbing activities could kill zooplankton, although it is not expected to result in

TABLE 4.4.6-6 Impacting Factors by Phase and Potential Effects on Marine Pelagic Habitat in the CPA and WPA of the GOM

Impacting Factor	Disturbance[a]
Exploration and Site Development	
Vessel traffic	Noise
Seismic surveys	Noise
Miscellaneous discharges (deck washing, sanitary waste, bilge and ballast water)	Degraded water quality
Drilling and discharge of drilling muds/cuttings	Noise; degraded water quality
Pipeline trenching	Noise; turbidity
Drilling platform placement	Noise; turbidity
Offshore lighting	Alteration of light field
Production	
Production platform placement	Noise; turbidity
Production	Noise
Produced water discharge	Degraded water quality
Miscellaneous discharges (deck washing, sanitary waste)	Degraded water quality
Offshore lighting	Alteration of light field
Decommissioning	
Miscellaneous discharges (deck washing, sanitary waste, bilge and ballast water)	Degraded water quality
Explosive platform removal	Noise, turbidity
Offshore lighting	Alteration of light field

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

population-level effects. Photosynthetic productivity of phytoplankton that specialize in near-bottom habitats may be reduced if the turbidity plume reduced solar irradiance at depth. However, the turbidity plume would be temporary, and phytoplankton populations have rapid replacement times (Behrenfeld et al. 2006). Therefore no long-term impacts on phytoplankton populations are anticipated. FPSO systems could potentially be used in deep water, which would reduce the need for pipeline placement and greatly reduce water quality impacts.

The discharge of drilling muds and cuttings can occur near the water's surface or the seafloor. Releases at the seafloor would affect bottom waters in ways similar to those of bottom-disturbing activities, resulting in a temporary reduction in water quality. Surface discharge of drilling muds and cuttings would create a turbidity plume that would diminish within some distance from the release point. The turbidity plume could smother or stress small zooplankton and reduce phytoplankton productivity by decreasing the depth and intensity of light penetration. While synthetic drilling fluids are not discharged directly, they do enter the pelagic environment by adhering to drilling cuttings (Neff et al. 2000). These cuttings tend to aggregate and settle rapidly to the sea floor. This tendency for aggregation increases the higher the concentration of adhered synthetic fluid. The rapid settling of the cuttings reduces their dispersion in the water column and water column turbidity (Neff et al. 2000). In addition, synthetic drilling fluids have low toxicity (Neff et al. 2000). Consequently, the release of such cuttings and associated synthetic drilling fluids should result in short-term and relatively localized impacts.

Similarly, in well-mixed ocean waters, water-based drilling muds and cuttings are diluted by 100-fold within 10 m (33 ft) of the discharge and by 1000-fold at a distance of about 100 m (330 ft) from the platform (Neff 2005). These estimates are for well-mixed water, and therefore the size of the turbidity field will vary with hydrology. The generally rapid dilution would limit the degradation of pelagic habitat to a localized area. Degradation of pelagic habitat would also be limited by NPDES permits regulating the discharge of drill cuttings in a way that reduced impacts on water quality (Neff et al. 2000; Neff 2005).

Pelagic habitat would be affected minimally and temporarily by miscellaneous discharges (deck drainage, sanitary and domestic waste, bilge and ballast water) during site development. Such releases would be small in quantity and would be rapidly diluted. In addition, many vessel and platform wastes are disposed of on land, and those that are discharged at sea must meet USEPA and/or USCG regulatory requirements that limit their environmental effects.

<u>Production.</u> Impacts from offshore lighting, miscellaneous discharges, and bottom disturbance from the movement of platform and support vessel anchors and chains will also exist in the production phase and are described above. In addition, production noise and produced water discharge could affect pelagic habitat quality (Table 4.4.6-6). Production noise is not expected to appreciably degrade habitat quality, as production platforms are known to have high biological abundance and diversity. Impacts on pelagic habitat from produced water are not expected because produced water is treated before being discharged and must meet NPDES permitting guidelines regarding discharge rate and toxicity. Produced water is high in organic matter and has the potential to generate local hypoxia (Rabalais 2005). However, a major study of produced water discharges across the northern GOM indicated that despite the large volume discharged, the contribution of produced water to bottom water hypoxia is minimal when compared to riverine inputs, and produced water did not make a significant contribution to the hypoxic zone in the GOM (Rabalais 2005).

Algae and sessile invertebrates would rapidly colonize the platform and would in turn attract mobile reef-oriented organisms. Thus, the platform structure would serve as a novel artificial reef in formerly open water habitat. The platform would function in a manner similar to existing reefs, banks, and topographic features and may increase zooplankton densities around the platform. A floating platform would extend from the surface to some depth below the waterline, potentially creating a floating reef habitat that would attract organisms to adjacent surface waters. The artificial reef would only exist during the production phase, unless the platform was permitted to remain in place after decommissioning. In deep sea areas, the platform and mooring structures would likely be completely removed during decommissioning, so impacts from bottom disturbance would be temporary.

<u>Decommissioning.</u> Impacts from vessel noise, platform lighting, and miscellaneous discharges are discussed above and would continue throughout the decommissioning phase (Table 4.4.6-6). In addition, bottom disturbance during platform removal (potentially including

the use of explosives) would temporarily disturb pelagic habitat by increasing noise and turbidity for some length of the water column (see individual sections on marine biota for discussions of the impacts of explosive platform removal). These impacts would temporarily degrade habitat quality, but conditions would return to normal as suspended sediments dispersed and resettled.

Impacts of Expected Accidental Events and Spills. Accidental hydrocarbon releases can occur at the surface or at the seafloor. Although not well studied, natural gas can be toxic to marine life, and therefore its release into the water would represent a degradation of habitat quality within the area affected by the gas release. A large methane release in the Sea of Azov resulted in cell damage, biochemical alteration, impaired movement, blood disorders, and alteration of biochemical processes in fish collected around the platform and in fish held in water near the platform (Patin 1999). However, natural gas is also less persistent in the environment than oil. Evidence from the DWH event indicates that methane gas released from the well was rapidly broken down by bacterial action with little oxygen drawdown (Kessler et al. 2011; Atlas and Hazen 2011). Consequently, the remainder of the discussion focuses on oil spills.

It is assumed that large spills (≥1,000 bbl), up to 70 spills between 50 and 999 bbl and 400 smaller spills between 1 and 50 bbl could occur during the lease period under the proposed action (Table 4.2.2-1). Accidental oil spills could be surface releases from platforms or vessels or seafloor releases from pipelines and the wellhead. Modeling indicates that oil spilled at the surface could mix by natural dispersion to a depth of 20 m (66 ft) at highly diluted concentrations (MMS 2008a). Accidental oil releases from pipeline leakage would degrade bottom water quality at local scales. Large spills would degrade pelagic habitat quality over a wider area and potentially reduce the habitat value and ecosystem function in the areas affected. Most released oil and gas would float above the seafloor, so exposures would be expected for zooplankton, which lack the mobility to avoid the oil. Oil exposure can also reduce the abundance of zooplankton in the oiled area, induce narcosis, and bind to feeding appendages (Teal and Howarth 1984). Zooplankton are known to ingest oil, some of which is retained in the gut and some of which is exported to the seafloor in fecal pellets (Teal and Howarth 1984). The oil would be broken down by natural processes, and pelagic habitat would recover. See Section 4.4.3.2.1 for a further discussion of the effects of oil spills on water quality in the GOM.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes an unexpected CDE with an assumed volume of 0.9-7.2 million bbl and a duration of 30–90 days (Table 4.4.2-2). Pelagic organisms could be exposed to lethal or sublethal concentrations of hydrocarbons or mixtures of hydrocarbons and dispersants (if used). The extent and magnitude of the impact depend primarily on the location of the well, the volume of oil released, and the season in which the spill occurs. Typically oil rises from the seafloor to the sea surface forming a surface slick. However, a subsurface plume capable of traveling long distances could form if dispersants are used, or if the well releases oil at high velocity or as a mixture of oil and gas. In the case of the DWH event, hydrocarbons were detected as far as 35 km (22 mi) northeast and southwest of the well (Camilli et al. 2010; Haddad and Murawski 2010). Existing studies of the DWH event suggest the GOM has a tremendous natural capacity to assimilate oil from accidental releases. Comprehensive sampling over a wide area and depth strata of the GOM reported less than 2% of water column samples taken from offshore and deepwater areas contained toxic PAH concentrations (OSAT 2010). The toxicity of water samples decreased with distance from the wellhead; after August 2010, no water samples exceeded the aquatic life benchmark for PAHs (OSAT 2010). Menthanotropic and oil-eating bacteria were greatly increased following the DWH event, which allowed rapid breakdown of the released oil and gas (Atlas and Hazen 2011; Kessler et al. 2011). However, the increase in microbial biomass did not result in significant oxygen depletion, even in deep water. The hydrocarbons appeared to be assimilated by bacteria and transferred up through the zooplankton food web (Graham et al. 2010). However, the DWH event may not be indicative of future oil spills, because recovery time would vary with local conditions and the degree of oiling. For example, shallow pelagic habitats would probably recover more quickly than deepwater pelagic habitats because of the greater physical and biological activity in shallow water.

CDE-response activities such as burning, skimming, and chemical release (e.g., dispersants or coagulants) could affect pelagic habitat and biota. Burning would kill pelagic biota in the burn area, and skimming would remove aquatic organisms from the water column or trap them in oiled water. The chemicals used during a spill response are toxic, but there is controversy about whether the combination of oil and dispersant is more toxic than oil alone (NRC 2005b; Fingas 2008; Holland-Bartels and Kolak 2011). The use of dispersant would likely increase the areal extent of oil dispersion and the exposure of pelagic biota to oil. The presence of, and noise generated by, oil spill-response equipment and support vessels could temporarily disturb pelagic habitat in the vicinity of the response action, potentially reducing habitat use or disturbing migration. As with the spill itself, the location and time of year the cleanup occurs would be important determinants of impacts on pelagic habitat and biota.

Sargassum.

Impacts of Routine Operations.

Exploration and Site Development. *Sargassum* could be affected by several activities during the exploration and site development phase of OCS oil and gas development including vessel traffic, miscellaneous discharge, and drilling waste discharge. Drilling muds and cuttings are typically discharged near surface waters and could come into contact with *Sargassum* mats. Turbidity generated by the discharge could reduce photosynthesis in *Sargassum* and cause physiological stress on associated animal communities. The cuttings should settle to the bottom within 1,000 m (3,280 ft) of the release point (Continental Shelf Associates, Inc. 2006), so the contact should be minimal. NPDES permit requirements regulating the toxicity and amount of drilling wastes discharged would also limit the potential for impacts on *Sargassum*. Miscellaneous discharges (deck drainage, sanitary and domestic waste, bilge and ballast water) are not expected to affect *Sargassum* because the releases would be small in quantity and would be rapidly diluted. Service vessels and drilling ships could damage *Sargassum* mats with their propeller or by entraining *Sargassum* in their cooling water intake. The effects on individual *Sargassum* mats and the associated communities could be complete or partial loss of the *Sargassum*. Given the small area affected relative to the size of known *Sargassum* habitat, vessel traffic is not expected to measurably reduce the biomass or productivity of *Sargassum* in the northern GOM.

Sargassum appears to originate in the northwestern GOM, and little new oil and gas development is expected to occur in this region. Given the small overall area of seafloor affected by new oil and gas development, and the new spring production of *Sargassum* that occurs in the GOM (Gower and King 2008), no detectable population level effects on *Sargassum* are anticipated.

Production. Miscellaneous discharges and vessel traffic will continue through the production phase, but they are not expected to affect *Sargassum* for the reasons described above. Contaminants in produced water discharged from the platform could affect *Sargassum* and associated biota. However, produced water is treated before discharge and must meet NPDES permitting guidelines. Other production activities would primarily affect subsurface habitat and are not anticipated to affect *Sargassum*.

Decommissioning. Miscellaneous discharges and vessel traffic will continue through the decommissioning phase, but they are not expected to affect *Sargassum* for the reasons described above. Platform removal activities would primarily affect subsurface communities, and while they are not anticipated to affect adult *Sargassum*, they could affect sediment-dwelling germlings. However, decommissioning impacts will be highly localized over a relatively small area.

Impacts of Expected Accidental Events and Spills. Spills could occur at the surface or at the seafloor. Surface spills as well as seafloor spills that rise to the surface could contact *Sargassum*, potentially resulting in complete or partial mortality of the *Sargassum* mat and lethal or sublethal effects to associated biota. Surface slicks would pose a potential threat to *Sargassum* communities until dilution and natural chemical, physical, and biological processes reduced the toxicity of the oil. Upon release, hydrocarbons would be diluted and broken down by natural processes, which would limit the potential for contact with and toxicity to Sargassum communities. The warm waters of the GOM are particularly conducive to rapid chemical and microbial breakdown of hydrocarbons.

Impacts of an Unexpected Catastrophic Discharge Event. The effects from a CDE would depend on the location of the particular spill and on various environmental factors, including water depth, currents, and wave action. Seafloor releases could reach *Sargassum* in surface waters if the spill occurred in shallow water or if dispersants were used or the oil released was well mixed with gas. A CDE could affect a large portion of the *Sargassum* population if the spill occurred in an area of high *Sargassum* density or if toxic concentrations of oil were spread over a large area of surface water. Surprisingly little is known about the lifecycle of *Sargassum*. *Sargassum* is generally only present in the WPA and CPA in spring through early fall, and recent data suggest *Sargassum* originates in the northwest GOM and is exported from the GOM by ocean currents (Gower and King 1998). Therefore, the potential for impacts on *Sargassum* are highly dependent on when the spill occurs. *Sargassum* reproduces every year, so it is expected that the population will recover if affected by an oil spill.

***Impact Conclusions*.**

Routine Operations. Impacts on pelagic habitat in the GOM planning areas could occur during the exploration through decommissioning phases. Impacts from routine Program activities would range from short-term for the exploration, site development, and decommissioning phases to long-term for those impacts occurring throughout the production phase. Impacts would primarily occur from noise and turbidity generated by bottom-disturbing activities. Temporary reduction in habitat quality could also result from the discharge of produced water and drilling muds and cuttings. Overall, impacts to pelagic habitats from routine oil and gas activities would be negligible to minor.

Expected Accidental Events and Spills. Most accidental oil spills would be small and result in only negligible, localized impacts on pelagic habitat. Large spills would temporarily reduce habitat quality over large areas of pelagic habitat. Accidental oil releases from pipeline leakage would degrade bottom water quality at local scales. Most released oil and gas would float above the seafloor, so exposures would be expected for zooplankton, which lack the mobility to avoid the oil. The oil would be broken down by natural processes, and pelagic habitat would recover. Surface spills as well as seafloor spills that rise to the surface could contact *Sargassum*, potentially resulting in complete or partial mortality of the *Sargassum* mat and lethal or sublethal effects to associated biota. However, *Sargassum* is widely distributed in the GOM so any one spill would generally not affect the resource as a whole. Overall, the impacts of oil spills on pelagic habitat would range from negligible for spills less than 50 bbl to minor for spills less than 1,000 bbl and from minor to moderate for large spills (≥1,000 bbl).

An Unexpected Catastrophic Discharge Event. A CDE would degrade pelagic habitat quality over a wider area and potentially reduce the habitat value and ecosystem function in the areas affected. Pelagic organisms could be exposed to lethal or sublethal concentrations of hydrocarbons or mixtures of hydrocarbons and dispersants (if used). The extent and magnitude of the impact depend primarily on the location of the well, the volume of oil released, and the season in which the spill occurs. CDE-response activities such as burning, skimming, and chemical release (e.g., dispersants or coagulants) could also affect pelagic habitat and biota. Unique pelagic habitat and associated biota such as *Sargassum* mats in the GOM could also be affected by oil spills. Contact with spilled oil could completely or partially kill *Sargassum* and cause lethal or sublethal effects to associated biota. The potential for impacts on *Sargassum* are highly dependent on when the spill occurs. *Sargassum* reproduces every year, so it is expected that the population will recover if affected by an oil spill. Over time, hydrocarbons in the water column would be diluted and broken down by natural processes and pelagic habitat would recover. Overall, a CDE could result in minor to moderate impacts to pelagic habitat.

4.4.6.3.2 Alaska – Cook Inlet.

Impacts of Routine Operations.

***Exploration and Site Development*.** See the Section 4.4.3.2.1 for a general discussion of the impacts of exploration and site development on water quality. During the exploration and site development phase, pelagic habitat would be affected by platform and pipeline placement, drilling activity, seismic surveys, platform lighting, and aircraft and vessel traffic (Table 4.4.6-7). Noise impacts would be greatest near the source and would temporarily reduce habitat quality for certain species. Construction lighting would alter the pelagic light regime of a small area and would attract phototaxic organisms to the platform.

Bottom water quality would be temporarily affected by turbidity from sediment disturbance during drilling, platform placement, and pipeline placement. Turbidity from bottom-disturbing activities could kill phytoplankton, although it is not expected to result in population-level effects. Photosynthetic productivity of phytoplankton that specialize in near-bottom habitats may be reduced if the turbidity plume reduced solar irradiance at depth. The turbidity plume would be temporary, and the effects on pelagic habitat are expected to be short term.

It is assumed that drilling muds and cutting would be discharged into Cook Inlet for exploration wells only. Drilling wastes from development and production wells would be reinjected into the wells. The discharge of drilling muds and cuttings can occur near the water's surface or the seafloor, and both would create a turbidity plume that would diminish within some distance from the release point. The turbidity plume could smother or stress small zooplankton and reduce phytoplankton productivity by decreasing the depth and intensity of light penetration. In well-mixed ocean waters, water-based drilling muds and cuttings are diluted by 100-fold within 10 m (33 ft) of the discharge and by 1,000-fold at a distance of about 100 m (330 ft) from the platform (Neff 2005). These estimates are for well-mixed water, and therefore the size of the turbidity field will vary with hydrology. Because the waters of Cook Inlet generally are vertically well mixed with a relatively large tidal range, dilution of drilling discharges would be expected to occur rapidly. Drilling wastes that are discharged are regulated by the USEPA under NPDES permits and must meet the toxicity, water quality, and discharge rate standards set by the permits, thereby reducing impacts on water quality (Neff et al. 2000; Neff 2005). Although such releases could result in temporary, localized increases in sediment load and deposition, this amount of sediment is small compared to the more than 40 million tons of suspended sediment carried annually into Cook Inlet by runoff from area rivers (Brabets et al. 1999). .

Pelagic habitat would be affected minimally and temporarily by miscellaneous discharges (deck drainage, sanitary and domestic waste, bilge and ballast water) during site development. Such releases would be small in quantity and would be rapidly diluted. In addition, many vessel and platform wastes are disposed of on land, and those that are discharged at sea must meet USEPA and/or USCG regulatory requirements that limit their environmental effects.

Production. Impacts from offshore lighting, miscellaneous discharges, and bottom disturbance from the movement of support vessel anchors and chains will also exist in the production phase and are described above. In addition, production noise and produced water discharge could impact pelagic habitat quality (Table 4.4.6-7). Production noise is not expected to have significant impacts on habitat quality, because production platforms are known to have high biological abundance and diversity (Stanley and Wilson 2000). There would be minimal impacts on pelagic habitat from produced water because it is assumed that all produced water will be reinjected into the well.

TABLE 4.4.6-7 Impacting Factors by Phase and Potential Effects on Marine Pelagic Habitat in the Cook Inlet Planning Area

Impacting Factor	Disturbance[a]
Exploration and Site Development	
Vessel traffic	Noise
Seismic surveys	Noise
Miscellaneous discharges (deck washing, sanitary waste, bilge and ballast water)	Degraded water quality
Drilling and discharge of drilling muds/cuttings	Noise; degraded water quality
Pipeline trenching	Noise; turbidity
Drilling platform placement	Noise; turbidity
Offshore lighting	Alteration of light field
Production	
Production platform placement	Noise; turbidity
Production	Noise
Produced water discharge	Degraded water quality
Miscellaneous discharges (deck washing, sanitary waste)	Degraded water quality
Offshore lighting	Alteration of light field
Decommissioning	
Miscellaneous discharges (deck washing, sanitary waste, bilge and ballast water)	Degraded water quality
Platform removal	Noise, turbidity
Offshore lighting	Alteration of light field

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

Decommissioning. Impacts from vessel noise, platform lighting, and miscellaneous discharges are discussed above and would continue throughout the decommissioning phase. In addition, bottom disturbance during platform removal would temporarily disturb pelagic habitat by increasing noise and turbidity for some length of the water column. These impacts would temporarily degrade habitat quality, but conditions would return to normal as suspended sediments dispersed and resettled. The use of explosives to remove platforms is not expected. Overall, activities conducted during the decommissioning phase are expected to have minor effects on pelagic habitat.

Impacts of Expected Accidental Events and Spills. Impacts on pelagic habitat from accidental oil spills could result from surface releases from platforms or vessels or from seafloor releases from pipelines and the wellhead. Spills could vary in size. It is assumed that 1 large spill (≥1,000 bbl), 1 to 3 small spills between 50 and 999 bbl and 7 to 15 smaller spills between 1 and 50 bbl could occur under the proposed action (Table 4.4.2-1). Such releases would reduce the habitat value and ecosystem function of pelagic habitat. Most spills would be small and the overall impacts on pelagic habitat resources will be localized and short term, given the natural dilution and breakdown of hydrocarbons. Large spills would degrade pelagic habitat quality over a wider area and potentially reduce the habitat value and ecosystem function in the areas affected. Most released oil and gas would float above the seafloor, so exposures would be expected for zooplankton, which lack the mobility to avoid the oil. Oil exposure can reduce the abundance of zooplankton in the oiled area, induce narcosis, and bind to feeding appendages (Teal and Howarth 1984). Zooplankton are known to ingest oil, some of which is retained in the gut and some of which is exported to the seafloor in fecal pellets (Teal and Howarth 1984). Pelagic habitat would recover as the oil was broken down by natural processes.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes an unexpected CDE with an assumed volume of 75,000-125,000 bbl and a duration of 50–80 days (Table 4.4.2-2). Oil from a CDE (Table 4.4.2-2) would form a surface slick and kill, injure, or displace pelagic biota over a large area of Cook Inlet. The extent and magnitude of the impact depend primarily on the time of year, the location of the well, the volume released, and the speed at which the well was capped. Most oil released would be rapidly diluted and broken down in the water column by physical and biological processes. Studies of water quality after the *Exxon Valdez* spill indicated that the hydrocarbon concentrations were highest in the first two months after the spill, but were well below the State of Alaska's water quality standard (Neff and Stubbenfield 1995). PAH concentrations in the water column of Prince William Sound reached background concentrations by 5 to 6 months after the spill. Toxicity tests also indicated no lethal or sublethal toxicity to pelagic phytoplankton, invertebrates, or larval fish test organisms due to exposure to water from Prince William Sound (Neff and Stubbenfield 1995). Within 1 yr of the *Exxon Valdez* spill, PAH concentrations generally declined to background levels (Boehm et al. 2007). In heavily oiled areas, toxic fractions of oil trapped in intertidal sediments can be periodically resuspended into the water column, where they are available to filter-feeding biota (Boehm et al. 2007). However, data from the *Exxon Valdez* spill suggest resuspended oil represented a contamination threat for biota less than 1 to 2 yr, with the highest PAH concentrations in intertidal waters (Boehm et al. 2007).

CDE-response activities such as burning, skimming, and chemical release (e.g., dispersants or coagulants) could affect pelagic habitat and biota. Burning would kill pelagic biota in the burn area, and skimming would remove aquatic organisms from the water column or trap them in oiled water. The chemicals used during a spill response are toxic, but there is controversy about whether the combination of oil and dispersant is more toxic than oil alone (NRC 2005b; Fingas 2008; Holland-Bartels and Kolak 2011). The use of dispersant would likely increase the areal extent of oil dispersion and the exposure of pelagic biota to oil. The presence of, and noise generated by, oil spill-response equipment and support vessels could temporarily disturb pelagic habitat in the vicinity of the response action, potentially reducing habitat use or disturbing migration. As with the spill itself, the location and time of year the cleanup occurs would be important determinants of impacts to pelagic habitat and biota.

Broken ice occurs in the northern and western portions of lower Cook Inlet during fall and winter. If an open water spill were to occur at this time, the ice would contain the oil somewhat and reduce spreading. However, oil cleanup is also made more difficult in broken ice conditions. Oil from spills occurring in winter would likely freeze in ice where it could be transported hundreds of kilometers. If the spilled oil became frozen in the ice, cleanup would not be possible and the unweathered oil would be released into pelagic habitat as the ice melted.

However, oil frozen into shorefast ice could be recovered using terrestrial cleanup methods, assuming the ice was stable and thick enough to support the cleanup activities.

Impact Conclusions.

Routine Operations. Impacts on pelagic habitat in the Cook Inlet Planning Area could occur during the exploration through decommissioning phases, and would range from negligible to minor. Impacts from routine Program activities would range from short-term for the exploration, site development, and decommissioning phases to long-term for those impacts occurring throughout the production phase. Impacts would primarily occur from turbidity generated by bottom-disturbing activities. Temporary reduction in habitat quality could also result from the discharge of drilling muds and cuttings.

Expected Accidental Events and Spills. Most accidental oil spills would be small and result in only negligible, localized impacts on pelagic habitat. Large spills would temporarily reduce habitat quality over large areas of pelagic habitat. Accidental oil releases from pipeline leakage would degrade bottom water quality at local scales. Most released oil and gas would float above the seafloor, so exposures would be expected for zooplankton, which lack the mobility to avoid the oil. The oil would be broken down by natural processes, and pelagic habitat would recover. Overall, the impacts of oil spills on pelagic habitat would range from negligible for spill less than 50 bbl to minor for spills less than 1,000 bbl and from minor to moderate for large spills greater than 1,000 bbl.

An Unexpected Catastrophic Discharge Event. An unexpected CDE would degrade pelagic habitat quality over a wider area and potentially reduce the habitat value and ecosystem function in the areas affected. Pelagic organisms could be exposed to lethal or sublethal concentrations of hydrocarbons or mixtures of hydrocarbons and dispersants (if used). The extent and magnitude of the impact depend primarily on the location of the well, the volume of oil released, and the season in which the spill occurs. CDE-response activities such as burning, skimming, and chemical releases (e.g., dispersants or coagulants) could also affect pelagic habitat and biota. Oil spills occurring near or under ice could be difficult to clean and may persist in the water column for an extended period. Over time, hydrocarbons in the water column would be diluted and broken down by natural processes and pelagic habitat would recover. Overall, a CDE could result in minor to moderate impacts to pelagic habitat.

4.4.6.3.3 Alaska – Arctic.

Impacts of Routine Operations.

Exploration and Site Development. See Section 4.4.3.3.1 for a general discussion of the impacts of exploration and site development on water quality. During the exploration and site development phase, pelagic habitat would be affected by multiple activities (Table 4.4.6-8). Noise impacts would be greatest near the source and would temporarily reduce habitat quality for certain species. (See Section 4.4.7 for detailed discussions of the effects of noise on different

TABLE 4.4.6-8 Impacting Factors by Phase and Potential Effects on Marine Pelagic Habitat in the Beaufort and Chukchi Sea Planning Areas

Impacting Factor	Disturbance
Exploration and Site Development	
Vessel traffic	Noise; air emissions
Seismic surveys	Noise
Miscellaneous discharges (deck washing, sanitary waste, bilge and ballast water)	Degraded water quality
Drilling and discharge of drilling muds/cuttings	Noise; degraded water quality
Pipeline trenching	Noise; turbidity
Drilling and subsea well an platform placement	Noise; turbidity
Offshore lighting	Alteration of light field
Production	
Production platform placement	Noise; turbidity
Production	Noise
Produced water discharge	Degraded water quality
Miscellaneous discharges (deck washing, sanitary waste)	Degraded water quality
Offshore lighting	Alteration of light field
Decommissioning	
Miscellaneous discharges (deck washing, sanitary waste, bilge and ballast water)	Degraded water quality
Platform removal	Noise, turbidity
Offshore lighting	Alteration of light field

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

categories of biota.) Construction lighting would alter the pelagic light regime of a small area and would attract phototaxic organisms to the platform.

Bottom water quality would be temporarily affected by turbidity from sediment disturbance during drilling, placement of subsea wells, platforms and pipelines, and the construction of artificial islands. In addition to lethal or sublethal impacts to benthic organisms (Section 4.4.7.5), turbidity from bottom-disturbing activities could kill plankton, but it is not expected to result in population-level effects. Photosynthetic productivity of phytoplankton that specialize in near-bottom habitats may be reduced if the turbidity plume reduced solar irradiance at depth. However, the turbidity plume would be temporary, and the effects on pelagic habitat are expected to be short-term.

It is assumed that drilling muds and cuttings would be discharged into the Beaufort and Chukchi Sea Planning Areas for exploration wells only. Drilling wastes from development and production wells would be reinjected into the wells. The discharge of drilling muds and cuttings can occur near the water’s surface or the seafloor, and both would create a turbidity plume that would diminish within some distance from the release point. The turbidity plume could smother or stress small zooplankton and reduce phytoplankton productivity by decreasing the depth and intensity of light penetration. In well-mixed ocean waters, water-based drilling muds and cuttings are diluted by 100-fold within 10 m (33 ft) of the discharge and by 1,000-fold at a distance of about 100 m (330 ft) from the platform (Neff 2005). These estimates are for well-mixed water, and therefore the size of the turbidity field will vary with hydrology. The drilling wastes that are discharged are regulated by the USEPA under NPDES permits and must not exceed the toxicity, water quality, and discharge rate standards set by the permits. These requirements greatly reduce the potential for sediment alteration and contamination.

Pelagic habitat would be affected minimally and temporarily by miscellaneous discharges (deck drainage, sanitary and domestic waste, bilge and ballast water) during site development. Such releases would be small in quantity and rapidly diluted. In addition, many vessel and platform wastes are disposed of on land, and those that are discharged at sea must meet USEPA and/or USCG regulatory requirements that limit their environmental effects.

Production. See Section 4.4.3.3.1 for a general discussion of the impacts of exploration and site development on water quality. Impacts from offshore lighting, miscellaneous discharges, and bottom disturbance from support vessel anchors and chains will also exist in the production phase and are described above. In addition, production noise and produced water discharge could impact pelagic habitat quality (Table 4.4.6-8). Recent analyses indicate that the discharge of produced water into the Chukchi Sea could result in elevated PAH concentrations in shallow water areas or in the winter (MMS 2007b). However, impacts on pelagic habitat from produced water are not anticipated because it is assumed that all produced water will be reinjected into the well.

Decommissioning. Impacts from vessel noise, platform lighting, and miscellaneous discharges are discussed above and would continue throughout the decommissioning phase. In addition, bottom disturbance during platform removal would temporarily disturb pelagic habitat by increasing noise and turbidity for some length of the water column. In addition, gravel islands would be left in place where they would wash away and introduce fine sediments into the water column over time. These impacts would temporarily degrade habitat quality, but conditions would return to normal as suspended sediments dispersed and resettled.

Impacts of Expected Accidental Events and Spills. It is assumed that up to 3 large oil spills (≥1,000 bbl) up to 35 small spills (50 to 999 bbl) and up to 190 smaller spills (>1 and <50 bbl) could occur during the lease period under the proposed action (Table 4.4.2-1). See Section 4.4.3.3.2 for a detailed discussion of the effects of oil spills on water quality in the Beaufort and Chukchi Sea Planning Areas. Accidental oil spills could result from surface releases from platforms or vessels or from seafloor releases from pipelines and the wellhead. Small releases would degrade bottom water quality, but the overall contaminant impacts on pelagic habitat resources will be short-term, given the localized nature of a small release and the natural dilution and breakdown of hydrocarbons. Large spills would degrade pelagic habitat quality over a wider area and potentially reduce the habitat value and ecosystem function in the areas affected. Most released oil and gas would float above the seafloor, so exposures would be expected for zooplankton, which lack the mobility to avoid the oil. Oil exposure can reduce the abundance of zooplankton in the oiled area, induce narcosis, and bind to feeding appendages

(Teal and Howarth 1984). Zooplankton are known to ingest oil, some of which is retained in the gut and some of which is exported to the seafloor in fecal pellets (Teal and Howarth 1984). The oil would be transported from the area as well as broken down by natural processes. Oil is not expected to persist in marine pelagic habitat for an extended period (Section 4.4.3.3).

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes an unexpected CDE in the Chukchi Sea Planning Area with an assumed volume of 1.4-2.2 million bbl and a duration of 40–75 days, and a CDE in the Beaufort Sea Planning Area with an assumed volume of 1.7-3.9 million bbl with a duration of 60–300 days. A CDE may affect pelagic habitats (Table 4.4.2-2). The extent and magnitude of the impact depend primarily on the time of year, the location of the well, the volume released, and the speed at which the well was capped. Typically oil rises from the seafloor to the surface, forming a surface slick capable of traveling greater than 50 km (31 mi) (MMS 2007b). Pelagic organisms could be exposed to lethal or sublethal concentrations of hydrocarbons or mixtures of hydrocarbons and dispersants (if used). Pelagic habitats would recover their habitat value as hydrocarbons broke down and were diluted. Recovery time would vary with local conditions and the degree of oiling. Studies following the *Exxon Valdez* spill indicated that PAH concentrations generally declined to background levels in less than 1 year, and during that period, water column hydrocarbon concentrations were not found to be toxic to marine life (Neff and Stubbenfield 1995; Boehm et al. 2007).

Spills in open water could be contained and much of the oil removed by standard oil spill-response methods. Oil spill-response activities such as burning, skimming, and chemical releases (e.g., dispersants or coagulants) could affect pelagic habitat and biota. Burning would kill pelagic biota in the burn area, and skimming would remove aquatic organisms from the water column or trap them in oiled water. The chemicals used during a spill response are toxic, but there is controversy about whether the combination of oil and dispersant is more toxic than oil alone (NRC 2005b; Fingas 2008; Holland-Bartels and Kolak 2011). The use of dispersant would likely increase the areal extent of oil dispersion and the exposure of pelagic biota to oil. The presence of, and noise generated by, oil spill-response equipment and support vessels could temporarily disturb pelagic habitat in the vicinity of the response action, potentially reducing habitat use or disturbing migration. As with the spill itself, the location and time of the year the cleanup occurs would be an important determinant of impacts on pelagic habitat and biota.

If the spill were to occur under ice or during winter, cleanup would be much more difficult because sea ice would limit access to the spill (reviewed in Holland-Bartels and Kolak 2011). For spills affecting areas of broken ice, the ice would contain the oil somewhat and reduce spreading. However, cleanup is also more difficult in broken ice conditions. Oil cleanup response plans and technologies for ice-covered areas are still evolving, and the efficacy of many proposed spill countermeasures is as yet unknown (Holland-Bartels and Kolak 2011). The oil could freeze into the ice where it could be transported hundreds of kilometers. Oil under ice or frozen in ice would undergo little weathering (Holland-Bartels and Kolak 2011) and could therefore degrade pelagic habitat for an extended period of time, with the extent of the impacts increasing with the size of the oiled area. Sea ice habitat could be degraded or lost if contact with oil spills results in lethal or sublethal effects on biota growing beneath the ice (e.g., fish, invertebrates, and algae).

Impact Conclusions.

***Routine Operations*.** Impacts on pelagic habitat in the Beaufort and Chukchi Sea Planning Areas could occur during the exploration through decommissioning phases. Impacts from routine Program activities would range from short-term for the exploration, site development, and decommissioning phases to long-term for those impacts occurring throughout the production phase. Impacts would primarily occur from turbidity generated by bottom-disturbing activities. Temporary reduction in habitat quality could also result from the discharge of produced water and drilling muds and cuttings. Overall, impacts to pelagic habitats from routine oil and gas activities would be negligible to minor.

Expected Accidental Events and Spills. Most accidental oil spills would be small and result in only negligible, localized impacts on pelagic habitat. Large spills would temporarily reduce habitat quality over large areas of pelagic habitat. Accidental oil releases from pipeline leakage would degrade bottom water quality at local scales. Most released oil and gas would float above the seafloor, so exposures would be expected for zooplankton, which lack the mobility to avoid the oil. The oil would be broken down by natural processes, and pelagic habitat would recover. Overall, the impacts of oil spills on pelagic habitat would range from negligible for spill less than 50 bbl to minor for spills less than 1,000 bbl and from minor to moderate for large spills (≥1,000 bbl).

***An Unexpected Catastrophic Discharge Event*.** A CDE could potentially reduce habitat quality over potentially large areas. Pelagic organisms could be exposed to lethal or sublethal concentrations of hydrocarbons or mixtures of hydrocarbons and dispersants (if used). The effects from oil spills would depend on the size, timing, duration, and location of the spill and on various environmental factors. Pelagic habitat in nearshore areas would likely have the greatest potential for long-term contamination. Unique pelagic habitat and associated biota such as sea ice could also be affected by oil spills. In the Arctic planning areas, oil could become trapped under sea ice for an extended period, where it would remain relatively unweathered and capable of being transported large distances. Oil under ice or frozen in ice could therefore degrade pelagic habitat for an extended period of time with the extent of the impacts increasing with the size of the oiled area; the largest area affected would occur with a CDE. Sea ice habitat could be degraded or lost if contact with oil spills results in lethal or sublethal effects on biota growing beneath the ice. CDE response activities such as burning, skimming, and chemical releases (e.g., dispersants or coagulants) could also affect pelagic habitat and biota. Over time, hydrocarbons in the water column would be diluted and broken down by natural processes and pelagic habitat would recover. Overall, a CDE could result in minor to moderate impacts to pelagic habitat and sea ice habitat.

4.4.6.4 Essential Fish Habitat

4.4.6.4.1 Gulf of Mexico. As described in Section 3.7.4.1, most of the coastal and marine waters of the GOM are considered EFH for life stages of one or more managed species, and any oil and gas development activity that degrades coastal or marine benthic and pelagic environments would affect EFH. Also, several offshore banks are considered HAPC (Section 3.7.4.1). EFH consists of benthic and water column habitats in marine coastal areas. The potential effects of exploration, site development, and production activities on these habitats are discussed in individual sections including coastal and estuarine habitats (Sections 4.6.1.1), marine benthic habitats (Section 4.4.6.2.1), and the marine water column (Section 4.4.6.3.1). Impacts on fish and fisheries from the Program are discussed in Sections 4.4.7.3.1 and 4.4.1.1.1.

Impacts of Routine Operations.

Exploration and Site Development. During the exploration and site development phase, impacts on EFH could occur as a result of drilling and drilling waste discharge, seismic surveys, and the placement of drilling units, production platforms, and pipelines. Noise from drilling, construction, and seismic surveys would temporarily disturb EFH and potentially kill, injure, or displace managed species. See Section 4.4.7.3.1 for a discussion of the impacts of noise on fish. It is anticipated that behavioral and distributional responses to such acoustic stimuli would be small and that these temporary effects would not persist for more than several hours after acoustic surveys are ended. All the noise associated with these activities would be temporary and affect a small area.

The vast majority of marine EFH affected by the Program would be soft sediments. The estimated bottom habitat that may be directly disturbed by new pipeline and platform installation ranges from 2,150 to 14,000 ha (5,313 to 34,594 ac) over the entire GOM. Pipelines placed on the sediment surface would eliminate natural soft sediment EFH. Sediment-disturbing activities would result in increased turbidity, which would lower the water quality of EFH in small areas for a limited time. Given their mobility, adult managed species are not likely to be injured or killed by bottom disturbance. However, bottom-disturbing activities could injure, displace, or kill early life stages of managed species or bury the benthic prey of managed species. Although mobile, adult managed species are not likely to be directly affected by bottom disturbance, bottom-disturbing activities could injure, displace, or kill early life stages of managed species or bury the benthic prey of managed species. Bottom disturbance would affect a small area relative to the size of the GOM, and no population-level effects on managed species are expected. Also, FPSO systems could potentially be used in deep water, and would reduce the need for pipelines.

The potential for bottom-disturbing activities to affect sensitive marine EFH such as hard-bottoms, deepwater corals, and chemosynthetic communities would be reduced by stipulations requiring buffers between these features and bottom-disturbing activities (NTL No. 2009-G39; Section 4.4.6.2.1). Up to two FPSO systems may be employed for deepwater wells. Under the FPSO system, oil would be transported from the well to a surface vessel and ultimately to shore. By eliminating the need for pipelines, an FPSO system would greatly reduce bottom disturbance and the chance for disturbing deepwater corals and chemosynthetic communities. Topographic features classified as HAPC are also protected by the Topographic Features Stipulation, which prohibits direct bottom disturbance or the deposition of drilling muds and cuttings in areas containing such habitat. Therefore, HAPC should be minimally affected by exploration and site development activities.

Coastal EFH could be affected by the estimated 0 to 12 new pipeline landfalls that are anticipated under the proposed action. Routing the pipelines through the most sensitive coastal EFH (i.e., mangroves and seagrass) is not likely to be permitted.

A total of up to 4,700 exploration and production wells will be drilled in the WPA and CPA under the proposed action. The subsequent discharges of drilling cuttings and muds would alter the grain size distribution and chemical characteristics of sediments immediately surrounding the drill sites and for some distance around the wells (typically less than 1 km [3,281 ft]), depending on the depth at which the material is discharged (Kennicutt et al. 1995; Continental Shelf Associates, Inc. 2004a, 2006). The deposited material could alter benthic habitat for EFH prey species and potentially affect spawning sites, which are often chosen on the basis of sediment grain size. Elevated sediment metal and PAH concentrations near the well (<500 m [1,640 ft]) would also likely result from drilling discharge, but with the exception of some metals, elevated tissue concentrations of contaminants have not been found in demersal fish or their benthic invertebrate food sources sampled around platforms in the GOM (Kennicutt et al. 1995; Continental Shelf Associates, Inc. 2004a, 2006).

It is expected that the overall impacts of exploration and site development activities on marine EFH would not result in population-level impacts on managed species. Recovery rates of EFH habitat and benthic food resources could range from short term to long term depending on the spatial and temporal scope of the disturbance.

Production. The primary production activities that could affect EFH include chronic bottom disturbance from the movement of platform mooring structures and the discharge of produced water. Bottom disturbance represents chronic, long-term, but localized impacts on marine EFH. NPDES permits would limit the potential for produced water discharges to contaminate sediment and water column EFH. Fish and invertebrates collected near platforms in the GOM do not appear to bioaccumulate the common contaminants in produced water such as radionuclides, metals, and hydrocarbons and do not exceed the USEPA-specified tissue concentrations considered to be harmful (Continental Shelf Associates, Inc. 1997).

After new platforms have been established, sessile fouling organisms would colonize the underwater portions of the structures, which would attract managed reef species such as snapper, grouper, and some coastal migratory pelagics. Over time, this could change the spawning, breeding, and feeding patterns of some managed fish. The effects of artificial reefs on fish populations are controversial (Section 4.4.7.3.1), as the reefs may benefit some species and adversely affect others. The benefit or detriment of artificial reefs as habitat depends on how fisheries on the reef are managed and on the individual life histories and habitat requirements of the species present (Bohnsack 1989; Macreadie et al. 2011). Unless platforms are permitted to remain, the reef function of the platforms would last only through the production phase.

Decommissioning. During decommissioning and structure removal, both explosive and nonexplosive methods may be used to sever conductors and pilings. With the exception of some water quality concerns, nonexplosive removals (e.g., abrasive, mechanical, or diver cutters) have little impact on the fish resources. With explosive removal, impacts on managed species range from disturbance and habitat loss to injury and death. From 150 to 275 explosive platform removals are expected, and most would occur in relatively shallow water. Floating platforms would not require explosive removals, although the seafloor would be temporarily disturbed by the removal of platform mooring structures. Removing structures would also remove the associated fouling communities that serve as prey for managed fish species, thereby forcing these species to relocate to other foraging areas. Pipelines would typically be left in place. Pipelines on the sediment surface could periodically move, resulting in chronic bottom disturbance to soft sediment EFH. Pipelines not buried, in both shallow and deepwater, would provide hard substrate and habitat. Overall, decommissioning activities are not expected to result in population-level impacts on managed species.

Impacts of Expected Accidental Events and Spills. It is assumed that up to 8 large spills (≥1,000 bbl), up to 70 spills between 50 and 999 bbl, and up to 400 smaller spills between 1 and <50 bbl could occur during the lease period under the proposed action (Table 4.4.2-1). See individual sections for detailed discussions of the potential impacts of oil spills on fish, shellfish, and marine and coastal habitat. Impacts to EFH would typically increase with the size of the spill. Small accidental hydrocarbon releases occurring in surface or near-bottom offshore habitats would temporarily degrade EFH in the vicinity of the release, but are not likely to reach sensitive marine EFH such as hard-bottom EFH (Section 4.4.6.2.1). Most nearshore spills would be small, so they are not likely to degrade a large fraction of EFH because the hydrocarbons would be rapidly metabolized and diluted. Large spills (≥1,000 bbl) have the potential to degrade EFH over a wider area that potentially reduce the habitat value and ecosystem function in the areas affected. Lethal and sublethal impacts to managed species at the individual level would result from large spills, particularly eggs and larvae which do not have the capability of avoiding oil. Impacts would be greatest if oil from the spill were to contact sensitive coastal marine habitat such as seagrass beds and wetlands resulting in long-term but temporary degradation of these EFH habitats. However, in most cases, the area affected would likely be small compared to the overall resources and the oil would be transported from the area as well as broken down by natural processes.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes an unexpected CDE with an assumed volume of 0.9-7.2 million bbl and a duration of 30–90 days (Table 4.4.2-2). See individual sections for detailed discussions of the potential impacts of a CDE on fish, shellfish, and marine and coastal habitat. Much of the hydrocarbon would likely be consumed relatively quickly by bacteria, both at the surface and at depth (Camilli et al. 2010; Kessler et al. 2011). The potential for oil from a CDE to reach marine HAPC at lethal concentrations would be reduced by the Topographic Features Stipulation prohibiting oil and gas development near these features. However, topographic features as well as unique deepwater communities could be partly or completely destroyed if contacted by a large quantity of oil. Oil from surface and subsurface spills contacting intertidal and estuarine habitats with emergent and submerged vegetation, sand and mud flats, and shell and oyster reefs would have the greatest impacts on EFH. These areas provide food and rearing substrate for a variety of federally managed juvenile fish and shellfish. In most cases, the coastal habitat would recover as the hydrocarbons were metabolized or buried, but marsh grasses currently stressed by subsidence may not recover.

A catastrophic spill could affect all life stages of federally managed species and their food sources. Managed species could be affected by the spill directly due to lethal or sublethal toxicity or indirectly by long-term reduction in food resources and juvenile and reproductive habitat. Adult life stages will likely avoid heavily oiled areas, although sublethal exposures are possible (Roth and Baltz 2009). Early life stages of managed species may be most vulnerable to hydrocarbon spills, which could trap and kill planktonic eggs and larvae in the affected area. Mortality to pelagic eggs and larvae contacting the oil could be particularly high in the case of a catastrophic spill at the surface that spreads over a wide area. In addition to the size of the spill, the location of the spill and the season in which the spill occurred would be important determinants of the impact magnitude. For example, catastrophic spills occurring during recruitment periods or spills that oil critical spawning areas could result in temporary population-level impacts on managed fish and invertebrates. Also, managed species currently in serious population decline, such as bluefin tuna, may experience population-level impacts if the spill were to kill a significant number of eggs and larvae in a given year. For example, the HAPC for bluefin tuna extends from the 100 m (328 ft) isobath and could also be affected by oil spills, and population-level impacts to Bluefin tuna could result from catastrophic spills (Teo et al. 2007; Atlantic Bluefin Tuna Status Review Team 2011).

Wave and wind action, weathering, and biological degradation would dissipate oil in the surface water, and suitable habitat condition would return. The period of time needed to reestablish appropriate habitat conditions following a spill would depend upon the characteristics of the individual spill and would be related to many factors, including the EFH resource affected, the location of the spill, the nature of transporting currents, the magnitude of the spill, and the chemical characteristics of the spilled oil. With the exception of sensitive habitats such as corals and chemosynthetic communities, EFH affected by oil spills is expected to fully recover within a few years. Sensitive habitats with slow-growing biota may take longer to recover or may not recover at all.

Impact Conclusions.

Routine Operations. Most impacts on EFH from oil and gas exploration and production activities would likely result from bottom disturbance and the creation of artificial reefs by production platforms, and would range from negligible to moderate. The magnitude of impacts on sensitive marine and coastal EFH would be limited by specific lease stipulations developed from site-specific analyses conducted for particular lease sales. Recovery of EFH habitat and benthic food resources from oil and gas activities would range from short-term to long-term. Managed species, particularly egg and larval stages, could be killed, injured, or displaced from the immediate vicinity of oil and gas activities, but no population-level impacts on managed species are expected. No more than moderate impacts on EFH are expected to result from routine Program activities.

Expected Accidental Events and Spills. The severity of effects of accidental hydrocarbon spills on EFH would depend on the size of the spill, its location, environmental factors, and the uniqueness of the affected EFH. While most accidents would be small and would have negligible to minor impacts on EFH, large spills that reach coastal EFH could have more persistent impacts and could require remediation. Adult managed species would probably not be greatly affected by a hydrocarbon spill in open-water areas, but small obligate benthic species, eggs, larvae, and some managed species and their prey could experience lethal and sublethal effects from contact with hydrocarbons. Overall, impacts to EFH from small spills would range from negligible for spill less than 50 bbl to minor for spills less than 1,000 bbl and from minor to moderate for large spills (≥1,000 bbl).

An Unexpected Catastrophic Discharge Event. A CDE could cause long-term declines of managed species that rely on shallow coastal, intertidal, and freshwater areas. Managed species that are currently in decline that suffer large losses of early life stages could suffer population-level effects from a CDE. Overall, a CDE could result in moderate to major impacts on EFH, largely depending on the size of the spill, its location, environmental factors, and the uniqueness of the affected EFH. Major impacts to coral EFH habitat could occur if the Flower Gardens Banks are heavily oiled and high mortality occurs.

4.4.6.4.2 Alaska – Cook Inlet. The Cook Inlet Planning Area contains EFH for a variety of fish and invertebrate species that can be broadly categorized into three groups based upon the relevant Fishery Management Plans (FMPs): Gulf of Alaska groundfish, Alaska salmon, and Alaska weathervane scallop. As identified in the FMPs, the EFH includes bottom and water-column habitat in streams, lakes, ponds, wetlands, and marine and coastal waters. Consequently, activities that degrade these aquatic habitats could adversely affect EFH for one or more species. For the purposes of this analysis, potential impacts on EFH resources in the Cook Inlet Planning Area and adjacent waters are generally addressed. EFH in Cook Inlet potentially affected by exploration, site development, and production activities are discussed in detail in individual sections including coastal and estuarine (Sections 4.4.6.1.2) and marine benthic habitats (Section 4.4.6.2.2) and the marine water column (Section 4.4.6.3.2). Impacts on Cook Inlet fish and fisheries from the Program are discussed in (Sections 4.4.7.3.2 and 4.4.11.2). Because of the connection with adjacent marine areas, this evaluation also considers the potential for effects on fish populations in the overall Gulf of Alaska.

As required by the Magnuson-Stevens Fishery Conservation and Management Act, the National Marine Fisheries Service, Alaska Region, has provided conservation recommendations that will avoid or minimize adverse impacts to EFH from oil and gas development activities. These recommendations are described in "Impacts to Essential Fish Habitat from Non-fishing Activities in Alaska" (NMFS 2011d) and include the following:

1. Avoid the discharge of produced waters into marine waters and estuaries. Reinject produced waters into the oil formation whenever possible.

2. Avoid discharge of muds and cuttings into the marine and estuarine environment. Use methods to grind and reinject such wastes down an approved injection well or use onshore disposal wherever possible. When not possible, provide for a monitoring plan to ensure that the discharge meets USEPA effluent limitations and related requirements.

3. To the extent practicable, avoid the placement of fill to support construction of causeways or structures in the nearshore marine environment.

4. As required by Federal and State regulatory agencies, encourage the use of geographic response strategies that identify EFH and environmentally sensitive areas. Identify appropriate cleanup methods and response equipment.

5. Evaluate potential impacts that may result to EFH that may result from activities carried out during the decommissioning phase of oil and gas facilities. Minimize such impacts to the extent practicable.

6. Vessel operations and shipping activities should be familiar with Alaska Geographic Response Strategies (GRS), which detail environmentally sensitive areas of Alaska's coastline.

Impacts of Routine Operations.

Exploration and Site Development. During the exploration and site development phase, the primary impacts on EFH could occur as a result of drilling and drilling waste discharge, seismic surveys, and the placement of drilling units, production platforms, and pipelines. Each seismic survey would be completed within weeks. Individual fishes, especially egg and larval life stages in close proximity (1 to 5 m [3 to 16 ft]) to airgun arrays (Dalen and Knutsen 1986; Holliday et al. 1987; Turnpenny and Nedwell 1994), could suffer mortality or injury, and adult fishes located farther from the noise could exhibit short-term avoidance and behavioral alteration. The migration of managed salmon could also be temporarily disrupted. Additional sources of noise from drilling, construction of platforms and pipelines, and boat traffic could also temporarily disturb or displace individual fish. All the noise associated with these activities would be temporary.

The vast majority of marine EFH affected by the Program would be soft sediments. It is anticipated that 1.5 to 4.5 ha (4 to 11 ac) of seafloor habitat in the Cook Inlet Planning Area could be affected by platform construction under the proposed action. It is also estimated that 80 to 241 km (50 to 150 mi) of new pipelines would be installed offshore. Pipelines could be trenched or installed and anchored on the sediment surface. Placing the pipeline on the sediment surface could result in loss of soft sediment EFH. Ground-disturbing activities would result in increased turbidity, which would lower the water quality of EFH in small areas for a limited amount of time. Although adult managed fish are not likely to be killed or injured during bottom disturbance, bottom-disturbing activities could injure, displace, or kill early life stages of managed species or bury the benthic prey of managed species. Scallops have less mobility than fish and may be killed, injured, or displaced by bottom disturbance. The migration of managed salmon could also be temporarily disrupted by bottom disturbance.

Pipeline construction in nearshore subtidal habitats could damage marine plant EFH by mechanically removing the plants or smothering them through sedimentation. Areas containing high densities of aquatic vegetation are typically avoided during construction activities due to a lease stipulation calling for protection of important or unique biological populations or habitats. Pipeline crossings of streams could affect EFH for several life stages of anadromous salmon, including eggs, larvae, juveniles, and adults. The Alaska Department of Fish and Game (ADFG) reviews plans for construction activities for potential impacts on salmon and other fish species and requires permits to be issued before stream pipeline crossings can be installed. Therefore, it is anticipated that impacts on anadromous salmon from freshwater pipeline crossings would be minimized through appropriate permitting and management actions once site-specific assessments are conducted.

It is anticipated that 4 to 12 exploration and delineation wells and 42 to 114 production wells will be drilled in Cook Inlet under the proposed action. It is assumed that drilling muds and cuttings from the exploration and delineation wells would be discharged into Cook Inlet and could temporarily affect benthic and water-column EFH resources. While the toxicity of those cuttings is expected to be low and within permitted levels, the drilling wastes that are discharged would temporarily increase turbidity and sediment deposition, and small numbers of managed species could be temporarily displaced. In the mixing area near the discharge site, eggs and larvae of managed groundfish and scallops could be killed or injured. Settlement of discharged cuttings on the seafloor could smother some prey species and change substrate composition in the area where the cuttings settle. However, the discharge of all drilling muds and cuttings would be subject to NPDES permitting requirements that would greatly reduce the impacts on EFH and managed species.

Production. The primary production activities that could affect EFH include bottom disturbance from anchors and the discharge of produced water. Bottom disturbance represents a chronic, long-term but localized impact on EFH. It is assumed that all produced water would be disposed of by injection into permitted disposal wells. Therefore, the effects of produced water discharges on sediment and water-column EFH are expected to be minimal.

After new platforms have been established, sessile fouling organisms would colonize the underwater portions of the structures, and they would attract prey for unmanaged species as well as managed species such as rockfish. Over time, this could change the spawning, breeding, and feeding patterns of some managed fish.

Decommissioning. During decommissioning and structure removal, only nonexplosive methods would be used to sever conductors and pilings. Nonexplosive removals (e.g., abrasive, mechanical, or diver cutters) are expected to have little impact on EFH resources and managed species (Section 4.4.7.3.2). Many platforms would be floating, and the seafloor would be temporarily disturbed by the removal of platform mooring structures. Removing structures would also remove the associated biological communities that serve as prey for managed fish species, thereby forcing these species to relocate to other foraging areas.

Impacts of Expected Accidental Events and Spills. It is assumed that 1 large spill (≥1,000 bbl), 1 to 3 small spills between 50 and 999 bbl and 7 to 15 smaller spills between 1 and 50 bbl could occur under the proposed action (Table 4.4.2-1). See individual sections for detailed discussions of the potential impacts of oil spills on fish, shellfish, and marine and coastal habitat. Most accidental hydrocarbon releases in the Cook Inlet Planning Area would be small and would result in short-term localized impacts on EFH and managed species, given the natural dilution and breakdown of hydrocarbons. Larger releases could have a greater adverse impact on various life stages of managed species and could potentially reduce the habitat value and ecosystem function of the EFH areas affected. Impacts from spills would be greatest if a large spill occurred during a reproductive period or contacted a location important for spawning or growth such as intertidal and nearshore subtidal habitats. In particular, egg and larval life stages of managed species as well as planktonic organisms that serve as their prey may be unable to avoid hydrocarbon spills. Impact to EFH from a large spill would depend upon the timing, location, and size of the oil spill. Oil reaching the intertidal zone can persist in the sediments and cause sublethal impacts on fish eggs and larvae for multiple years. Following the spill, the oil would be transported from the area as well as broken down by natural processes. Wave and wind action, weathering, and biological degradation by microbes would dissipate oil in the surface water, and EFH would be reestablished after some period of time.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes an unexpected CDE with an assumed volume of 75,000-125,000 bbl and a duration of 50–80 days (Table 4.4.2-2). See individual sections for detailed discussions of the potential impacts of a CDE on fish, shellfish, and marine and coastal habitat. The potential for severe impacts from accidents would be greatest from oil washed inshore into wetlands, intertidal zones, and shorelines where spilled oil could contaminate nearshore habitat and associated prey species. Deeper subtidal sediment EFH may be less affected because hydrocarbons would tend to float over the sediments. Spilled oil could also kill kelp and other marine plants that provide food and nursery habitat for managed salmon and groundfish. Spilled oil concentrated along the coastline at the mouths of streams or rivers may disrupt migration patterns for some species, such as eulachon or salmon, by causing fish to avoid contaminated areas. In some cases, toxic fractions (e.g., PAHs) of spilled oil could also reach freshwater areas where salmon eggs are deposited in stream bottoms. PAHs in the parts-per-billion range can cause sublethal impacts on developing fishes (MMS 2007b). Depending on the timing and severity of an oil spill, adult anadromous fish migrating from marine waters to freshwater to spawn and juveniles migrating seaward from freshwater could be harmed by high concentrations of hydrocarbons. Large, mobile adult managed species in Cook Inlet would likely avoid hydrocarbon spills by temporarily moving to other areas. However, small obligate benthic species as well as pelagic eggs and larvae of some managed species and organisms that serve as their prey may be unable to avoid the oil.

The period of time needed to reestablish appropriate EFH conditions following a CDE would depend upon the characteristics of the individual spill and many other factors, including the location of the spill, the nature of transporting currents, the magnitude of the spill, and the chemical characteristics of the spilled oil. For example, while most of the waters within the Cook Inlet Planning Area remain open throughout the winter, currents could transport oil under ice to surrounding areas. Oil spilled under ice is more difficult to locate and clean than that in surface spills. As evidenced by effects of the *Exxon Valdez* oil spill, recovery of some EFH resources could occur within less than a year, while shoreline resources could continue to be affected at some level for 10 years or more (*Exxon Valdez* Oil Spill Trustee Council 2009a). Wave and wind action, weathering, and biological degradation would dissipate spilled oil in the surface water, and water-column EFH resources would likely recover most quickly. Sediments could recover much more slowly. Following the *Exxon Valdez* oil spill, contamination persisted in some freshwater benthic habitats for at least 4 years and oil contaminating intertidal sediments continued to reduce survival of eggs for anadromous salmon for a number of years after the spill (reviewed in Peterson et al. 2003). Similarly, intertidal sediments and benthic communities are still listed as recovering (*Exxon Valdez* Oil Spill Trustee Council 2010a). Like EFH, managed species would recover from catastrophic spills, although the recovery could take many years. The *Exxon Valdez* Oil Spill Trustee Council evaluated the status of several managed species following the *Exxon Valdez* spill, including sockeye salmon, pink salmon, and rockfish. The salmon were listed as recovered within a decade after the spill and rockfish as very likely recovered (*Exxon Valdez* Oil Spill Trustee Council 2010a).

Impact Conclusions.

Routine Operations. Most impacts on EFH from oil and gas exploration and production activities would likely result from bottom disturbance associated with platform and pipeline placement, and result in negligible to moderate impacts to EFH. The magnitude of impacts on sensitive marine and coastal EFH would be limited by specific lease stipulations developed from site-specific analyses conducted for particular lease sales. Recovery of EFH habitat and benthic food resources from oil and gas activities would range from short-term to long-term. Managed species, particularly egg and larval stages, could be killed, injured, or displaced from the immediate vicinity of oil and gas activities, but no population-level impacts on managed species are expected.

***Expected Accidental Events and Spills*.** The severity of effects of accidental hydrocarbon spills on EFH would depend on the size of the spill, its location, environmental factors, and the uniqueness of the affected EFH. While most accidents would be small and would have relatively small impacts on EFH, large spills that reach coastal EFH could have more persistent impacts and could require remediation. Adult managed species would probably not be greatly affected by a hydrocarbon spill in open water areas, but small obligate benthic species, eggs, larvae, and some managed species and their prey could experience lethal and sublethal effects from contact with hydrocarbons. Overall, impacts to EFH from small spills would range from negligible for spill less than 50 bbl to minor for spills less than 1,000 bbl and from minor to moderate for large spills greater than 1,000 bbl.

An Unexpected Catastrophic Discharge Event. A CDE could cause long-term declines of managed species that rely on shallow coastal, intertidal, and freshwater areas. Managed species that suffer large losses of early life stages or long-term sublethal impacts could suffer population-level effects from catastrophic oil spills. Overall, a CDE could result in moderate to major impacts on EFH, largely depending on the size of the spill, its location, environmental factors, and the uniqueness of the affected EFH.

4.4.6.4.3 Alaska – Arctic. There are two FMPs designating EFH in the Beaufort/Chukchi Planning Areas: one for Alaska salmon and one for Arctic fishes (NPFMC and NMFS 1990; NPFMC 2009). Activities that degrade these aquatic habitats could adversely affect EFH for one or more species. For the purposes of this analysis, potential impacts on EFH resources in the Beaufort/Chukchi Planning Area and adjacent waters are generally addressed. EFH in the Beaufort and Chukchi Seas potentially affected by exploration, site development, and production activities are discussed in detail in individual sections including coastal and estuarine (Sections 4.4.6.13) and marine benthic habitats (Section 4.4.6.2.3) and the marine water column (Section 4.4.6.3.3). Impacts on Beaufort/Chukchi Planning Area fish and fisheries from the Program are discussed in Section 4.4.7.3.3 and Section 4.4.11.3.

As required by the Magnuson-Stevens Fishery Conservation and Management Act, the National Marine Fisheries Service, Alaska Region, has provided conservation recommendations that will avoid or minimize adverse impacts to EFH from oil and gas development activities. These recommendations are described in *Impacts to Essential Fish Habitat from Non-fishing Activities in Alaska* (NMFS 2011d) and can be found in Section 4.4.6.4.2.

Impacts of Routine Operations.

Exploration and Site Development. During the exploration and site development phase, impacts on EFH could occur as a result of drilling and drilling waste discharge, seismic surveys, the placement of subsea drilling units, production platforms, pipelines, and construction of artificial islands. Individual fishes, especially egg and larval life stages, in close proximity (1 to 5 m [3 to 16 ft]) to airgun arrays could suffer mortality or injury, and juvenile and adult fishes located farther away could exhibit temporary behavioral alteration including spawning/migratory behavior (Dalen and Knutsen 1986; Holliday et al. 1987; Turnpenny and Nedwell 1994). Additional sources of noise from activities such as drilling, platform and pipeline placement, and boat traffic could also temporarily disturb or displace individual fish. All the noise associated with these activities would be temporary and affect a small area of EFH in the Beaufort/Chukchi Planning Area.

The vast majority of marine EFH affected by the Program would be soft sediments on the continental shelf in less than 91 m (300 ft) of water. Under the proposed action, up to 13.5 ha (33 ac) of seafloor habitat could be covered by up to 9 artificial islands, and as much as 567 ha (1,401 ac) of seafloor habitat could be disturbed by pipeline placement. Pipelines located in water less than 50 m (165 ft) would be trenched to avoid damage from ice scour. In addition, up to 92 subsea production wells could be constructed. The construction of artificial islands and the placement of pipelines on the sediment surface would alter existing seafloor EFH and the associated communities. Sediment-disturbing activities would increase turbidity, which would lower the water quality of EFH in small areas for a limited amount of time, typically causing fish to leave the areas until water quality improves. The migration of managed salmon could also be temporarily disrupted by bottom disturbance, although salmon are relatively uncommon in the Beaufort and Chukchi Seas. Although adult managed species are less likely to be killed or injured during bottom disturbance, bottom-disturbing activities could injure, displace, or kill early life stages of managed species or bury the benthic prey of managed species. However, the sediments would eventually settle out. Pipeline trenching and island construction could damage marine plants associated with EFH by mechanically removing the plants or smothering them through sedimentation. Marine vegetation is concentrated in relatively few areas within the Beaufort Sea and Chukchi Sea Planning Areas (e.g., the Stefansson Sound Boulder Patch

Community), and impacts on such areas are typically minimized during construction activities by stipulations protecting sensitive biological habitats.

It is assumed that drilling muds and cuttings from the exploration and delineation wells would be discharged into the Beaufort and Chukchi Seas. The discharges of drilling fluids and cuttings could temporarily affect some EFH resources. While the toxicity of those cuttings is expected to be low and within permitted levels, the drilling wastes that are discharged would temporarily increase turbidity and sediment deposition, and a small number of managed species could be temporarily displaced. In the mixing area near the discharge site, eggs and larvae of managed Arctic fishes could be killed or injured. Settlement of discharged cuttings on the seafloor could smother some prey species and change substrate composition in the area where the cuttings settle. However, the discharge of all drilling muds and cuttings would be subject to NPDES permitting requirements that would greatly reduce the impacts on EFH and managed species.

Gravel island and ice road construction may affect freshwater fish and fish habitat. Gravel for island construction is mined from river bars and water for construction of ice roads is pumped from local rivers and lakes to desired areas to build a rigid surface. Removal of gravel could increase turbidity and reduce the water quality in affected rivers. Water withdrawal for ice road construction could potentially remove large numbers of fish from the water body and reduce dissolved oxygen concentrations in the remaining lake water (Cott et al. 2008). For ice roads traversing lakes, long-term impacts to fish populations could result from traffic-related noise disturbance. Truck noise is not expected to be great enough to result in injury to fish, even in the vicinity of the road noise (Stewart 2003). However, fish may temporarily avoid the area experiencing noise and vibrational disturbance (Stewart 2003). The potential for entrainment can be reduced by mitigative intake screens and by taking water from lakes with groundfast ice, which are less likely to contain significant fish populations. Impacts to water quality can be avoided by avoiding excessive water removal. For example, Cott et al. (2008) found that water withdrawals of 10% of under-ice water volume did not significantly reduce oxygen concentration, while a 20% reduction reduced both dissolved oxygen and the amount of suitable fish habitat. Impacts to fish will also be reduced by the ADFG, which requires reviews of gravel extraction and water withdrawal activities for potential impacts on salmon and other fish species and requires permits to be issued before activities can be initiated.

Artificial islands would increase the diversity of habitat available on an otherwise homogeneous ocean. Specifically, such construction would introduce an artificial hard substrate that opportunistic benthic species, especially those that prefer gravel substrate, could colonize. Fishes may be attracted to the newly formed habitat complex, and fish population numbers in the immediate vicinity of the platforms are likely to be higher than in surrounding waters away from the structures. The overall change in habitat could result in changes in local community assemblage and diversity. The number of platforms projected for the Beaufort Sea and Chukchi Sea Planning Areas under the proposed action (up to nine) would create a small amount of hard substrate habitat and would likely have little effect on overall fish populations.

Production. The primary production activities that could affect EFH include bottom disturbance from anchors and the discharge of produced water. Bottom disturbance represents chronic, long-term, but localized impacts on EFH. Pipelines not buried would be anchored in place which would minimize their movement and potential to disturb sediment EFH. It is assumed that all produced water would be disposed of by injection into permitted disposal wells. Therefore, the effects of produced water discharges on sediment and water-column EFH are expected to be minimal. Platform and island construction will introduce floating or benthic hard substrate that may attract managed species and their prey. Over time, this could change the spawning, breeding, and feeding patterns of some managed fish.

Chronic discharges of contaminants in ice roads would occur during every breakup from fluids entrained in the roads. Entrained contaminants from vehicle exhaust, grease, antifreeze, oil, and other vehicle-related fluids could potentially affect EFH. These discharges would exist over the life of the field.

Decommissioning. Bottom disturbance during platform removal would temporarily disturb EFH by increasing noise and turbidity for some length of the water column. During decommissioning and structure removal, only nonexplosive methods would be used to sever conductors and pilings. Nonexplosive removals (e.g., abrasive, mechanical, or diver cutters) are expected to have little impact on EFH resources and managed species (Section 4.4.7.3.2). These impacts would temporarily degrade EFH quality and potentially kill or injure managed species, but conditions would return to normal as suspended sediments dispersed and resettled with no long-term impacts on EFH. Removing structures would also remove the associated fouling communities that serve as prey for managed fish species, thereby forcing these species to relocate to other foraging areas. Gravel islands would be left in place where they would wash away and introduce fine sediments into the water column over an extended period of time.

Impacts of Expected Accidental Events and Spills. It is assumed that up to 3 large oil spills (≥1,000 bbl) up to 35 small spills (50 to 999 bbl) and up to 190 smaller spills (>1 and <50 bbl) could occur during the lease period under the proposed action (Table 4.4.2-1). Impacts to EFH and managed species would generally increase with the size of the spill. See individual sections for detailed discussions of the potential impacts of oil spills on fish, shellfish, and marine and coastal habitat. Most accidental hydrocarbon releases in the Beaufort and Chukchi Planning Areas would be small. Small releases would degrade bottom water quality, but the overall contaminant impacts on pelagic habitat resources will be short-term, given the localized nature of a small release and the natural dilution and breakdown of hydrocarbons. Large spills would degrade EFH over a wider area than small spills and potentially reduce the habitat value and ecosystem function in the areas affected. Impacts from spills would be greatest if a large spill occurred during a reproductive period or contacted a location important for spawning or growth such as intertidal and nearshore subtidal habitats. The oil would be transported from the area as well as broken down by natural processes. Wave and wind action, weathering, and biological degradation by microbes would dissipate oil in the surface water, and EFH would be reestablished after some period of time.

Toxic fractions of oil in the parts-per-billion range can cause sublethal impacts on developing fishes (MMS 2007b). Depending on the timing and severity of an oil spill, adult anadromous fish migrating from marine waters to fresh water to spawn and juveniles migrating seaward from freshwater could be harmed by high concentrations of hydrocarbons. Most adult managed species in the Beaufort and Chukchi Seas are highly mobile and would likely avoid oil spills by temporarily moving to other areas. However, small obligate benthic species and egg and larval life stages of managed species as well as planktonic organisms that serve as their prey may be unable to avoid hydrocarbon spills. In addition, oil reaching the intertidal zone can persist in the sediments and cause sublethal impacts on fish eggs and larvae for multiple years (Peterson et al. 2003).

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes an unexpected CDE in the Chukchi Sea Planning Area with an assumed volume of 1.4- 2.2 million bbl and a duration of 40–75 days, and a CDE in the Beaufort Sea Planning Area with an assumed volume of 1.7-3.9 million bbl and a duration of 60–300 days (Table 4.4.2-2). See individual sections for detailed discussions of the potential impacts of a CDE on fish, shellfish, and marine and coastal habitat. Deeper subtidal sediment EFH may be less affected because hydrocarbons would tend to float over the sediments. The potential for severe impacts from accidents would be greatest if large quantities of oil from catastrophic spills washed inshore into wetlands, intertidal zones, and shorelines where spilled oil could contaminate nearshore EFH and associated prey species. Spilled oil reaching wetland habitat could kill vegetation and associated invertebrates and small fish that are prey species for managed species. Oil spills occurring under ice or frozen in ice would be more difficult to clean and may persist for longer in the environment.

The period of time needed to reestablish appropriate EFH conditions following a CDE would depend upon the characteristics of the individual spill and would be related to many factors, including the habitat affected, the location of the spill, the nature of transporting currents, the magnitude of the spill, and the chemical characteristics of the spilled oil. Studies following the *Exxon Valdez* spill found that water column EFH recovered in less than 1 to 2 years (Boehm et al. 2007). Subtidal habitat and communities are considered to be very likely recovered by the *Exxon Valdez* Oil Spill Trustee Council (2010a), but as of 2010, intertidal sediments and communities are considered to still be recovering from the *Exxon Valdez* spill (*Exxon Valdez* Oil Spill Trustee Council 2010a). Impacts to kelp habitat from an oil spill could be long-term. Laminaria beds oiled by the *Exxon Valdez* spill recovered within 10 years (Dean and Jewett 2001).

Deeper subtidal sediment EFH may be less affected because hydrocarbons would tend to float over the sediments. Similar effects are expected to those described above, but managed species that suffer large losses of early life stages or that are currently in decline could suffer population-level effects from catastrophic oil spills. A single catastrophic spill could cause long-term declines of managed species that rely on shallow coastal, intertidal, and freshwater areas. Of the offshore managed species, the Arctic cod is particularly vulnerable to spills because they spawn in winter under ice when cleanup is most difficult. In addition, their larvae are pelagic and likely to come into contact with oil and gas, which tends to float on the surface. Arctic cod are also susceptible because they are dependent on algal production in open water and under sea ice, which could be affected by oil and gas exposure. Arctic cod are keystone species in the Arctic, and significant impact to this species could have broad ecosystem effects. Spilled oil could smother kelp and other marine plants, reducing habitat and substrate for potential prey of managed species. Oil spilled under ice is more difficult to locate and remove than surface spills.

Since weathering would be greatly reduced by ice cover, managed species with mobility could continue to be harmed or killed as they drift into the trapped oil. In addition, the sea ice that provides habitat for managed species such as juvenile Arctic cod could be uninhabitable.

Impact Conclusions.

Routine Operations. Most impacts on EFH from oil and gas exploration and production activities would likely result from bottom disturbance during the placement of pipelines and production platforms, and result in negligible to moderate impacts to EFH. The magnitude of impacts on sensitive marine and coastal EFH would be limited by specific lease stipulations and site-specific analyses conducted for particular lease sales. Recovery of EFH habitat and benthic food resources from oil and gas activities would range from short-term to long-term. Managed species, particularly egg and larval stages, could be killed, injured, or displaced from the immediate vicinity of oil and gas activities, but no population-level impacts on managed species are expected.

***Expected Accidental Events and Spills*.** The severity of effects of accidental hydrocarbon spills on EFH would depend on the size of the spill, its location, environmental factors, and the uniqueness of the affected EFH. While most accidents would be small and would have relatively small impacts on EFH, large spills that reach coastal EFH could have more persistent impacts and could require remediation. Most adult managed species could avoid hydrocarbon spills in open water areas, but small obligate benthic species, eggs, larvae, and some managed species and their prey could experience lethal and sublethal effects from contact with hydrocarbons. Overall, impacts to EFH from small spills would range from negligible for spill less than 50 bbl to minor for spills less than 1,000 bbl and from minor to moderate for large spills (≥1,000 bbl).

An Unexpected Catastrophic Discharge Event. A CDE could cause long-term declines of managed species that rely on shallow coastal, intertidal, and freshwater areas or species that are associated with sea ice. Spills occurring under ice could result in long-term degradation of EFH and managed species because of the cleanup difficulties. Managed species that suffer large losses of early life stages or long-term sublethal impacts could suffer population-level effects from a CDE. Overall, a CDE could result in moderate to major impacts on EFH, largely depending on the size of the spill, its location, environmental factors, and the uniqueness of the affected EFH.

4.4.7 Potential Impacts on Marine and Coastal Fauna

4.4.7.1 Mammals

This section addresses the potential impacts to both marine mammals and terrestrial mammals in context of each program area. It should be noted that both NMFS and USFWS have statutory and regulatory mandates under the ESA and MMPA for mammals. Under the MMPA (16 USC 1371; 50 CFR Subpart 1), the taking of marine mammals without a permit or exemption is prohibited. The term "take" under the MMPA means "to harass, hunt, capture, kill or collect, or attempt to harass, hunt, capture, kill or collect." The MMPA has defined takes by "harassment" in two ways: (1) Level A harassment is "any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild," and (2) Level B harassment is "any act of pursuit, torment, or annoyance, which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild." In 30 CFR Part 250, Subpart B, BOEM requires operators of Federal oil and gas leases to meet the requirements of ESA and MMPA. The regulations outline the environmental, monitoring, and mitigation information that operators must submit with proposed plans for exploration, development, and production.

4.4.7.1.1 Gulf of Mexico.

Marine Mammals. There are 29 species of marine mammals, including six endangered whale species and the endangered West Indian manatee, that may occur in the northern GOM (Section 3.4.4.2.1), and which therefore could be affected by normal operations associated with the proposed action.

Impacts of Routine Operations. As part of the proposed action, 1,000 to 2,100 exploration and delineation wells and 1,300 to 2,600 development and production wells are projected to be drilled, while 200 to 450 new platforms and up to 2 FPSOs are projected to be used. Additional activities planned as part of the proposed action include 3,862 to 12,070 km (2,400 to 7,500 mi) of new pipeline (Table 4.4.1-1). Although a specific scenario for geophysical operations has not been prepared, exploratory and on-lease seismic surveys are expected to result from the Program. Table 4.4.7-1 illustrates how each of the impacting factors associated with OCS oil and gas development may affect marine mammals and their habitats, while Figure 4.4.7-1 presents a conceptual model of potential impacting factors for marine mammals from oil- and gas-related activities (including accidental oil spills).

Because of differences in the distribution and ecology of marine mammal species, routine operations under the proposed action would not equally affect marine mammal species. All of the mysticetes (baleen whales), except for the Bryde's whale, are considered extralimital or rare in the northern GOM (Würsig et al. 2000). Because of their rarity, it is unlikely that individuals of these species would be present where OCS-related activities would occur, and thus they would not be affected by routine operations of the proposed action. Although the Bryde's whale is the most frequently sighted mysticete whale, it is uncommon. While the Bryde's whale is present throughout the year, it occurs primarily in the Eastern Planning Area (Davis et al. 2000; Würsig et al. 2000; MMS 2004a). Most sightings are recorded in the region of the DeSoto Canyon and over the Florida Escarpment (Mullin et al. 1994a; Davis et al. 2000). Waring et al. (2010) estimate a population size of 15 individuals. Thus, it would not be expected to be affected to any great extent by routine operations under the proposed action.

TABLE 4.4.7-1 Impact Factor Data Matrix for Marine Mammals[a]

	O&G Impacting Factor								
		Noise							
Resource Receptor Category Potentially Affected	Collisions with Support Vessels	Seismic Exploration	Construction, Operation, and Decommissioning	Presence of Support Vessels	Onshore Construction and Operation	Offshore Infrastructure Construction, Operation, Decommissioning	Produced Water, Drill Cuttings and Mud	Solid Wastes and Debris	Accidental Oil Spills
Individuals (adults and juveniles)	Injury from ship strikes (A)[b]	Injury; disruption of normal behavior (A)	Disruption of normal behavior (B)[b]	Disruption of normal behavior (B)	Physical disturbance or reduced habitat quality associated with noise and/or human presence (A)	Physical disturbance or reduced habitat quality associated with noise and/or human presence (A)	Toxicity (A)	Ingestion and/or entanglement (A)	Fouling, toxicity (A)
Onshore Habitats (e.g., haul-out sites and rookeries)	–	–	–	–	Physical disturbance or loss; reduced habitat quality (A)	–	–	–	Physical habitat loss; reduced quality (A)
Offshore Habitats (e.g., calving grounds, foraging areas, or wintering grounds)	–	–	–	–	–	Temporary habitat disturbance during construction; possible long-term increase in habitat (B)	Reduced habitat quality (A)	–	Physical habitat loss; reduced quality (A)
Migration	Displacement or impediment (B)	Displacement or impediment (B)	Displacement or impediment (B)	Displacement or impediment (B)	Displacement or impediment for terrestrial movements (e.g., polar bears) (B)	Displacement or impediment (B)	–	–	Displacement or impediment (B)

[a] A dash indicates that no impact is anticipated.

[b] A = Level A Harassment (potential to injure a marine mammal or marine mammal stock in the wild). B = Level B Harassment (potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but that does not have the potential to injure a marine mammal or marine mammal stock in the wild).

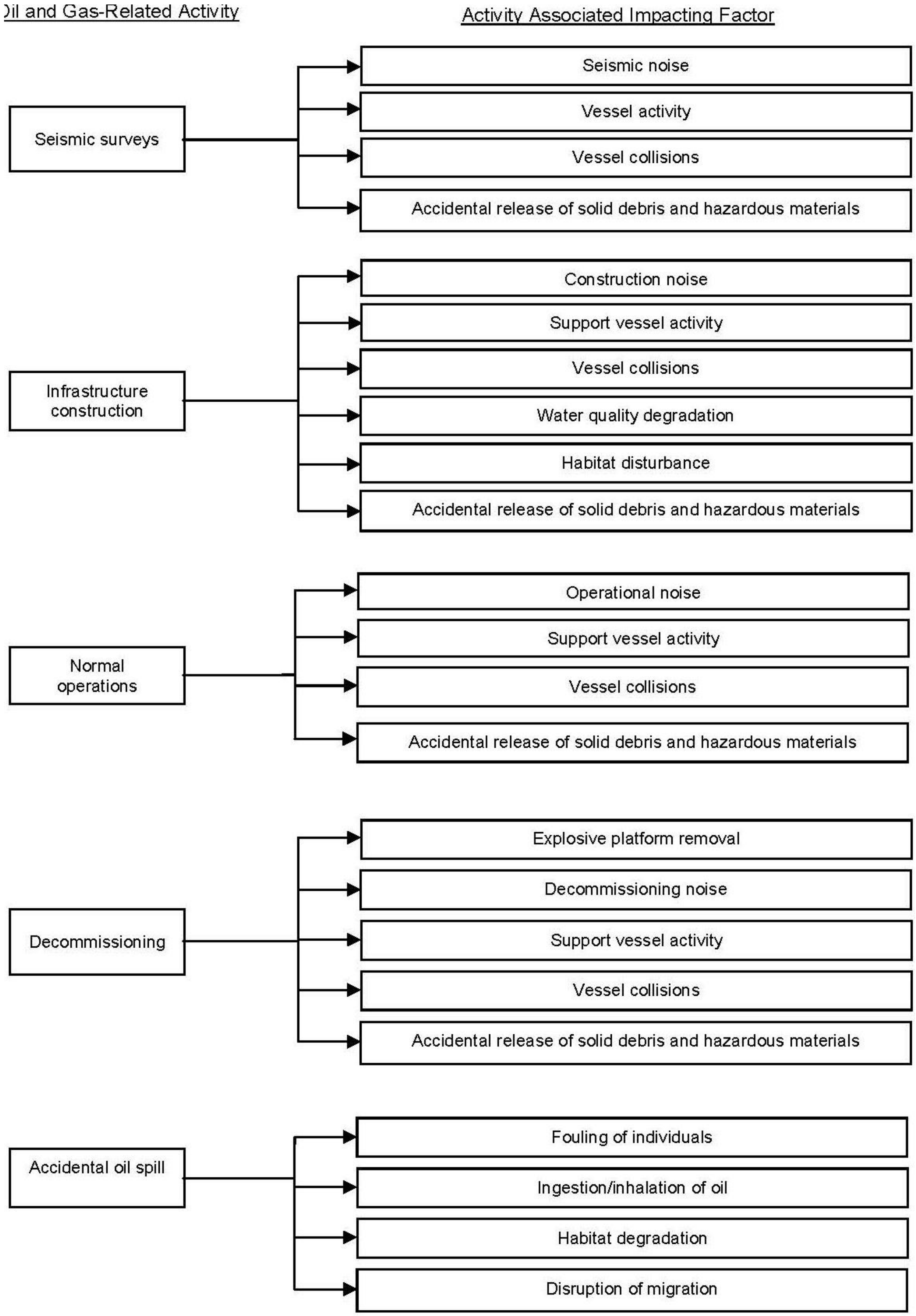

FIGURE 4.4.7-1 Conceptual Model for Anticipated Impacting Factors for Marine Mammals

In contrast to the mysticetes, many of the odontocetes (toothed whales) are considered relatively common in the GOM OCS (Davis et al. 2000; MMS 2004a). Thus, there is a greater potential that some individuals of these species to occur in areas where OCS-related activities occur and to be affected during routine operations. The only odontocete listed as endangered is the sperm whale, which is the most common large whale in the GOM. Sperm whales occur year-round in all deepwater areas of the U.S. GOM, with a well-documented aggregation consistently found in the shelf-edge waters around the 305-m (1,000-ft) depth contour south of the Mississippi River Delta (Davis et al. 2000; MMS 2004a). Jochens et al. (2008) reported that females and immature sperm whales have a high site fidelity to the region south of the Mississippi Delta and Mississippi Canyon and in the western GOM, while bachelors and lone males were mainly observed in the DeSoto Canyon and along the Florida slope. Thus, this species may encounter OCS-related activities occurring within the northern GOM, especially in deepwater areas of the Central Planning Area.

Although manatees appear to prefer nearshore habitats, there are rare observations around structures at offshore sites. Negligible impacts on the West Indian manatee are anticipated because the 2012-2017 proposed action does not include routine operations in most of the Eastern Planning Area. The potential for impacts on manatees would occur in nearshore habitats where interactions with OCS-related activities (i.e., vessel traffic) exist. Service vessel impacts would mainly occur in the Central and Western Planning Areas where manatees occasionally occur during warmer months (Fertl et al. 2005).

The following analysis presents an overview of impacts on marine mammals from the following routine operations: (1) seismic surveys, (2) construction of offshore facilities and pipelines, (3) operations of offshore facilities and drilling rigs, (4) discharges and waste generation, (5) service vessel and helicopter traffic, and (6) decommissioning.

<u>Seismic Surveys.</u> Sections 4.4.1.1 and 4.4.5.1.1 provide descriptions of seismic survey technologies, energy outputs, operations, and general acoustic impacts. The type of O&G activities presently occurring in the GOM include:

- Seismic surveys (includes high-resolution site surveys and various types of seismic exploration and development surveys, including narrow azimuth, multi azimuth and wide azimuth);

- Side-scan sonar surveys;

- Electromagnetic surveys;

- Geological and geochemical sampling; and

- Remote sensing (including gravity, gravity gradiometry, and magnetic surveys).

Marine mammals produce and use sound to communicate as well as to orient, locate and capture prey, and to detect and avoid predators (Hofman 2004; Southall et al. 2007). A panel of experts in acoustic research from behavioral, physiological, and physical disciplines generated a report, *Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations* (Southall et al. 2007), which summarized existing acoustic and marine mammal data and made recommendations for regulatory criteria and research. Noise generated by seismic surveys may have physical and/or behavioral effects on marine mammals, such as (1) permanent or temporary hearing loss, discomfort, and injury; (2) masking of important sound signals; and (3) behavioral responses such as fright, avoidance, and changes in physical or vocal behavior (Richardson et al. 1995; Davis et al. 1998; Gordon et al. 2003/2004; Nowacek et al. 2004, 2007). Parente et al. (2007) noted a decrease in the diversity of cetacean species, possibly associated with an increase in the number of seismic surveys off Brazil. The authors hypothesized that lowered diversity resulted from avoidance or changes in migration routes in some cetacean species exposed to seismic pulses. Seismic surveys may also indirectly impact marine mammals by altering prey availability (Gordon et al. 2003/2004).

Southall et al. (2007) synthesized the understanding of underwater and aerial hearing in some marine mammal groups and recommended some acoustic criteria. A precautionary approach was used to derive frequency-specific marine mammal weighting functions; the marine mammal hearing groups are broken down into five categories: (1) low-frequency cetaceans, which are the mysticetes, have an estimated lower and upper frequency range of 7 Hz to 22 kHz; (2) mid-frequency species are estimated to have lower and upper frequency limits of hearing at approximately 150 Hz and 160 kHz, respectively; (3) high-frequency cetaceans have an estimated functional hearing between approximately 200 Hz and 180 kHz; (4) pinnipeds in air have an estimated functional hearing between 75 Hz and 30 kHz; and (5) pinnipeds in water have an estimated functional hearing between 75 Hz and 75 kHz.

Although airgun arrays are a source of primarily low-frequency sound energy, they are a broadband source, so higher frequencies are also transmitted. Some pulse components of airgun arrays have the bulk of their energy at frequencies from 300 Hz to 3 kHz, frequency ranges beyond those of interest to seismic exploration but of concern for potential impact on odontocetes such as the sperm whale, beaked whales, and dolphins (Madsen et al. 2006). Although airguns concentrate energy at low frequencies, noise was detectable to at least 100 kHz (Bain and Williams 2006). Goold and Coates (2006) noted that 60 cubic inch and 250 cubic inch airguns both had a high frequency output up to 150 kHz at 10 m (33 ft) from the source. Therefore, airguns cover the entire frequency range known to be used by marine mammals (Goold and Coates 2006).

Almost all impacts of seismic surveys have been inferred or assumed by implication rather than observed. There have been no documented instances of deaths, physical injuries, or auditory (physiological) effects on marine mammals from seismic surveys. Behavioral responses have been observed but the biological importance of such behavioral responses (to the individual animals and populations involved) has not been determined.

The types of potential effects can be broken down into non-auditory injury, auditory effects, behavioral effects, and masking. Nowacek et al. (2007), Richardson et al. (1995), and Southall et al. (2007) have reviewed the effects of anthropogenic sound on marine mammals and are incorporated by reference.

For the purpose of analysis, it is assumed that operators will implement survey and monitoring mitigation (e.g., ramp-up, marine mammal observers, speed restrictions, exclusion zones) currently required in the GOM to minimize or avoid impacts of seismic on marine mammals with an emphasis on prevention of injury (auditory and non-auditory). Assuming the implementation of these mitigations, the potential for injury is minimized. There remains a greater potential for behavioral effects; therefore, the following discussion focuses on the potential behavioral changes resulting from exposure to seismic operations. More detailed discussions of impacts to marine mammals from seismic surveys in the GOM can be found in MMS (2004a).

Non-Auditory Injury. Non-auditory injury could include direct acoustic impact on tissue, indirect acoustic impact on tissue surrounding a structure, acoustically mediated bubble growth within tissues from supersaturated dissolved nitrogen gas, or resonance. However, resonances are not anticipated given that the resonance frequencies of marine mammal lungs are generally below that of the G&G seismic survey source signal (Nowacek et al. 2007; Zimmer and Tyack 2007).

Auditory Effects (PTS and TTS). The hearing of marine mammals varies based on individuals, thresholds of the species, location in relation to the sound source, frequency discrimination, and the motivation of an individual to change behaviors due to the sound (Richardson et al. 1995). Permanent loss of hearing in a marine mammal (i.e., permanent threshold shift [PTS]) is defined as the deterioration of hearing due to prolonged or repeated exposure to sounds that accelerate the normal process of gradual hearing loss (Kryter 1985), or the permanent hearing damage due to brief exposure to extremely high sound levels (Richardson et al. 1995). PTS results in a permanent elevation in hearing threshold — an unrecoverable reduction in hearing sensitivity (Southall et al. 2007); this is considered Level A harassment under the MMPA. NMFS' policy has been to use the 180 dB rms isopleths, where onset Level A harassment from acoustic sources potentially begins for cetaceans. Noise may cause a temporary threshold shift (TTS), a temporary and reversible loss of hearing that may last for minutes to hours. Animals suffering from TTS over longer time periods, such as hours or days, may be considered to have a change in a biologically significant behavior, because they could be prevented from detecting sounds that are biologically relevant, including communication sounds, sounds of prey, or sounds of predators. TTS is considered Level B harassment under the MMPA. NMFS uses the 160 dB rms isopleth to indicate where Level B harassment begins for acoustic impulse sounds, such as those created by airguns used for seismic surveys.

Behavioral Effects. A number of studies have documented behavioral effects in response to seismic surveys, primarily for marine mammals (Richardson et al. 1995, Southall et al. 2007). Species with similar hearing capabilities can exhibit markedly different behavioral responses to airgun noises (Bain and Williams 2006). The Bryde's whale is the only mysticete species occurring regularly in the GOM. As discussed in Southall et al. (2007), the expected frequencies of best hearing sensitivity in mysticetes and maximal airgun output at source may overlap. Given that no direct audiograms of mysticetes have been obtained, it is impossible to define what level of sound above hearing threshold may cause behavioral effects, which would be expected to be variable, complicated, and dependent upon more than just the received sound level. For this reason, observations at sea have concentrated on relating received sound levels to observed behavioral changes (Malme et al. 1983, 1986; Richardson et al. 1986; Ljungblad et al. 1988; McDonald et al. 1995; Richardson 1998; McCauley et al. 2000a, b).

Auditory thresholds of adult sperm whales have not been obtained. Ridgeway and Carder (2001) studied the vocalizations of a neonate sperm whale which led them to believe that they are sensitive to a wide range of frequencies. This was also hypothesized by Bowles et al. (1994). Miller et al. (2009) did not observe the course of travel or foraging dives of sperm whales to be affected by seismic surveys at distances of 1 to 13 km (0.6 to 8 mi), although the benefits of staying in an area could possibly outweigh the costs of moving away from the noise. Sperm whales are a highly vocal species under natural conditions (i.e., they click almost continuously during dives). Jochens et al. (2008) synthesized the findings of the Sperm Whale Seismic Study (SWSS) in the GOM. They stated that it does not appear that sperm whales in the SWSS study area showed any horizontal avoidance to controlled exposure of seismic airgun sounds. The data analysis suggested that, for at least some individuals, it is more likely that some decrease in foraging effort may occur during exposure to full-array airgun firing as compared to the post-exposure condition (Jochens et al. 2008). Sperm whales are most likely acoustically aware of their environment and can exhibit behavioral reactions in a number of ways, including interruption of vocal activity and foraging. However, there are insufficient data to assign thresholds for acoustic disturbance to sperm whales. Sperm whales are also deep divers, spending relatively little time at the surface while feeding. Therefore, they may be less likely to receive any surface shielding afforded by refractive effects caused by near surface hydrographic conditions, which can sometimes occur. As airgun arrays are generally configured to produce a maximum, low frequency energy lobe directly downwards toward the seabed, sperm whales may enter a region of increased ensonification.

Behavioral changes observed in sperm whales may result from behavioral changes in their prey to seismic surveys (Miller et al. 2009). In addition, strandings of giant squid (*Architeuthis dux*) along the west coast of Asturias, Spain, were linked to acoustic trauma caused by high-intensity, low-frequency sound waves from seismic surveys (Andre et al. 2011). There is no record of acoustic trauma to squid from seismic surveys in the GOM.

Dwarf and pygmy sperm whales are also deep-diving and use echolocation clicks in the sonic and low ultrasonic frequency range (Willis and Baird 1998). Few audiograms have been obtained for pygmy sperm whales, dwarf sperm whales, or beaked whales (Cook et al. 2006; Finneran et al. 2009; Ridgway and Carder 2001), so there still are insufficient data to determine avoidance thresholds. Like sperm whales, they may be sensitive to a wide range of sound frequencies, including those produced by airgun arrays. Similarly, beaked whales are also deep divers, use echolocation clicks to find their prey, and have been shown to be susceptible to acoustic disturbance (Frantzis 1998; Balcomb and Claridge 2001). Since they have similar deep-diving habits and relatively widespread distributions in the GOM, this may warrant concern for dwarf and pygmy sperm whales and beaked whales.

Delphinids include dolphins, killer whales, and pilot whales. Several studies have been conducted documenting the effects of seismic operations on delphinid species. Finneran et al. (2000a) discuss a behavioral response study measuring masked underwater hearing thresholds in bottlenose dolphin and beluga whale, before and after exposure to seismic pulses from a watergun. Ridgway et al. (1997) showed that captive delphinids produced behavioral reactions at levels at least 10 dB below those that induced TTS. Soto et al. (2006) and Van Parijs and Corkeron (2001) showed vessel presence is sufficient to change behavior in some species and situations.

Dolphin species are generally mid- to high-frequency hearing specialists (Southall et al. 2007). While airguns are primarily low frequency (<200 Hz), they are considered broadband and therefore there is energy at higher frequencies. These energies encompass the entire audio frequency range of 20 Hz to 20 kHz (Goold and Fish 1998), and extend well into the ultrasonic range up to 50 kHz (Sodal 1999). This high-frequency energy must be taken into account when considering seismic interactions with Delphinids. The high-frequency components of airgun emissions are of sufficient level to exceed the dolphin auditory threshold curve at these low frequencies, even after spreading loss (Goold and Fish 1998).

Marine mammal vocalizations may be altered by airguns (Gordon et al. 2003/2004). Stone and Tasker (2006) reported that cetaceans can be disturbed by seismic surveys. However, some marine mammals are known to continue calling in the presence of seismic pulses. Their calls can be heard between the seismic pulses (e.g., Richardson et al. 1986; McDonald et al. 1995; Greene et al. 1999; Nieukirk et al. 2004). Although Delphinids specialize in hearing ranges generally outside of the majority of seismic survey impulse sounds, there is still the potential for sounds from these surveys to fall within the acoustic sensitivity of toothed whales and for behavioral responses to seismic noise to occur.

Masking. Auditory masking occurs when a sound signal that is of importance to a marine mammal (e.g., communication calls, echolocation, environmental sound cues) is rendered undetectable due to the high noise-to-signal ratio in a frequency band relevant to a marine mammal's hearing range. In other words, noise can cause the masking of sounds that marine mammals need to hear to in order to function effectively (Erbe et al. 1999). If sounds used by the marine mammals are masked to the point where they cannot provide the individual with needed information, critical natural behaviors could be disrupted and harm could result (Erbe and Farmer 1998; Di Iorio and Clark 2010).

In the case of seismic surveys, where potential masking noise takes a pulsed form with a low duty cycle (~10%, or 1 s of active sound for every 10 s of ambient noise) (MMS 2004a) to very low duty cycle (<1.3 to 2%, or <200 ms of active sound for every 10 s to 15 s of ambient noise) (Pulfrich 2011), the effect of masking is likely to be low relative to continuous sounds such as ship noise. Some marine mammals are known to continue calling in the presence of seismic pulses. Their calls can be heard between the seismic pulses (e.g., Richardson et al. 1986; McDonald et al. 1995; Greene et al. 1999; Nieukirk et al. 2004). Bowles et al. (1994) reported that sperm whales ceased calling when exposed to pulses from a very distant seismic ship, while other studies reported that sperm whales continued calling in the presence of seismic pulses (Madsen et al. 2002; Tyack et al. 2003; Smultea et al. 2004; Holst et al. 2006; Jochens et al. 2008).

Some marine mammals are known to increase the source levels of their calls in the presence of elevated sound levels, or to shift their peak frequencies in response to strong sound signals (Dahlheim 1987; review in Richardson et al. 1995; Lesage et al. 1999; Terhune 1999; Parks et al. 2007). However, these studies tested other anthropogenic sounds, not seismic pulses, and it is not known if airguns would elicit this same response. If so, these adaptations would all reduce the importance of masking.

Construction of Offshore Facilities and Pipelines. Figure 4.4.7-2 presents a conceptual model for potential effects of infrastructure construction on marine mammals. Construction and trenching activities may affect habitat use for the short or long-term. Marine mammals are mobile and able to avoid areas where construction or trenching is occurring so they are less likely to be injured or killed but their behavior may be altered. Noise and human activity associated with the construction of offshore facilities and pipelines (e.g., pile driving, vessel presence) could disturb marine mammals that may be present in the vicinity of the construction activity. Construction activities could disturb normal behaviors (e.g., feeding, social interactions), mask calls from conspecifics, disrupt echolocation capabilities, temporarily affect localized air/water quality and mask sounds generated by predators. Depending on the size of the project, at any single location, offshore construction and trenching activities would be of relatively short duration since the majority of construction activities would occur on land. The length of time necessary for offshore construction depends on what is being constructed, the water depth, procurement activities, the climatic conditions to install the platform could be considered. It also depends on if the construction project is a fixed platform, semi-submersible platform, or jack-up drilling platform and each one could take approximately 1 to 2 months to set up, depending on the contractor. In addition, running a pipeline likely would not take more than 2–3 weeks.

Animals may leave the vicinity of a constructions area. Some known locations for the endangered sperm whale includes, but is not limited to, the continental slope waters off the Mississippi River Delta in the Central Planning Area (Jochens et al. 2008; Davis et al. 2000; MMS 2004a). Portions of the GOM that would be disturbed by the construction of new wells and pipelines would be largely limited to the immediate footprint of the new structure and its surroundings. Animals would be expected to locate to other suitable habitat nearby. Some long-term displacement may occur, but would be largely limited to the local environment surrounding individual wells or areas with well aggregations, and thus would not be expected to affect overall habitat availability or cetacean access.

Currently in the northern GOM, the West Indian manatee is the only marine mammal that has a federally designated critical habitat, and this habitat is limited to specific coastal and inland marine and freshwater areas in peninsular Florida (west, southeast, and northeast Florida). As pipeline landfalls and land-based facilities associated with the proposed action would not be located in Florida, no impacts to West Indian manatee critical habitat would occur.

Under the proposed action, only a few individuals or small groups of marine mammals would be temporarily disturbed behaviorally by routine construction of offshore facilities, and disturbance of these individuals, given their localized nature, would not be expected to result in

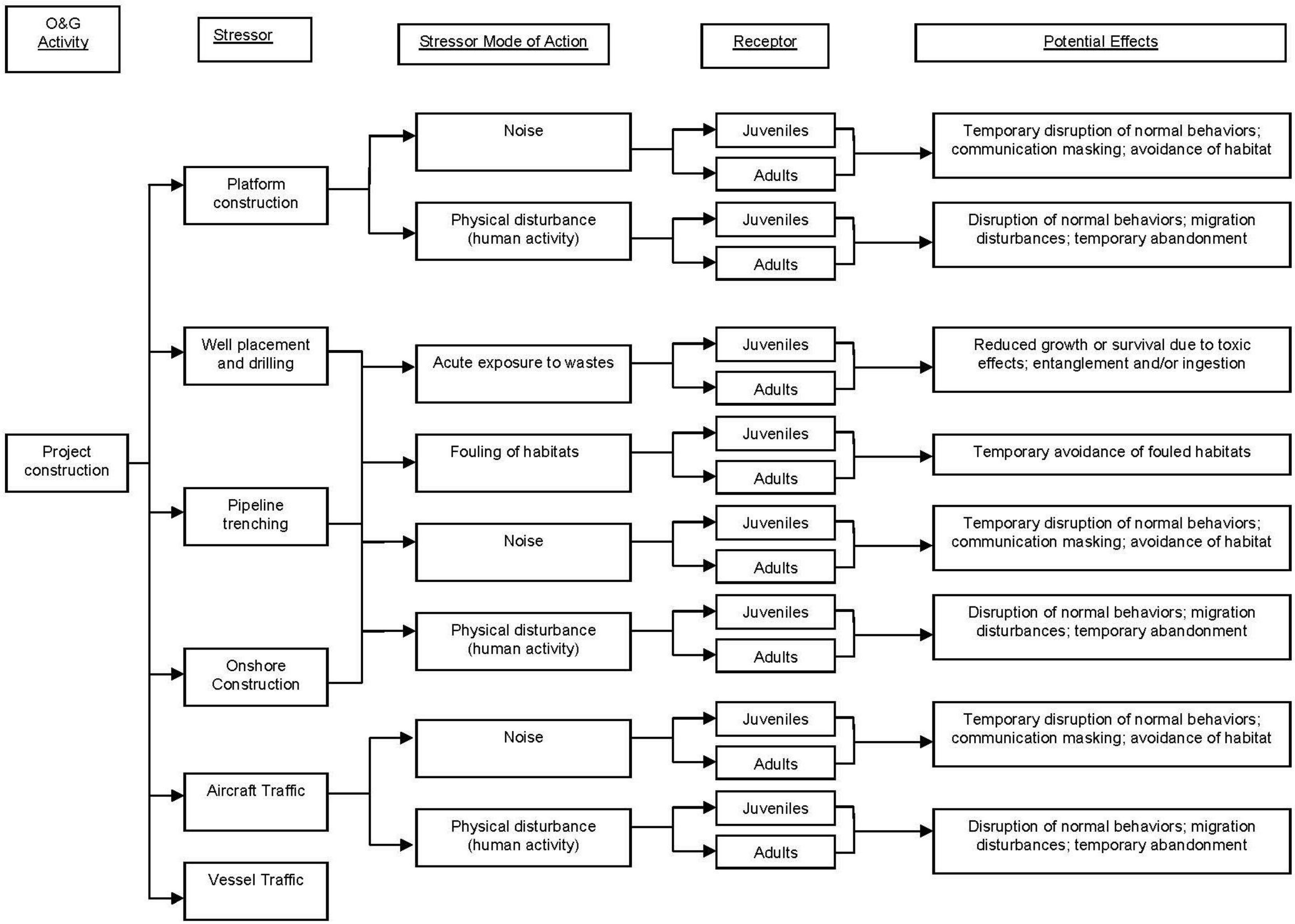

FIGURE 4.4.7-2 Conceptual Model for Potential Effects of Infrastructure Construction on Marine Mammals

population-level effects. Any impacts on marine mammals incurred from structure placement or trenching would be short term and localized to the construction area and immediate surroundings, and therefore unlikely to cause more than minor impacts to marine mammals. Onshore construction and operation activities are unlikely to impact cetacean and sirenian populations. Overall, the impacts associated with construction of offshore facilities and pipelines are unlikely to have significant adverse effects on the size and recovery of any marine mammals species or population in the GOM. It is assumed that BOEM will continue to implement GOM guidelines currently in place to reduce impacts to marine mammals such as vessel strike avoidance measures and marine debris awareness.

Operations of Offshore Facilities and Drilling Rigs. Noise from drilling could be intermittent, sudden, and at times could be high intensity as operations take place. Sound from a fixed, ongoing source like an operating drillship is continuous. However, the distinction between transient and continuous sounds is not absolute on a drillship, as generators and pumps operate essentially continuously; however, there are occasional transient bangs and clangs from various impacts during operations (Richardson et al. 1995). Estimated frequencies from drilling by semisubmersible vessels are broadband from 80 to 4,000 Hz, with an estimated source level of 154 dB re: 1 µPa at 1 m. Tones of 60 Hz had source levels of 149 dB, 181 Hz was 137 dB, and 301 Hz was 136 dB (Greene 1987). The potential effects that water-transmitted noise have on marine mammals include disturbance (subtle changes in behavior, interruption of previous activities, or short- or long-term displacement), masking of sounds (calls from conspecifics, reverberations from own calls, and other natural sounds such as surf or predators), physiological stress, and hearing impairment. Individual marine mammals exposed to recurring disturbance could be negatively affected. Malme et al. (1986) observed the behavior of feeding gray whales in the Bering Sea during four experimental playbacks of drilling sounds (50–315 Hz; 21-minute overall duration and 10% duty cycle; source levels of 156–162 dB re: 1 µPa-m). In two cases for received levels 100–110 dB re: 1 µPa, there was no observed behavioral reaction. Avoidance behavior was observed in two cases where received levels were 110–120 dB re: 1 µPa. These source levels are at or below NMFS's current 120-dB Level B harassment threshold for non-pulse noise under the MMPA.

The source levels from drilling are relatively low (154 dB and below, as cited by Greene [1986] in Richardson et al. [1995]), below the Level B (behavioral) harassment threshold of 160 dB (set by NMFS). According to Southall et al. (2007), for behavioral responses to nonpulses (such as drill noise), data indicate considerable variability in received levels associated with behavioral responses. Contextual variables (such as novelty of the sound to the marine mammal and operation features of the sound source) appear to have been at least as important as exposure level in predicting response type and magnitude. While there is some data from the Arctic on baleen whales, there is little data on the behavioral responses of marine mammals in the GOM from the sound of drilling. Southall et al. (2007) summarized the existing research, stating that the probability of avoidance and other behavioral effects increases when received levels increase from 120 to 160 dB. Marine mammals may exhibit some avoidance behaviors, but their behavioral or physiological responses to noise associated with the proposed action, however, are unlikely to have population-level impacts to marine mammals in the northern GOM. NMFS' policy has been to use the 180 dB rms isopleths, where onset Level A harassment from acoustic sources potentially begins for cetaceans. The Level B harassment onset level is at the 160 dB rms isopleth for impulsive noise and 120 dB rms for non-pulse noise.

Discharges and Waste Generation. Table 4.4.1-1 presents information on drilling fluids, drill cuttings, and produced waters discharged offshore as a result of the proposed action. Produced water, drilling muds, and drill cuttings are discharged into offshore marine waters in compliance with applicable regulations and permits. Compliance with regulations and permits will limit the exposure of marine mammals to waste discharges. The discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by BOEM (30 CFR 250.40) and the USCG (International Convention for the Prevention of Pollution from Ships [MARPOL], Annex V, P.L. 100-220 [101 Statute 1458]).

Most operational discharges are diluted and dispersed when released in offshore areas and are considered to have sublethal effects (NRC 1983; API 1989; Kennicutt et al. 1996). Any potential impacts from drilling fluids would be indirect, either as a result of impacts to prey species or possibly through ingestion via the food chain (Neff et al. 1989). However, marine mammals are generally not considered good bioaccumulators of petroleum compounds from eating contaminated prey due to rapid metabolism and excretion rates (Geraci and St. Aubin 1988). As such, impacts from discharges related to the proposed action would not be expected to result in long-term impacts to marine mammals because these compounds would not assimilated.

Many types of plastic materials end up as solid waste during drilling and production operations. Some of this material is accidentally lost overboard where cetaceans could consume it or become entangled in it. The incidental ingestion of marine debris and entanglement could adversely affect marine mammals. Industry has made good progress in debris management on vessels and offshore structures in the last several years. It is assumed that BOEM will continue to require implementation of current trash and debris elimination guidelines that appreciably reduce the likelihood of marine mammals encountering marine debris from the proposed action.

Service Vessel and Helicopter Traffic. There may be 300 to 600 vessel and 2,000 to 5,500 helicopter trips per week under the proposed action (Table 4.4.1-1). Figure 4.4.7-3 presents a conceptual model for the potential effect of vessel traffic on marine mammals. Vessel traffic could occur during seismic exploration, drilling and platform construction, platform operation, and platform decommissioning.

Ship strikes are a concern for marine mammals. There have been documented reports of cetaceans being struck by ships in the oceans throughout the world (Laist et al. 2001; Jensen and Silber 2004; Glass et al. 2008), although none to date in the GOM as a result of offshore oil/gas operations. Analyses by Vanderlaan and Taggart (2007) provides evidence that as vessel speeds fall below 15 knots (27.75 km/hr or 17.25 mph), there is a substantial decrease in the probability of a vessel strike to prove lethal to a large whale. Collisions with vessels greater than 80 m (260 ft) in length are usually either lethal or result in severe injuries (Laist et al. 2001). In addition, a majority of ship strikes seemed to occur over or near the continental shelf. Collisions with vessels can cause major wounds on marine mammals and/or be fatal. Debilitating injuries may have negative effects on a population through impairment of reproductive output (MMS 2003e). Cetaceans are more likely to be struck by vessels if they are young or sick, slow

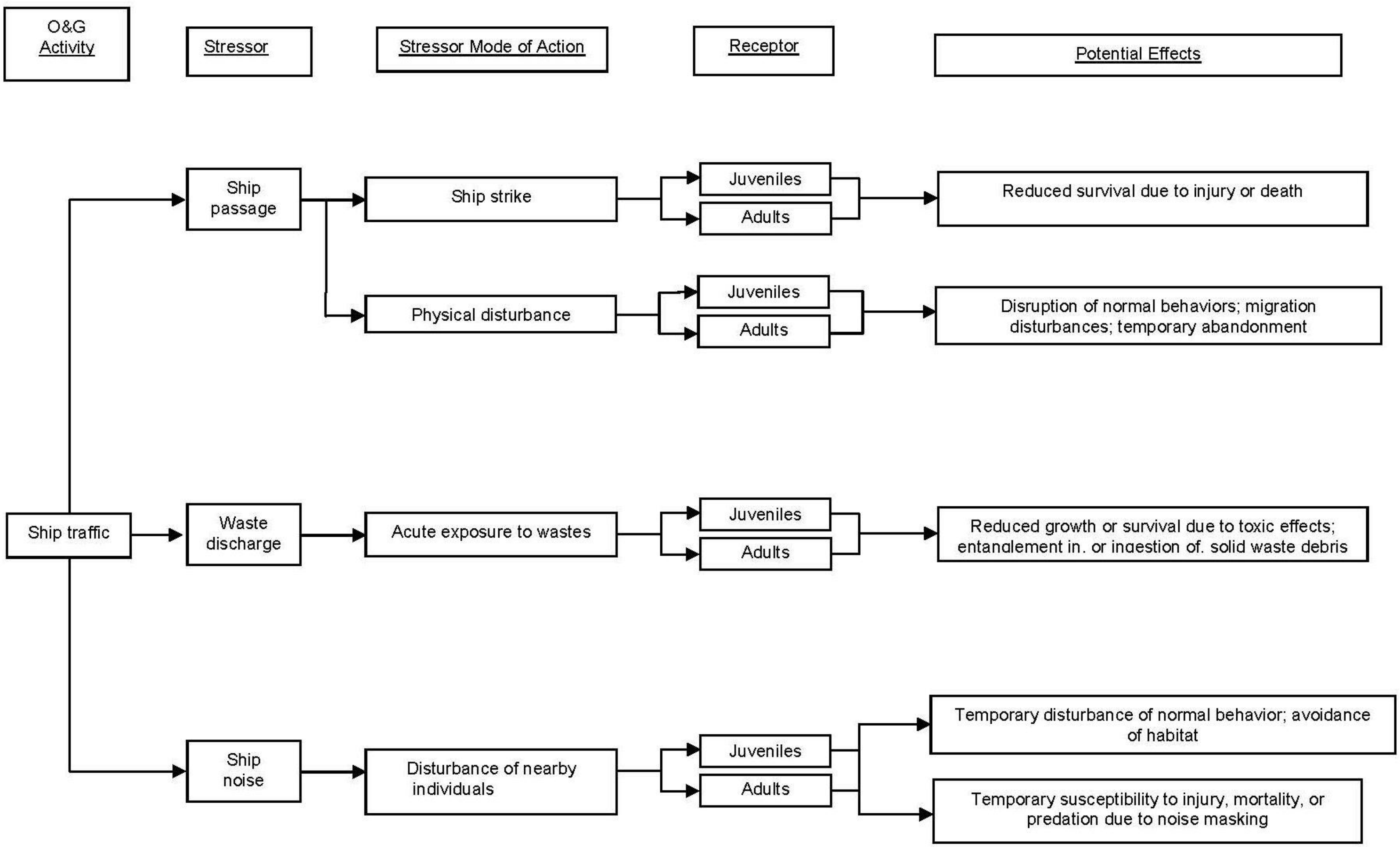

FIGURE 4.4.7-3 Conceptual Model for Potential Effects of Vessel Traffic on Marine Mammals

swimmers, distracted by feeding or mating activities, habituated to vessels, or congregated in an area for feeding or breeding (Dolman et al. 2006). Vessel strikes in inland waterways are a major cause of death in the manatee population. Because this species is rare in these planning areas, encounters with OCS-related vessels in these areas would be unlikely.

Deep-diving whales, such as the sperm whale, may be more vulnerable to vessel strikes given the longer surface period required to recover from extended deep dives. NMFS has determined that vessel strikes are a “discountable” concern for sperm whales when vessel avoidance measures are implemented (NMFS 2007b); it is assumed for the purpose of this analysis that BOEM will continue to requirement operator implementation of such avoidance criteria and speed limitations.

It is possible that noise produced from vessels and, to a lesser extent helicopters, can cause disturbance, masking of sounds, and physiological stress. The dominant source of noise from vessels is from the propeller operation, and the intensity of this noise is largely related to ship size and speed. Vessel noise from activities resulting from the proposed action will produce levels of noise, generally in the 150- to 170-dB re 1 µPa-m at frequencies below 1,000 Hz. Most ship noise occurs at low frequencies; however, modern cargo ships can produce frequencies as high as 30 kHz (Arveson and Vendittis 2000; Soto et al. 2006), which can mask the vocalization and echolocation of many toothed-whale species. Soto et al. (2006) believe that Cuvier’s beaked whale may react to shipping noise by changing dive and foraging behaviors.

The noise and the shadow from helicopter overflights, take-offs, and landings can cause a startle response and can interrupt whales and dolphins while resting, feeding, breeding, or migrating (Richardson et al. 1995). The Federal Aviation Administration’s Advisory Circular 91-36D (September 17, 2004) encourages pilots to maintain higher than minimum altitudes over noise-sensitive areas. Guidelines and regulations put in place by NOAA Fisheries under the authority of the Marine Mammal Protection Act include provisions specifying that helicopter pilots maintain an altitude of 305 m (1,000 ft) within 91 m (300 ft) of marine mammals. Helicopter occurrences would be temporary and pass within seconds. Marine mammals are not expected to be adversely affected by routine helicopter traffic operating at prescribed altitudes.

Decommissioning. Under the proposed action, 150 to 275 platforms may be removed with explosives from the northern GOM. Figure 4.4.7-4 presents a conceptual model for potential impacts of decommissioning on marine mammals.

BOEM published a programmatic EA on decommissioning operations (MMS 2005d) that, in part, addresses the potential impacts of explosive- and nonexplosive-severance activities on OCS resources, particularly upon marine mammals and sea turtles. Pursuant to 30 CFR 250 Subpart Q, operators must obtain a permit from BOEM before beginning any platform removal or well-severance activities. The NMFS has issued regulations (50 CFR Part 216) under the MMPA for “Taking Marine Mammals Incidental to the Explosive Removal of Offshore Structures in the Gulf of Mexico,” and operators are required to obtain a Letter of Authorization from NMFS in accordance with these regulatory conditions. This analysis assumes the continued implementation of current BOEM guidelines on decommissioning which specify

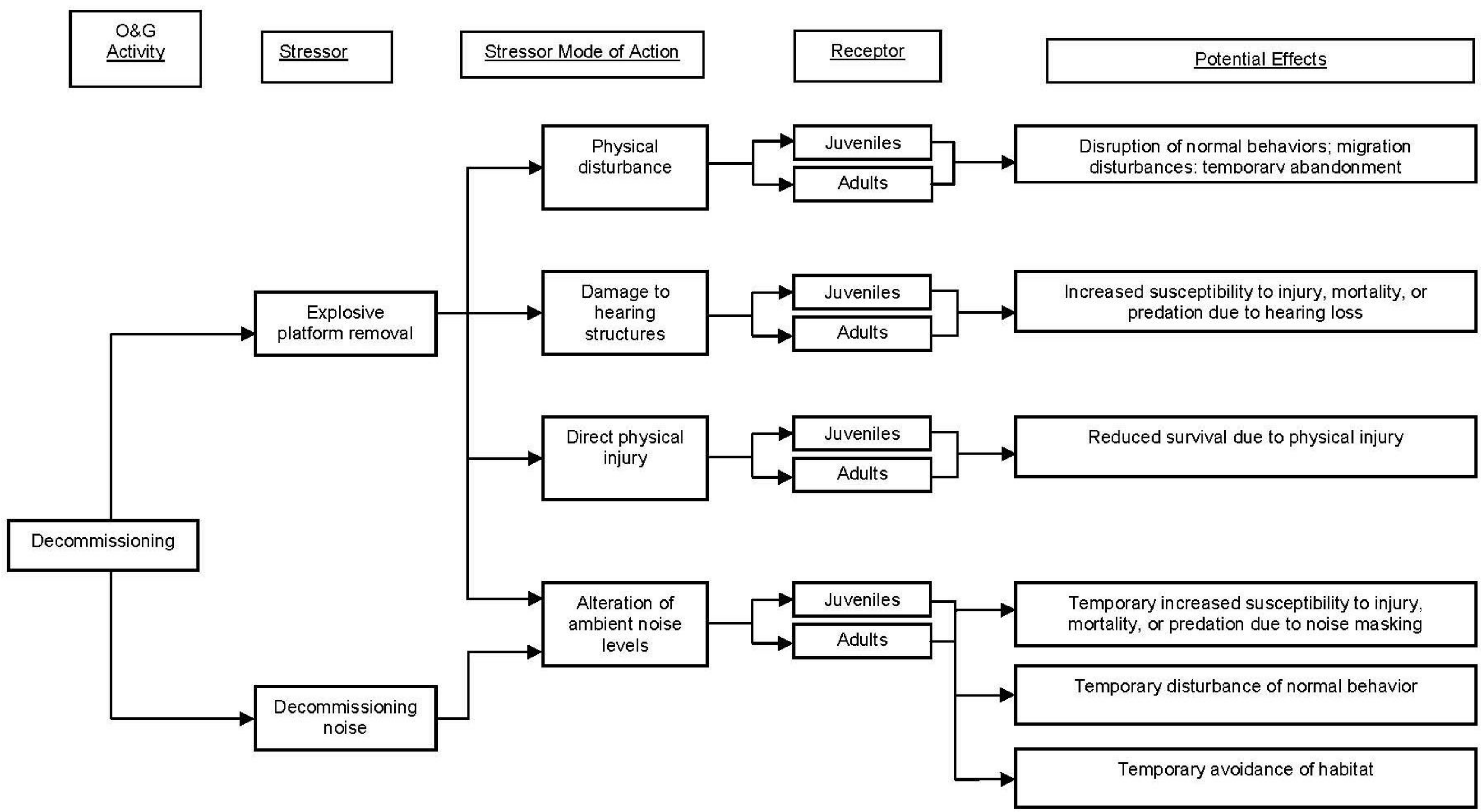

FIGURE 4.4.7-4 Conceptual Model for Potential Effects of Decommissioning on Marine Mammals

limits on the type and size of explosives that can be used and the times when detonations can occur; require explosives to be placed at a minimum depth of 15 m (49 ft) below the sediment surface; and require a monitoring plan that uses qualified observers to monitor the detonation area for protected species, including all marine mammals, prior to and after each detonation. The detection of a marine mammal (or other applicable biota) within the blast zone would, without exception, would delay explosive detonation. Thus, explosive platform removals conducted under the proposed action and complying with BOEM guidelines would not be expected to adversely affect marine mammals in the GOM.

Impacts of Expected Accidental Spills. Potential effects on marine mammal species could occur from accidental activities associated with the proposed action and may be direct or indirect. Accidental spills, including oil spills, chemical spills, vessel collisions, and loss of well control, could occur in the GOM under the proposed action (Section 4.4.2.1). Tables 4.4.2-1 presents the expected oil spill assumptions for the purpose of analyzing the proposed action, while Figure 4.4.7-5 presents a conceptual model for potential effects of oil spills on marine mammals. Between 200 and 400 spills of 50 bbl or less, 35 to 70 spills between 50 and 1,000 bbl (both considered small spills), and 4 to 8 large spills greater than 1,000 bbl are postulated for the GOM Program.

The major potential impact-producing factors include accidental blowouts, platform and pipeline oil spills, and spill-response activities. Impacts (i.e., acute vs. chronic impacts) depend on the magnitude, frequency, location, and date of accidents; characteristics of spilled oil; spill-response capabilities and timing; and various meteorological and hydrological factors. Impacts could include decreased health, reproductive fitness, and longevity; and increased vulnerability to disease). Spilled oil can cause soft tissue irritation, fouling of baleen plates, respiratory stress from inhalation of toxic fumes (e.g., irritation and damage to mucus membranes), direct ingestion of oil and/or tar, and temporary displacement from preferred habitats (St. Aubin and Lounsbury 1988; Geraci and St. Aubin 1980, 1988). An oil spill can also lead to the localized reduction, disappearance, or contamination of prey species. Generally, the potential for ingesting oil-contaminated prey is highest for benthic-feeding marine mammals (e.g., those that feed on clams and polychaetes that tend to concentrate petroleum hydrocarbons), reduced for plankton-feeding whales, and lowest for fish-eating marine mammals, as food-web biomagnification of petroleum hydrocarbons does not occur (Würsig 1988). Depending on the extent and magnitude of a spill, diminished prey abundance and availability may cause marine mammals to move to less suitable areas and/or consume less suitable prey.

The long-term impacts to marine mammal populations are poorly understood but could include decreased survival and lowered reproductive success. Chronic or acute exposure could result in harassment, harm, or mortality to marine mammals. In some cases, marine mammals made no apparent attempt to avoid spilled oil (Smultea and Würsig 1995); however, marine mammals have been observed apparently detecting and avoiding slicks in other cases (Geraci and St. Aubin 1980, 1988). One assumption concerning the use of dispersants is that the chemical dispersion of oil will considerably reduce the impacts of oil on marine mammals, primarily by reducing their exposure to petroleum hydrocarbons (French-McCay 2004; NRC 2005b). However, the impacts on marine mammals from chemical dispersants could include nonlethal injury (e.g., tissue irritation, inhalation), long-term exposure through

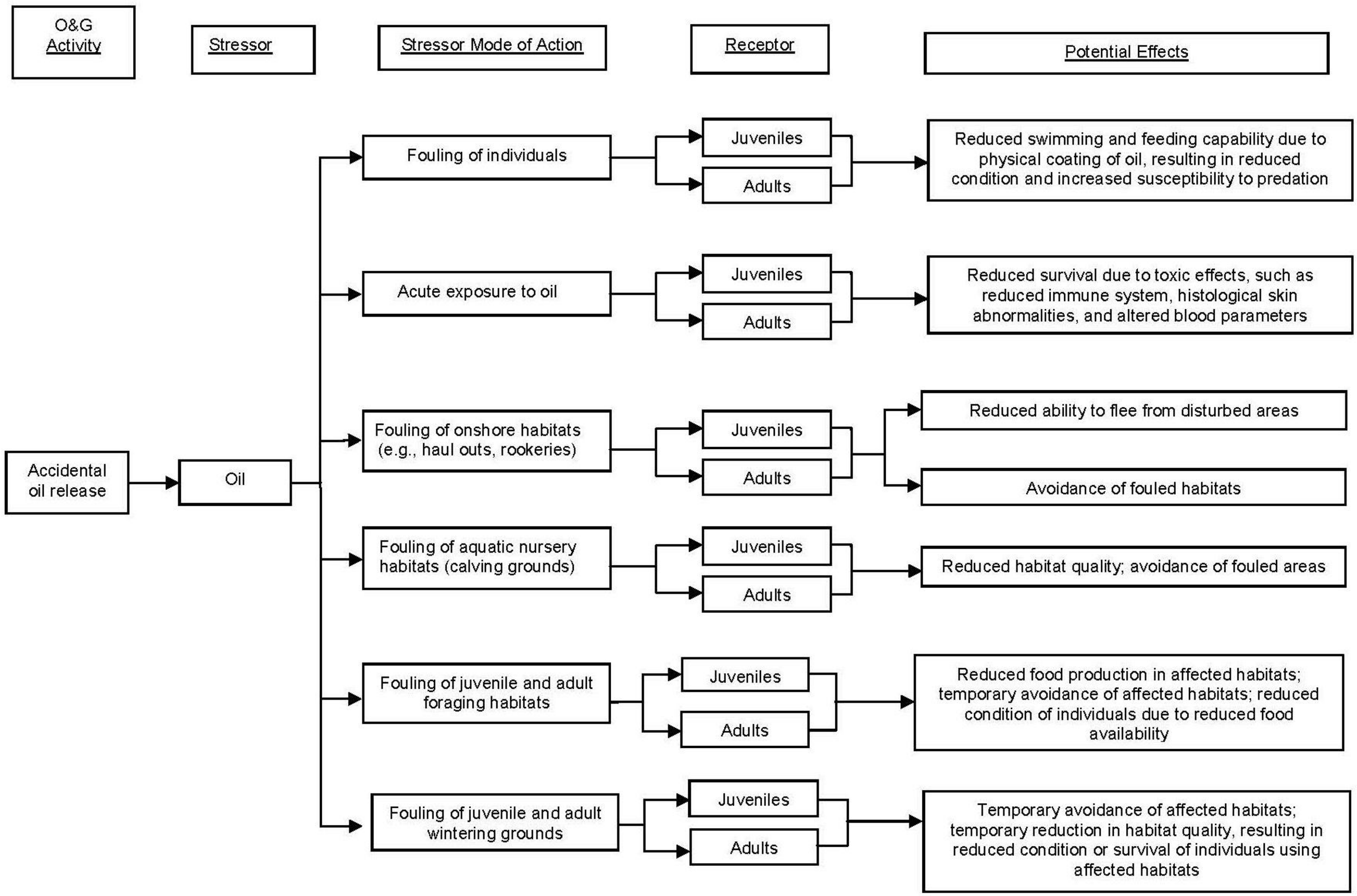

FIGURE 4.4.7-5 Conceptual Model for Potential Effects of Oil Spills on Marine Mammals

bioaccumulation, and potential shifts in distribution from some habitats. Water and air quality degradation associated with response and cleanup vessels could also affect marine mammals.

Impacts on marine mammals from smaller accidental events could adversely affect individual marine mammals in the spill area, but are unlikely to rise to the level of population effects (or significance) given the size and scope of such spills. Assuming that all small spills would not occur at the same time and place, water quality could rapidly recover and therefore not have significant effects on marine mammals or their prey species. The potential effects associated with a large spill could be more adverse than a smaller accidental spill and could potentially contribute to longer lasting effects. Impacts from dispersants are unknown but could be irritants to tissues and sensitive membranes (NRC 2005b).

Spill response activities that may impact marine mammals include increased vessel traffic, use of dispersants, and remediation activities (e.g., use of controlled burns, skimmers, and booms). Vessel noise and other factors related to increased human presence would likely cause changes in marine mammal behavior and/or distribution. This could increase stress levels and perhaps make individuals more vulnerable to various physiologic and toxic effects of spilled oil. Increased numbers of response vessels could also increase the risk for vessel collisions with marine mammals.

Impacts of an Unexpected Catastrophic Discharge Event. A CDE is considered to be an unexpected, very low-probability event unlikely to occur during routine operations (see Section 4.4.2.2). The PEIS analyzes a CDE in the GOM with an assumed volume of 0.9-7.2 million bbl and lasting from 30 to 90 days (Table 4.4.2-2). If a CDE occurs, there is greater potential for more severe effects compared to the risk of effects from an assumed large oil spill. A CDE would result in sustained degradation of water quality and, to a lesser extent, air quality that would impact marine mammals from direct contact, inhalation, and ingestion (either directly or indirectly through the consumption of oiled forage or prey species). These effects would be significant, causing a multitude of acute and chronic effects. Additional effects on marine mammals would occur from water and air quality degradation associated with response and cleanup vessels, *in situ* burning of oil, dispersant use, discharges and seafloor disturbances from relief well drilling, and activities on shorelines associated with cleanup, booming, beach cleaning, and monitoring.

A CDE has the potential to increase the area and duration of an oil spill, thereby increasing the potential for population-level effects, or at a minimum, an increase in the number of individuals killed. For example, following the DWH event, dead marine mammals collected from April 30, 2010 (before the DWH event), through April 12, 2011, included 142 bottlenose dolphins, 3 spinner dolphins, and 2 each of *Kogia* spp., melon-headed whales, and sperm whales (NMFS 2011b). The actual number of marine mammal deaths is undoubtedly underestimated (Williams et al. 2011). In addition, it is not known if other species, such as the Bryde's whale, were impacted by the DWH event, as much of the data collected after the spill has not yet been released. It is important to note that the cause of death of these marine mammals has not yet been confirmed; therefore, it is possible that many, some, or none of the deaths were related to the DWH event. The final determinations regarding damages to marine mammal resources from the DWH event will ultimately be made through the NRDA process.

There have not been any reported cases of manatee strandings within the areas affected by the DWH event. Therefore, it is likely that there were few to no effects on manatees. Nevertheless, a spill from a CDE could enter coastal waters, where manatees and coastal and estuarine dolphins would be the most likely marine mammals affected. Individual manatees would most likely be impacted if a spill occurred during warmer months, when manatees may occur along most of the coastal areas of the GOM. However, a population-level impact to manatees would be most likely during winter if an oil spill reached the Florida coast and contaminated areas where manatees are concentrated in their warm-water refuges.

Impact Conclusions.

Routine Operations. Within the GOM planning area, noise generated during seismic surveys, exploration and production activities, platform removal, and by OCS-related vessels and helicopters may temporarily disturb some individuals. Contaminants in waste discharges and drilling muds might indirectly affect marine mammals through food-chain biomagnification, although the scope of effects and their magnitude are not known. However, this information is not essential to the determination of a reasoned choice among alternatives. Small numbers of marine mammals could be killed or injured by chance collision with service vessels and by eating indigestible debris, particularly plastic items, lost from service vessels, drilling rigs, and platforms (including FPSO facilities). While vessels may collide with marine mammals, the most likely impact on marine mammals would be changes in behavior (e.g., avoidance responses). Normal behavior is expected to return once a vessel or helicopter has passed. The potential also exists for some individuals to entangle in OCS-related trash and debris. Structure removal would cause only minor behavioral changes and non-injurious physiological effects on cetaceans as a result of the implementation of BOEM guidelines and the NOAA Fisheries Observer Program for explosive removals.

Overall, impacts on cetaceans from routine operations could range from negligible to moderate, while impacts on the West Indian manatee would be negligible. Rare or extralimital species are not likely to be affected by routine operations.

Expected Accidental Spills. Any of the expected oil spill scenarios developed for the proposed action (Section 4.4.2) may expose marine mammals to oil or its weathering products. The magnitude of effects from expected accidental spills would depend on the location, timing, and volume of the spills; the environmental settings of the spills (e.g., restricted coastal waterway, deepwater pelagic location); and the species (and its ecology) exposed to the spills. Spill cleanup operations could result in short-term disturbance of marine mammals in the vicinity of the cleanup activity, while a collision with a cleanup vessel could injure or kill the affected individual. Most spills would occur far from shore and would be cleaned up or dissipate before reaching shore. Impacts from small coastal spills are likely to have localized, short-term effects. Large spills would have more of an effect on marine mammals.

Overall, small oil spills ≤50 bbl are expected to have negligible to minor impacts on marine mammals. Small spills (>50 bbl) and large spills (≥1,000 bbl) are expected to have minor to moderate impacts on marine mammals. Oil spill impacts on species that are extralimital to rare are expected to be negligible to minor, but could in unusual circumstances be moderate to major depending on the number of individuals contacted by a spill. Impacts on marine mammals from oil spill response activities are expected to be minor.

An Unexpected Catastrophic Discharge Event. In the case of an unexpected, low-probability CDE, there is greater potential for more severe and population-level effects compared to a large oil spill (i.e., impacts could be moderate to major on one or more species of marine mammals). The combination of a CDE and cleanup efforts could persist beyond one season, perhaps lasting several years.

Terrestrial Mammals. The terrestrial mammals considered in this section are those species listed as endangered under the ESA that may be affected by routine OCS operations or accidents under the proposed action. These include the Alabama, Choctawhatchee, Perdido Key, and St. Andrew beach mice (subspecies of the old-field mouse) and the Florida salt marsh vole (Section 3.8.1.1.2).

Impacts of Routine Operations. The endangered beach mice subspecies inhabit mature coastal barrier sand dunes on the Alabama and northwest Florida coasts; the Florida salt marsh vole inhabits salt marsh habitats and is known from two locations (Waccasassa Bay in Levy County, Florida, and the Lower Suwannee National Wildlife Refuge), in southeastern Dixie and northwestern Levy Counties, Florida; Figure 3.8.1-1). Under the proposed action, no new OCS-related facilities or activities would occur in close proximity to the known habitats for these species; therefore, routine operations would not affect the beach mice subspecies or the Florida salt marsh vole.

Impacts of Expected Accidental Spills. Three types of oil residues on or near beach environments are particularly challenging or potentially damaging to the environment if removed (OSAT 2011):

- Supratidal buried oil — oil residue typically buried below the 15-cm (6-in.) surface cleaning depth near sensitive habitats, removal of which would damage these sensitive habitats and affect protected species;

- Small surface residual balls — oil residue left behind after beaches are cleaned (removal would involve sieving sand so finely that it could remove material used for habitat by organisms, thus altering the natural condition of the beach; and

- Surf zone submerged oil mats — submerged oil mats in nearshore surf zone in troughs between sand bars.

In the event of an accidental offshore or coastal oil spill, the four beach mice subspecies and the Florida salt marsh vole could be affected by oil washing up on their beach or marsh habitats, respectively, and by subsequent spill containment and cleanup activities. Individuals coming in direct contact with spilled oil may experience skin, ear, eye, throat, and mucous membrane irritations. Oiling of fur may affect thermoregulation. Individuals inhaling petroleum vapors may aggravate linings of the respiratory system and in extreme cases may result in asphyxiation. Oil may be ingested through contaminated food or during cleaning of oiled fur. Exposure to oil via inhalation or ingestion may lead to a variety of lethal and sublethal effects, including lung, liver, and kidney damage. Beach mice could be exposed to small surface residual balls via ingestion of residual oil in soil and by exposure in their burrows (OSAT 2011).

In addition to affecting individuals, an oil spill may also affect the habitats of these small mammals. Oil contacting their habitats could result in a reduced food supply (oiled vegetation), reduced physical habitat quality (oiled sands), and fouling of nests and burrows. The fouling of nests and burrows may also lead to a temporary displacement from or long-term abandonment of these habitats. Depending on the persistence of the oil in these habitats and the effectiveness of spill cleanup, long-term reductions in overall habitat quality and quantity may occur.

An accidental spill fairly close to shore would have the potential to contact beaches adjacent to beach mouse habitat, particularly if a spill were to occur nearshore or within inshore waterways. However, beach mice are generally restricted to interior dune habitats, which would not be expected to come in contact with spilled oil unless the accident occurred during a period of high storm surge. However, erosion from high seas during storms is likely to do more damage than oiling. For example, Yuro (2011) postulated that the Alabama beach mouse population would be extirpated in the event of successive major hurricanes. In contrast, habitats of the Florida salt marsh vole may be more vulnerable to an oil spill because of their being connected to coastal waters. However, the location of this species and its habitat on the western Florida coast are far removed from those portions of the GOM OCS where expected accidental spills might occur.

If an oil spill occurs and contacts a coastal area associated with these species, oil spill response activities, including beach cleanup activities and vehicular and pedestrian traffic, could result in habitat degradation. However, cleanup activities would be designed and conducted in consultation with the USFWS and other appropriate stakeholders so that the potential for impacts on these species and their habitats would be minimized or avoided.

It is not expected that small oil spills, particularly those <50 bbl that are most likely to occur, would contact beach mouse or Florida salt marsh vole habitats. The probabilities of large oil spills (≥1,000 bbl) resulting from the proposed action occurring and contacting beach mouse or Florida salt marsh vole habitat within 3 to 30 days from a spill in various locations in the WPA, CPA, and far western EPA is ≤5%. In most instances, the probabilities were 0% to 1% (MMS 2004a). Large-scale oiling of beach mice or vole habitats, and if not properly regulated, oil spill-response and cleanup activities could have a significant impact on the species and their habitats (up to and including population extirpations or subspecies/species extinctions). Vehicle traffic and activity associated with oil spill cleanup can trample or bury nests and burrows or cause displacement from preferred habitat (MMS 2008b). If disturbance results in the temporary abandonment of young by adults, survival of young may be reduced (MMS 2007e).

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes an unexpected CDE with an assumed volume of 0.9-7.2 million bbl and lasting 30 to 90 days (Table 4.4.2-2). If a CDE occurs, there is greater potential for oiling of beach or marsh habitats in Alabama or Florida, increasing the potential for impacts to beach mouse subspecies or the

Florida salt marsh vole compared to the risk of effects from expected small to large oil spills. A CDE would potentially result in sustained degradation of water quality, shoreline terrestrial habitats, and, to a lesser extent, air quality that could impact terrestrial mammals from direct contact, inhalation, and ingestion (either directly or indirectly through the consumption of oiled forage or prey species). These effects could be significant, causing a multitude of acute and chronic effects. Additional effects on terrestrial mammals would occur from land and air quality degradation associated with response and cleanup vessels, *in situ* burning of oil, dispersant use, and activities on shorelines associated with cleanup, booming, beach cleaning, and monitoring. A CDE has the potential to alter terrestrial mammal habitats and populations, and, could foreseeably contribute to population-level effects on one or more of the beach mice subspecies and/or the Florida salt marsh vole. The potential for these impacts would be more probable if the CDE occurs coincident with a severe storm event (e.g., a hurricane). BOEM (2012) concluded that in all likelihood beach mice were minimally impacted by the DWH event. An investigation, conducted through the NRDA process, regarding the effects of the DWH event cleanup activities on beach mice and their habitat is still pending.

Impact Conclusions.

<u>Routine Operations.</u> The four federally endangered GOM coast beach mice subspecies and the federally endangered Florida salt marsh vole and their habitats would not be affected by normal operations under the proposed action. Thus, routine operations would have negligible effects on these species.

<u>Expected Accidental Spills.</u> Oil spills may expose terrestrial mammals to oil or its weathering products. Most expected spills would occur far from shore and would be cleaned up or dissipate before reaching shore. A large spill in coastal waters could potentially reach beach or salt marsh habitats. Because of their locations on inner dunes, the beach mouse habitats are unlikely to be affected by an accidental offshore oil spill (particularly by the more commonly expected small spills). While the habitat of the Florida salt marsh vole could be affected by an oil spill, this species and its habitat are located far from areas where oil leasing and development may occur under the proposed action. Thus, it is unlikely that their habitats would be contacted by expected small or large oil spills. If their habitats are oiled, the potential impacts on terrestrial mammals are expected to be minor (for small spills) to minor or moderate for large spills. Protective measures required under the ESA should prevent any oil spill response and cleanup activities from having more than minor to moderate impacts on beach mice, the Florida salt marsh vole, and their habitats. Extirpation of beach mouse populations or the extinction of a beach mouse subspecies or the Florida salt marsh vole from expected spill are not expected (i.e., major impacts from an expected spill are not anticipated).

<u>An Unexpected Catastrophic Discharge Event.</u> In the case of an unexpected, low-probability CDE, there is greater potential for the habitats of the beach mice subspecies and the Florida salt marsh vole to be oiled. An unexpected, low-probability CDE and associated cleanup activities could potentially result in the oiling and physical destruction of habitats (including critical habitat) for one or more subspecies of beach mice and, less likely, habitat for the Florida salt marsh vole. The combination of a CDE and cleanup efforts could persist beyond one season, perhaps lasting several years. Impacts from a CDE could be minor to major. A CDE would

increase the threat of their extinction for one or more beach mice subspecies and the Florida salt marsh vole.

4.4.7.1.2 Alaska – Cook Inlet.

Marine Mammals. There are 18 species of marine mammals that occur in south Alaskan waters and that may either occur in or near (such as the Gulf of Alaska, Kenai Peninsula, and Kodiak Archipelago) the Cook Inlet Planning Area (Section 3.8.1.2.1; Table 3.8.1-2). Nine of these species or species stocks are threatened or endangered under the ESA. These species include the North Pacific right, sei, blue, fin, humpback, sperm, and beluga whales; the Steller sea lion; and the sea otter. The non-listed species commonly occur in portions in or near the Cook Inlet Planning Area (MMS 2003e). Marine mammals may be exposed to OCS-related oil and gas exploration, development, and operations that could occur under the proposed action.

Impacts of Routine Operations. As part of the proposed action, a maximum of 4 to 12 exploration and delineation wells and 42 to 114 development and production wells will be drilled and 1 to 3 new platforms are projected to be used. Additional activities planned as part of the proposed action include 40 to 241 km (25 to 150 mi) of new offshore pipeline. No onshore facilities or pipelines are proposed under the proposed action (Section 4.4.1.2). Table 4.4.7-1 (Section 4.4.7.1) illustrates how each of the impacting factors associated with OCS oil and gas development may affect marine mammals and their habitats, while Figure 4.4.7-1 (Section 4.4.7.1) presents a conceptual model of potential impacting factors for marine mammals from oil- and gas-related activities (including accidental oil spills). The following text presents an overview of potential impacts to marine mammals in and near Cook Inlet from the following routine operations (seismic surveys, construction of offshore facilities and pipelines, operations of offshore facilities and drilling rigs, discharges and waste generation, service vessel and helicopter traffic, and decommissioning) and from accidents.

<u>Seismic Surveys.</u> Section 4.4.5 provides a detailed discussion of the issues surrounding anthropogenic noise. In Cook Inlet, noise generated by seismic surveys may have physical and/or behavioral effects on marine mammals, such as (1) permanent or temporary hearing loss, discomfort, and injury; (2) masking of important sound signals; and (3) behavioral responses such as fright, avoidance, and changes in physical or vocal behavior (Richardson et al. 1995; Davis et al. 1998; Gordon et al. 1998; Nowacek et al. 2004, 2007). Seismic surveys may also indirectly impact marine mammals by altering prey availability (Gordon et al. 2003/2004). Section 4.4.7.1.1 provides a more detailed discussion on the impacts of noise from seismic surveys on marine mammals.

Non-Auditory Injury. Direct acoustic impact on tissue, indirect acoustic impact on tissue surrounding a structure, and acoustically mediated bubble growth within tissues from supersaturated dissolved nitrogen gas (if source intense and animals within short distance to source: Nowacek et al. 2007; Zimmer and Tyack 2007); resonance (although not anticipated given resonance frequencies of marine mammal lungs are generally below that of the G&G seismic survey source signal).

Auditory Injury (Temporary or Permanent Hearing Loss). The hearing of marine mammals varies based on individuals, absolute threshold of the species, masking, localization, frequency discrimination, and the motivation to be sensitive to a sound (Richardson et al. 1995). As stated previously (Section 4.4.7.1.1), Southall et al. (2007) described the frequency sensitivity in five functional hearing categories. Similarly, the previous discussion in Section 4.4.7.1.1 on permanent and temporary loss of hearing in a marine mammal (i.e., PTS, TTS) is incorporated.

Masking. In the case of seismic surveys in Cook Inlet, , the effect of masking is likely to be low relative to continuous sounds such as ship noise. In addition, a few cetaceans are known to increase the source levels of their calls in the presence of elevated sound levels, or to shift their peak frequencies in response to strong sound signals (Dahlheim 1987; review in Richardson et al. 1995; Lesage et al. 1999; Terhune 1999; Parks et al. 2007). These studies involved exposure to other types of anthropogenic sounds, not seismic pulses, and it is not known whether these types of responses ever occur upon exposure to seismic sounds. If so, these adaptations, along with directional hearing and preadaptation to tolerate some masking by natural sounds (Richardson et al. 1995), would all reduce the importance of masking.

Behavioral Change. As described in Section 4.4.7.1.1, a number of studies have documented behavioral effects in response to seismic surveys, primarily for mysticetes (Richardson et al. 1995), given their possible overlap between the expected frequencies of best hearing sensitivity (low threshold) in mysticetes and maximal airgun output at source. Given that no direct audiograms of mysticetes have been obtained, it is impossible to define what level of sound above hearing threshold may cause behavioral effects, which could be expected to be variable, complicated and dependent upon more than just the received sound level. For this reason, observations at sea have concentrated on relating received sound levels to observed behavioral changes.

Beluga whales are mid-frequency hearing specialists. For belugas exposed to a single seismic watergun pulse (a watergun was used in the experiment rather than an airgun because its impulses contain more energy at higher frequencies where odontocete hearing thresholds are relatively low), TTS-onset occurred with unweighted peak levels of 224 dB re: 1 μPa (peak) and 186 dB re: 1 μPa2-s (Finneran et al. 2002). The latter is equivalent to a weighted (M- weighting for mid-frequency marine mammals) SEL exposure of 183 dB re: 1 μPa2-s as some of the energy in the pulse was at low frequencies to which the beluga is less sensitive. Adding 6 dB to the former (224 dB) values, Southall et al. (2007) estimates the pressure criterion for injury for mid-frequency cetaceans is 230 dB re: 1 μPa (peak).

Southall et al. (2007) also went on to discuss pinnipeds, which include 16 species and subspecies of sea lions and fur seals (otariids), 23 species and subspecies of true seals (phocids), and two subspecies of walrus (odobenids). They produce a variety of social signals, most occurring at relatively low frequencies but lack the highly specialized active biosonar systems of toothed cetaceans. Because of they are active both in and out of water, pinnipeds communicate acoustically in air and water, have significantly different hearing capabilities in the air versus water, and may be subject to both aerial and underwater noise exposure (Kastak & Schusterman 1998; Kastak et al. 2005). Therefore, pinnipeds have different hearing criteria. NMFS' policy has been to use 190 dB rms, where onset Level A harassment from acoustic sources potentially begins for pinnipeds in water. NMFS has not established in-air Level A harassment criteria. However, USFWS uses 180 dB-A (air) for their Level A harassment criteria. The Level B harassment criteria are 160 dB rms for impulsive noise and 120 dB rms for non-pulse noise (NMFS 2012).

Since seismic surveys are less likely to affect pinnipeds, such as Steller sea lions, in air, the in-water impacts are discussed here. It is also acknowledged that there are "among species differences in the exposure conditions that elicited TTS under water" (Southall et al. 2007). Steller sea lion hearing has not specifically been studied but for the purposes of this analysis, it is assumed that their hearing is comparable to that of California sea lions. Comparative analyses of the combined underwater pinniped data (Kastak et al. 2005) indicated that, in the harbor seal, a TTS of *ca*. 6 dB occurred with 25-min exposure to 2.5 kHz OBN with SPL of 152 dB re: 1 μPa (SEL: 183 dB re: 1 μPa2-s). Under the same test conditions, a California sea lion showed TTS-onset at 174 dB re: 1 μPa (SEL: 206 dB re: 1 μPa2-s), and a northern elephant seal experienced TTS-onset at 172 dB re: 1 μPa (SEL: 204 dB re: 1 μPa2-s). Data on underwater TTS-onset in pinnipeds exposed to pulses are limited to a single study. Finneran et al. (2003) exposed two California sea lions to single underwater pulses from an arc-gap transducer. They found no measurable TTS following exposures up to 183 dB re: 1 μPa (peak-to-peak) (SEL: 163 dB re: 1 μPa2-s).

Southall et al. (2007) did not discuss sea otters due to a lack of key hearing data. Further, there is little information on the effects of noise associated with oil and gas exploration on sea otters. Their production and use of sound underwater has not been studied. Airborne sounds are diverse and include screams, whines, whistles, growls, cooing, squeaks, hisses, and grunts (McShane et al. 1995). Mothers and their pups communicate by calling, and both call to one another if separated. Most of the sounds in these mother-pup communications are 3-5 Hertz, but there are higher harmonics. Sandegren, Chu, and Vandervere (1973) recorded these calls from a distance of 50 meters in air. It is not known how far sea otters can hear these sounds. Available data do not indicate that sea otters are likely to be seriously impacted by seismic exploration. Riedman (1983) reported no evident disturbance reactions by sea otters in California coastal waters in response to noise from a full-scale array of airguns (67 L) and a single airgun. No disturbance was noted either when the operating seismic ship passed as close as 1.85 and 0.9 kilometers to sea otters. Sea otters continued to feed, groom, interact with pups, rest, and to engage in other normal behaviors. Riedman (1983) reported there was also no apparent reaction to the single airgun. Riedman (1983) cautioned that there are no data for the reactions of sea otters more than 400 meters offshore. Riedman (1983) reported no evidence of changes in behavior of sea otters during underwater playbacks of drillship, semisubmersible, and production platform sound. Most of the animals studied were 400 or more meters from the source of the sound. Foraging otters continued to dive and feed.

Whales and other marine mammals sometimes continue with important behaviors even in the presence of noise. Some marine mammals may be motivated by feeding opportunities to the extent that they subject themselves to increased noise levels. For example, Native hunters reported to Huntington (2000) that beluga whales often ignore the approach of hunters when feeding, but at other times will attempt to avoid boats of hunters. There is a potential for effects from geophysical survey operations on marine mammals found in Cook Inlet from non-auditory or auditory effects, including PTS, but this is expected to be negligible. Local effects could result to endangered species near noise and other disturbance caused by exploration. For example, in specific areas, particularly near the Barren Islands, these disturbances could affect the haulouts and behavior of Steller sea lions; cause local, short-term effects on the feeding of mysticetes; and locally affect some Cook Inlet beluga whales. Behavior of sea otters could be affected and some displacement of sea otters could occur near areas of activity. Although small numbers of individuals could be affected, regional population or migrant populations of non-endangered marine mammals would experience a negligible effect from disturbance and habitat alteration. The potential for injury is greatly lessened through effective implementation of assumed mitigation. Mitigation that is often implemented to reduce impacts includes use of marine mammal observers, survey vessel speed reductions, and establishment of exclusion zones.

Construction and Operation of Offshore Platforms and Pipelines. Figure 4.4.7-2 (Section 4.4.7.1.1) presents a conceptual model for potential effects of infrastructure construction on marine mammals. Under the proposed action, up to 1 to 3 offshore platforms and 40 to 241 km (25 to 150 mi) of offshore pipeline could be constructed in the Cook Inlet Planning Area (Table 4.4.1-3).

If exploration leads to development and production, impacts likely could occur from the following:

- Noise from construction of pipelines and production facilities;
- Routine and recurring traffic associated with crew and supply activities;
- Domestic wastewaters generated at the offshore facility (the scenario assumes on-platform disposal wells will reinject drilling fluids, muds, cuttings, and produced waters generated from production wells. Discharges and Wastes are described further below.);
- Trash and debris from production activities;
- Gaseous emissions from production facilities, both onshore and offshore, and from transportation vessels and aircraft; and
- Physical placement, presence, and removal of offshore production facilities, including platforms and pipelines to onshore common carrier pipelines.

Noise generated by industrial activities can come from a variety of sources, such as transportation, general machinery use, construction, and human activity. Noise, whether carried through the air or under water, may cause some species to alter their feeding routines, movement, and reproductive cycles. For cetaceans, effects from noise and disturbance associated with development would be much the same as discussed for exploration. The most likely impacts could be the disturbance of sea otters and Steller sea lions that are hauled out and the displacement of females and pups that occur near regions of focused activity. These effects are expected to be extremely local and have no population-level impacts on sea otters or Steller sea lions.

Construction may also cause an alteration in habitat and water quality for marine mammals. However, the activities associated with construction are not likely to significantly affect water quality. Construction activities would increase the turbidity in the water column along segments of the 40-km (25-mi) corridors for up to a few months, but no significant water quality degradation could occur. Further, construction activities could affect benthic organisms and fish (prey species) in the immediate vicinity. Organisms in soft substrates (bivalves and polychaetes) could be adversely affected; however, platforms would add a hard substrate to the marine environment, providing additional habitat for marine plants and animals (for example, kelp and mussels) that require a hard substrate. Therefore, the overall effect of platform and pipeline installation could be to alter species diversity in a small area. Construction activities may disturb pelagic and demersal finfishes and shellfishes, potentially displacing them from preferred habitat, as turbidity, vibrations, and noise from construction increases. Positive effects may accrue because following construction, offshore structures provide refugia to some species and their prey. Any disturbance or displacement should be localized and short term (hours to days to months), limited to only the time of construction and shortly thereafter. Effects are expected to be limited to negligible numbers of individuals in the immediate vicinity of construction activities.

The landfall of a pipeline would avoid sensitive aquatic habitat. The route for the pipeline would be sited inland from shorelines and beaches, and pipeline crossings of anadromous fish streams would be minimized and consolidated with other utility and road crossings of such streams. Pipelines would be buried wherever possible and sited in existing rights-of-way for other utilities or transportation systems wherever possible, such as that provided by the Sterling Highway. The pipelines would be designed, constructed, and maintained to minimize risk to fish habitats from a spill, pipeline break, or other construction activity. Habitat alteration due to pipeline laying and platform construction are expected to be localized and should not cause significant impacts to mobile species.

The immediate response of disturbed individuals or groups could be to leave or avoid the construction areas. This displacement or avoidance could be short or long term in duration, depending on the duration of the construction activity. Because relatively few individuals would be expected to be affected by the limited amount of construction and few new facilities that would be operating, the construction and operation of new offshore facilities would not be expected to result in population-level effects to affected marine mammals.

Facilities to be constructed and operated under the proposed action may occur in or near beluga whale critical habitat area 2 (76 FR 20180). Construction and operation of offshore platforms and pipelines are expected to have negligible impact to beluga habitat and would not be expected to affect movement of belugas within Cook Inlet. However, if activities were to occur in or near the beluga whale critical habitat, ESA consultation would occur to ensure the protection of the species and their habitat.

Critical habitat designation for the Steller sea lion (50 CFR 226.202) includes a 0.9-km (3,000-ft) radius terrestrial and air zones around designated rookeries within the Cook Inlet Planning Area, as well as a 37-km (20-NM or 23-mi) aquatic zone around all major rookeries and haulouts. Additional restrictions (50 CFR 223.202) associated with Steller sea lion critical habitat include a 5.5-km (3-NM or 3.4-mi) radius vessel approach zone around listed rookeries, and 1.9-km a (1-NM or 1.2-mi) minimum distance for vessel passing near rookery sites (50 CFR 223.202). Compliance with these critical habitat designations, restrictions, and buffer zones could greatly reduce the likelihood of exposure of Steller sea lion rookeries and haulouts to OCS activities that could occur in the Cook Inlet Planning Area.

Discharges and Wastes. Table 4.4.1-3 presents information on drilling fluids, drill cuttings, and produced waters discharged offshore as a result of the proposed action. Figure 4.4.7-3 (Section 4.4.7.1.1) presents a conceptual model for potential effects of operational waste discharges on marine mammals. Produced water, drilling muds, and drill cuttings are discharged into offshore marine waters in compliance with applicable regulations and permits. Compliance with regulations and permits will limit the exposure of marine mammals to waste discharges.

Up to 500 bbl of drill fluids and 600 tons of drill cuttings will be discharged at each exploration and delineation well (Table 4.4.1-3). Heavier components of these muds and cuttings (such as rock) would settle to the bottom, while lighter components could increase turbidity around the drill site. While this increased turbidity could cause marine mammals to avoid the area, any increase in suspended solids associated with the discharge of drilling wastes would be rapidly diluted and dispersed, and thus not be expected to adversely affect marine mammals in the area. Drilling fluids and cuttings associated with development and production wells would be treated and disposed of in the wells, minimizing impacts to marine mammals from these wastes.

The OCS-related vessels supporting exploration activities and the construction and operation of offshore platforms and pipelines will generate waste fluids (such as bilge water) which may be discharged to the surface water. Such discharges, if allowed, would be regulated under applicable NPDES permits. Sanitary and domestic wastes would be processed through shipboard waste treatment facilities before being discharged overboard, and deck drainage would also be processed aboard ship to remove oil before being discharged. Because of the low level of expected vessel traffic, relatively small volumes of operational wastes would be discharged, and these would be rapidly diluted and dispersed.

Solid debris can adversely impact marine mammals through ingestion or entanglement (Marine Mammal Commission 2003). Mammals that ingest debris, such as plastics, may experience intestinal blockage, which in turn may lead to starvation, while toxic substances present in the ingested materials (especially in plastics) could lead to a variety of lethal and sublethal toxic effects. Entanglement in plastic debris can result in reduced mobility, starvation, exhaustion, drowning, and constriction of, and subsequent damage to, limbs caused by tightening of the entangling material. The discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by BOEM (30 CFR 250.40) and the USCG

(International Convention for the Prevention of Pollution from Ships [MARPOL], Annex V, P.L. 100-220 [101 Statute 1458]).

Only small amounts of drilling fluids and produced waters are anticipated to be discharged during production. The hydrodynamic processes in the Cook Inlet suggest the water column generally is well mixed, and dilution would reduce the concentration of the substances in the discharges. Degradation processes also act to continuously reduce the concentrations of many substances deliberately or accidentally released into the environment. We do not expect the discharge of drilling muds and cuttings and other discharges associated with exploration drilling to have any effect on the overall quality of Cook Inlet water. Within a distance of between 100 and 200 m (328 and 656 ft) from the discharge point, the turbidity caused by suspended-particulate matter in the discharged muds and cuttings would dilute to levels that are less than the chronic criteria (100–1,000 parts per million) and within the range associated with the variability of naturally occurring suspended particulate matter concentrations. Mixing in the water column would reduce the toxicity of the drilling muds that already fall into the "practically nontoxic" category to levels that would not be harmful to organisms in the water column. In general, the amounts of additives in the other discharges are likely to be relatively small (from 4 to 400 or 800 liters/month and diluted with seawater several hundred to several thousand times before being discharged into the receiving waters. The potential effects in any of the areas where there are permitted discharges would last for about 3–4 months for each exploration well drilled.

Vessel and Aircraft Traffic. There may be up to 9 surface vessels and 9 helicopter trips per week under the proposed action (Table 4.4.1-3). Figure 4.4.7-3 (Section 4.4.7.1.1) presents a conceptual model for potential effect of vessel traffic on marine mammals. Vessel traffic could occur during seismic exploration, drilling and platform construction, platform operation, and platform decommissioning. Generally, marine mammals may be affected by direct collisions with vessels or by visual and noise disturbances.

In addition to possible collision-related injuries and/or mortalities, cetaceans and pinnipeds in the vicinity of an OCS-related vessel may be disturbed by the presence of vessels and helicopters and the noise they generate. Noises emitted by shipping vessels are expected to range between 140 dB re 1 μPa for smaller vessels to 198 dB re 1 μPa for larger tankers and cargo ships (Heathershaw et al. 2001; Erbe 2002; Hildebrand 2004). Helicopters flying at 150 m (492 ft) altitude are expected to emit noises received at ground level of approximately 80 to 86 dB re 20 μPa (Born et al. 1999). Reactions of cetaceans, including both odontocetes and mysticetes, may include apparent indifference, cessation of vocalizations or feeding activity, increases in vocal behavior, and evasive behavior (e.g., turns, diving, etc.) (Richardson et al. 1995; Nowacek et al. 2001; Buckstaff 2004; Doyle et al. 2008). Noise from service vessels may also mask cetacean sound reception (MMS 2003e). Disturbed individuals would be expected to cease their normal behaviors and likely move away from the vessel. Following passage of the vessel, affected individuals may return and resume normal behaviors.

Cetaceans, such as humpback whales, near the Barren Islands and the southern portions of the Cook Inlet also could be negatively affected by vessel transport and construction activities. However, this area has a high volume of fishing- and tourism-related vessel traffic in the summer months when the whales are present. The incremental addition of noise from two vessels per day associated with the proposed action is unlikely to add significantly to this existing noise.

Based on their distributions, humpbacks are more vulnerable to aircraft noise than fin whales. Shallenberger (1978) reported that some humpbacks were disturbed by overflights at 305 m (1,000 ft), whereas others showed no response at 152 m (500 ft). As with the response to airgun noise, pods varied in their response. Humpbacks in large groups showed little or no response but some adult-only groups exhibited avoidance (Lukenberg and Parsons 2009). Other authors report no response (for example, Friedl and Thompson, 1981).

Belugas could be disturbed by noise and disturbance from exploration and development-related aircraft, especially helicopters. Belugas reacted to aircraft flying at 150–200 m (492–656 ft) by diving for longer periods, reducing surfacing time and sometimes swam away (see references cited in Richardson et al. 1995). They did not respond to aircraft at 500 m (1,640 ft). Richardson et al. (1991) found variable reactions to turbine helicopters and fixed wing aircraft in offshore waters near Alaska. Some individuals exhibited no discernible response even when the aircraft was within 100–200 m (328–656 ft), whereas other individuals dove abruptly, looked upward, or turned sharply in response to aircraft at altitudes up to 460 m (1,510 ft). As reviewed by Norman (2011), beluga whales are apparently less responsive to overflights when engaged in feeding, social activities, or mating than when resting. Also, Cook Inlet belugas rarely react to fixed-wing aircraft flown at altitudes of 244 m (800 ft). They tend to react to overflights at lateral distances of ≤250 m (820 ft) than to overflights at farther lateral distances.

Vessel traffic may disturb pinnipeds and sea otters (which are discussed further below) in the water and hauled out on ice or terrestrial habitats. For example, when approached too closely or disturbed too often, harbor seals are known to abandon their favorite haul-out sites or their pups (Kinkhart et al. 2008). Hauled out pinnipeds may exhibit behavioral reactions to the physical disturbance of an approaching vessel or aircraft by exhibiting startle reactions, slipping into the water. In recognition of their vulnerability to loud and startling noises, Steller sea lion critical habitat has been defined to include a terrestrial zone that extends 914 m (3,000 ft) landward from the baseline or base point of each Steller sea lion major rookery or major haulout and an air zone that extends 914 m (3,000 ft) above the terrestrial zone, as measured at sea level around them. Assuming aircraft flying to any platforms maintain sufficient distances from these rookeries, based on recognition of this critical habitat, it not likely this form of disturbance would have a major impact on Steller sea lions. However, it is possible that sea lions could be negatively affected by oil- and gas-activity-related helicopters (and possibly by other noise) operating at further distances. Under the proposed scenario, one to two helicopter trips per day would be made to oil and gas operations from Kenai or other sites along the western Kenai Peninsula shore. In most of the proposed Cook Inlet multiple-sale area, these flights would not require transit over any terrestrial components of Steller sea lion critical habitat and adverse effects could easily be avoided. The greatest potential for such disturbance could come from helicopters transiting to blocks on the far side of the Barren Islands if flights originated on the Kenai Peninsula and stayed, as geography permits, near land until crossing of the entrances of Cook Inlet was required to reach drill (or production) sites on the far sides of the Barren Islands.

Major rookeries in and near the Cook Inlet include Outer Island, Sugarloaf Island, Marmot Island, Chirikof Island, and Chowiet Island. There are several major haulouts in and near the Cook Inlet, 20-NM aquatic zones, and an aquatic foraging area in Shelikof Strait. All of these are part of Steller sea lion critical habitat. Support-vessel traffic would be unlikely to adversely affect these habitats as long as operators avoided transiting near to the rookeries or haulouts or deliberately approaching sea lions in the water. Critical habitat of Steller sea lions is unlikely to be impacted by exploration activities. As noted above, terrestrial zones are legally protected from activities degrading them by disturbance. Shelikof Strait was designated as critical habitat because of its proximity to major rookeries and important haulouts, its use by foraging sea lions and its value as an area of high forage-fish production. Any adverse impacts of oil and gas development that adversely affect the production and availability of prey to Steller sea lions in this and other critical habitat could adversely modify the habitat. Aircraft restrictions associated with Steller sea lion critical habitat protection (50 CFR 223.202; 50 CFR 226.202) could further reduce the likelihood of helicopter flights impacting designated rookery sites for this listed species. Careful planning of flight paths to avoid rookeries and haulouts of other pinnipeds could further reduce or eliminate the potential for disturbing animals in these habitats.

Boat traffic associated with OCS oil and gas exploration activity could disturb sea otters in specific areas. In summer, these impacts are likely to be insignificant compared to the quantity of fishing, tourism, shipping, and other boat traffic in the region. In winter, boat traffic in a remote region could have local impacts on distribution of females and pups. Garshelis and Garshelis (1984) reported that sea otters in Prince William Sound avoided waters with frequent boat traffic but reoccupy these areas when boats are less frequent. Rotterman and Monnett (2002) concluded that disturbance after the *Exxon Valdez* oil spill was sufficient to keep sea otters from feeding habitat in certain bays in oiled areas of Prince William Sound. Udevitz et al. (1995) reported that about 15% of sea otters along boat survey transects are not detected because they move away from the approaching boat. Boat traffic could disturb resting patterns of sea otters. Sea otters in Alaska haul out regularly. Sea otters that are hauled out will often move into the water with the approach of a boat. Garrott et al. (1993) reported that sea otters on shore would move into the water with approach of a single small motorboat moving parallel to and 100 m (328 ft) from shore.

As previously discussed, the FAA Advisory Circular 91-36D (FAA 2004) encourages pilots to maintain higher than minimum altitudes over noise-sensitive areas. Also, guidelines and regulations issued by NMFS under the authority of the MMPA include provisions specifying helicopter pilots to maintain an altitude of 305 m (1,000 ft) within 91 m (300 ft) of marine mammals (MMS 2007e). Helicopter operations would only be expected to occur below specified minimums during inclement weather. In MMS (2007e), it was concluded that this could occur for about 10% of helicopter operations. Because of the low level of vessel and aircraft traffic that could occur under the proposed action, potential impacts to marine mammals from this traffic would likely be limited to a few individuals, be largely short-term in nature, and not result in population-level effects.

<u>Decommissioning.</u> Under the proposed action, no platforms will be removed with explosives from the Cook Inlet Planning Area. Therefore, potential impacts of decommissioning on marine mammals, as summarized in Figure 4.4.7-4 (Section 4.4.7.1.1), will not occur.

Impacts of Expected Accidental Spills. Accidental oil spills are expected to occur in Cook Inlet under the proposed action (Section 4.4.2). Table 4.4.2-1 presents the oil spill assumptions for the proposed action, while Figure 4.4.7-5 (Section 4.4.7.1.1) presents a conceptual model for potential effects of oil spills on marine mammals. It is assumed that as many as 15 very small oil spills (≤50 bbl), 3 small oil spills between 50 and 1,000 bbl, and 1 large spill greater than 1,000 but less than 75,000 bbl could occur under the Program. Small oil spills (≤1,000 bbl) break-up and dissipate within hours to a day (MMS 2009a). Larger spills, particularly those that continue to flow fresh hydrocarbons into waters for extended periods (i.e., days, weeks, or months), pose an increased likelihood of impacting marine mammal populations (MMS 2008b). While the numbers of spills have been steadily decreasing since the 1970s, operational discharges such as tank washing with seawater, oil content in ballast water, and fuel oil sludge are among the sources of small oil spills from tankers (Jernelöv 2010). Large oil spills from tankers have decreased significantly in recent years (modern tankers have double hulls and are sectioned to prevent losing the ship's entire cargo and sea lanes have been established) while spills from ageing, ill-maintained or sabotaged pipelines have increased.

Characteristics of impacts (i.e., acute vs. chronic impacts) depend on the magnitude, frequency, location, and date of accidents; characteristics of spilled oil; spill-response capabilities and timing; and various meteorological and hydrological factors. Chronic or acute exposure may result in harassment, harm, or mortality to marine mammals. Studies have shown varying results. Bottlenose dolphins made no consistent avoidance of spilled oil (Smultea and Würsig 1995); however, marine mammals have been observed apparently detecting and avoiding slicks in other cases (Geraci and St. Aubin 1988). Marine mammals' exposure to hydrocarbons persisting in the sea following the dispersal of an oil slick may result in sublethal impacts (e.g., decreased health, reproductive fitness, and longevity; and increased vulnerability to disease) to marine mammals.

Impacts on marine mammals from exposure to oil spills could include decreased health, reproductive fitness, and longevity, and increased vulnerability to disease. Spilled oil can cause soft tissue irritation, fouling of baleen plates, respiratory stress from inhalation of toxic fumes (e.g., irritation and damage to mucus membranes), food reduction or contamination, direct ingestion of oil and/or tar, and temporary displacement from preferred habitats (St. Aubin and Lounsbury 1988; Geraci and St. Aubin 1980, 1988). The long-term impacts to marine mammal populations are poorly understood but could include decreased survival and lowered reproductive success. One assumption concerning the use of dispersants is that the chemical dispersion of oil will considerably reduce the impacts to marine mammals, primarily by reducing their exposure to petroleum hydrocarbons (French-McCay 2004; NRC 2005b). However, the impacts to marine mammals from chemical dispersants could include nonlethal injury (e.g., tissue irritation, inhalation), long-term exposure through bioaccumulation, and potential shifts in distribution from some habitats. Water and air quality degradation associated with response and cleanup vessels could also affect marine mammals.

Impacts on marine mammals from smaller accidental spill events could adversely affect individual marine mammals, but are unlikely to rise to the level of population-level effects, given the size and scope of such spills. Assuming that all small spills would not occur at the same time and place, water quality could rapidly recover and therefore not have significant effects on marine mammals or their prey species. The potential effects associated with a large spill could be more adverse than a smaller accidental spill and could potentially contribute to longer-lasting effects. Impacts from dispersants are unknown, but they could be irritants to tissues and sensitive membranes (NRC 2005b).

Small and large spills occurring in the Cook Inlet Planning Area are not expected to affect the listed blue, sei, sperm, or North Pacific right whales, as these species occur only infrequently, if at all, within the area (MMS 2003e). However, it is important to note that any impacts that affect the survival or reproductive capacity of individuals of species that are already declining (listed species) could result in population-level impacts. The endangered beluga, fin, and humpback whales, as well as the minke and killer whales, which do occur within or in the vicinity of the Cook Inlet Planning Area, could be affected by accidental spills occurring in or reaching the Shelikof Strait. Gray whales migrating past Cook Inlet could be exposed to accidental spills occurring near the Kennedy and Stevenson entrances to Cook Inlet. Accidental spills in the Cook Inlet Planning Area could also expose beluga whales and smaller cetacean species (such as Dall's porpoise) and pinnipeds foraging in open marine waters. Because of the small number and mostly small size of spills expected under the proposed action, anticipated exposures of most of these species to spilled oil would be temporary and likely affect only a few individuals (MMS 2003e). However, a large oil spill in upper Cook Inlet could severely impact beluga whales and put the population at risk (NMFS 2008a).

Oil spills could have serious impacts on pinnipeds during periods when they are concentrated at rookeries (typically, late spring, summer, and early fall). At such times, spills and/or spill response operations have the potential to disturb hundreds of pinnipeds. If a spill contaminates a rookery, a significant population decline could occur (Calkins et al. 1994). Sea otters, sea lions, and harbor seals had elevated hydrocarbon levels in areas contaminated by the *Exxon Valdez* oil spill; but only sea otters and harbor seals showed population declines associated with the spill (Loughlin et al. 1996). The findings for harbor seals were refuted by Hoover-Miller et al. (2001). They concluded that rather than high unsubstantiated mortality, the evidence was more consistent with harbor seals avoiding or moving away from oiled haulouts. Also, the cause of deaths of the harbor seals recovered (mostly pups) could not be determined, nor could the proportion of individuals that would have died naturally.

Spills occurring in or reaching coastal areas, especially sheltered coastal habitats such as bays and estuaries, pose the greatest risk to marine mammals. These spills may be more likely to affect species such as the sea otter and the Steller sea lion that use coastal habitats for pupping, foraging, and resting. A large spill contacting an active pinniped rookery site could result in population-level effects for some species, while spills in nearshore areas could result in the direct oiling of large numbers of pinnipeds and sea otters, and adversely affect local populations of some of these species (primarily the sea otter and fur seals), while sublethal effects may be incurred by all individuals ingesting or inhaling spilled oil.

As discussed in Section 4.4.7.1.1, oil spill response activities may affect marine mammals through exposure to spill response chemicals (e.g., dispersants or coagulants) and through behavioral disturbance during cleanup and restoration operations. The chemicals used during a spill response are toxic, but are considered much less so than the constituents of spilled oil (Wells 1989), although there is little information regarding their potential effects on marine mammals. The presence of, and noise generated by, oil spill response equipment and support vessels could temporarily disturb marine mammals in the vicinity of the response action, with affected individuals likely leaving the area. While such displacement may affect only a small number of animals, cleanup operations disturbing adults in pup-rearing areas may decrease pup survival and result in population-level effects. While some smaller marine mammal species such as seals and otters can be collected and examined closely, impacts on whales from oil spills are difficult to assess because large numbers of most of the species cannot be easily captured, examined, weighed, sampled, or monitored closely for extended periods of time.

If loss of control of a natural gas well occurs and results in explosion and fire, beluga whales or other marine mammals in the immediate vicinity could be killed. Natural gas and gas condensates that did not burn would be hazardous to any organism exposed to high concentrations. Effects from losses of natural gas well control are likely to be short-term and localized, lasting a year or less and extending for about 1.6 km (1 mi) (MMS 2003a).

Impacts of an Unexpected Catastrophic Discharge Event. A CDE in the Cook Inlet Planning Area would be a possible, but unexpected, very low-probability event under the five-year plan. The PEIS analyzes an unexpected CDE in the Cook Inlet Planning Area that ranges from 75 to 125 thousand bbl that lasts from 50 to 80 days (Table 4.4.2-2). If a CDE occurs, there is greater potential for more severe effects compared to the risk of effects from an assumed large oil spill. A CDE would result in sustained degradation of water quality and, to a lesser extent, air quality that would impact marine mammals from direct contact, inhalation, and ingestion (either directly or indirectly through the consumption of oiled forage or prey species). These effects would be significant, causing a multitude of acute and chronic effects. Additional effects on marine mammals would occur from water and air quality degradation associated with response and cleanup vessels, *in situ* burning of oil, dispersant use, discharges and seafloor disturbances from relief well drilling, and activities on shorelines associated with cleanup, booming, beach cleaning, and monitoring. Contraction of the Cook Inlet beluga whale population northward into the upper portions of the inlet makes the population more vulnerable to a CDE (NMFS 2008a). A CDE in Cook Inlet would potentially impact marine mammals throughout much of south central Alaska and has the potential to increase the area and duration of an oil spill, thereby increasing the potential for population-level effects, or at a minimum, an increase in the number of individuals killed.

One resident killer whale pod (AB Pod) and one transient killer whale population (AT1 Group) suffered losses of 33 and 41%, respectively, in the year following the *Exxon Valdez* oil spill. Sixteen years after the spill, the resident pod had not returned to pre-spill numbers, while the transient population lost nine members following the spill and continued to decline to the point that it is listed as depleted under the MMPA (Matkin et al. 2008). Additionally, sea otters and harbor seals showed population declines associated with the spill (Loughlin et al. 1996). An estimated 3,905 sea otters were killed by the *Exxon Valdez* oil spill (DeGange et al. 1994). Sea otter abundance in some oiled areas remains under pre-spill estimates, suggesting that sea otters have not fully recovered (USFWS 2008). Oiling and ingestion of oil-contaminated shellfish may have affected reproduction and caused a variety of long-term sublethal effects (Fair and Becker 2000). The recovery of sea otters may be constrained by residual spill effects resulting from elevated mortality and emigration (Bodkin et al. 2002). An estimated 302 harbor seals were killed by the *Exxon Valdez* oil spill, probably due to the inhalation of toxic fumes (Frost and Lowry 1994). Subsequent investigations revealed that there were no significant quantities of oil in the tissues (liver, blubber, kidney, and skeletal muscles) of harbor seals exposed to the *Exxon Valdez* spill (Bence and Burns 1995), and that the cause of the decreasing trend in harbor seal numbers since the spill (4.6% per year) is complicated because seal populations were declining prior to the spill (Frost et al. 1999). As previously discussed, Hoover-Miller et al. (2001) also refuted Frost and Lowry's (1994) findings for harbor seals.

During an oil spill off Santa Barbara in 1969, an estimated 80,000 bbl of oil may have entered the marine environment. Gray whales, beginning their annual northern migration during the spill event, swam through the slick. Several dead whales were observed and six carcasses recovered. No link was established between oil contamination and the death of the gray whales. Also, no effects on the gray whale population or migration were observed (BOEMRE undated). The Battelle Memorial Institute concluded the whales were either able to avoid the oil or were unaffected when in contact with it. Similarly, extensive beached carcass surveys made after the *Exxon Valdez* oil spill included a number of gray whales. The number of carcasses found was the result of such an atypical survey effort and were comparable to gray whale strandings along the Pacific coast, well south of the *Exxon Valdez* oil spill area.

MMS (2003a) provided an assessment of an unexpected, low-probability CDE on marine mammals in the Cook Inlet Planning Area. In that assessment, it was determined that individuals or small groups of humpback, fin, and beluga whales, and potentially larger groups of humpback whales, could be exposed, injured, or potentially killed. At a minimum, this could cause short-term changes in the local distribution and abundance of these species. A population-level impact to humpback whales could potentially occur if a CDE occurred in the Barren Islands area when large numbers of humpback whales are present and feeding. Fin whales would be vulnerable to a CDE if oil entered the Shelikof Strait at any time of the year; humpback whales would primarily be vulnerable from late spring through late fall. Beluga whales from the Cook Inlet DPS could incur both direct and indirect adverse impacts, particularly during the winter months when they occur in the middle and lower reaches of Cook Inlet. A CDE could potentially result in a population-level impact to the beluga whale DPS. Some Steller sea lion rookeries and haulouts could be exposed to oil from a CDE. A population-level effect could occur if pups are on the rookeries or large numbers of sea lions are exposed when on haulouts. Possible population-level effects could also occur to sea otters. Impacts could also occur to most of these marine mammal species if their prey are significantly reduced or contaminated by a CDE. Other cetaceans such as harbor seals, Dall's porpoise, and killer and gray whales could potentially encounter oil. Some individuals could potentially be killed (e.g., if they inhaled lethal amounts of toxic fumes). If such losses occurred in a family group of killer whales, recovery could take more than one generation (e.g., more than 10 years).

Impact Conclusions.

Routine Operations. Within the Cook Inlet Planning Area, noise generated during seismic surveys, exploration and production activities, platform removal, and by OCS-related vessels and helicopters may temporarily disturb some individuals. Contaminants in waste discharges and drilling muds might indirectly affect marine mammals through food-chain biomagnification, although the scope of effects and their magnitude are not known. However, this information is not essential to the determination of a reasoned choice among alternatives. Small numbers of marine mammals could be killed or injured by chance collision with service vessels and by eating indigestible debris, particularly plastic items, lost from service vessels, drilling rigs, and platforms. While vessels may collide with marine mammals, the most likely impact on marine mammals would be changes in behavior (e.g., avoidance responses). Normal behavior is expected to return once a vessel or helicopter has passed. The potential also exists for some individuals to entangle in OCS-related trash and debris.

Overall, impacts on marine mammals could range from negligible to moderate. Many of the listed cetacean species occur infrequently, if at all, within the Cook Inlet Planning Area and thus would not be expected to be affected by normal operations. However, some areas inhabited by the Cook Inlet beluga DPS, including portions of their critical habitat, overlap the Cook Inlet Planning Area.

<u>Expected Accidental Spills.</u> Any of the oil spill scenarios developed for the proposed action (Section 4.4.2) may expose marine mammals from the Cook Inlet Planning Area to oil or its weathering products. The magnitude of effects from accidental spills would depend on the location, timing, and volume of the spills; the environmental settings of the spills (e.g., restricted coastal waterway, deepwater pelagic location); and the species (and its ecology) exposed to the spills. Spill cleanup operations could result in short-term disturbance of marine mammals in the vicinity of the cleanup activity, while a collision with a cleanup vessel could injure or kill the affected individual.

Overall, small oil spills ≤50 bbl are expected to have negligible to minor impacts on marine mammals. Small spills (>50 bbl) and large spills (≥1,000 bbl) are expected to have minor to moderate impacts on marine mammals. Oil spill impacts on species that are extralimital to rare are expected to be negligible to minor, but could in unusual circumstances be moderate to major depending on the number of individuals contacted by a spill. Impacts on marine mammals from oil spill response activities are expected to be minor.

<u>An Unexpected Catastrophic Discharge Event.</u> In the case of an unexpected, low-probability CDE, there is greater potential for more severe and population-level effects compared to a large oil spill (i.e., impacts could be moderate to major on one or more species of marine mammals). The combination of a CDE and cleanup efforts could persist beyond one season, perhaps lasting several years.

Terrestrial Mammals. There are approximately 40 species of terrestrial mammal that occur in southern Alaska. Among these, 10 species may regularly use mainland and island habitats adjacent to or near the Cook Inlet Planning Area (Section 3.8.1.2.2), and thus could be affected by OCS-related activities.

Impacts of Routine Operations. Under the proposed action, up to 80 km (50 mi) of new onshore pipeline would be installed along Cook Inlet, which could result in up to 364 ha (900 ac) of soil disturbance. The area disturbed represents an extremely small portion of terrestrial wildlife habitat that occurs inshore of the Cook Inlet Planning Area. Wildlife are expected to avoid the area where construction of new pipeline is occurring. Few additional impacts, other than those that might occur from helicopter overflights, would occur on terrestrial mammals. Helicopter traffic could disturb wildlife near the existing onshore facilities and pipelines or along the overland portions of flight paths between the existing onshore facilities and new offshore platforms. The aircraft effects on wildlife vary by species, habitat type, and the wildlife activity occurring at the time of the overflight. During overflights, some wildlife will cease their normal behaviors until the aircraft has passed and then resume their normal activity; others may flee the area, while some species may become habituated and experience no disturbance (Harting 1987). Aircraft overflights would be relatively infrequent (no more than three flights per week per offshore platform). Thus, no long-term, population-level effects are expected from aircraft overflights associated with routine operations.

Impacts of Expected Accidental Spills. An offshore oil spill that contaminates beaches and shorelines could affect terrestrial mammals, such as the Sitka black-tailed deer, brown bear, and river otter, that forage in intertidal habitats (*Exxon Valdez* Oil Spill Trustees 1992). An onshore oil spill could similarly affect terrestrial animals, such as American black bear or moose that may forage in the area of the onshore pipeline. Spills contacting high-use areas, such as coastal habitats along Shelikof Strait heavily used by brown bears, could locally affect a relatively large number of animals (MMS 2003e). The impacts on wildlife from an oil spill would depend on such factors as the time of year and volume of the spill, type and extent of habitat affected, and home range or density of the wildlife species. The potential effects on wildlife from oil spills could occur from direct contamination of individual animals, contamination of habitats, and contamination of food resources (ADNR 1999). Acute (short-term) effects usually occur from direct oiling of animals, while chronic (long-term) effects generally result from such factors as accumulation of contaminants from food items and environmental media (e.g., sediments). Terrestrial mammals directly contaminated by an accidental release of oil could inhale volatile organics and/or ingest oil while grooming contaminated fur (MMS 1996b). Exposure may also occur through the consumption of contaminated foods. The moose and opportunistic omnivores, such as brown and American black bears, may experience a greater potential of exposure than many other wildlife species. Staging and support activities for a large spill cleanup could temporarily displace terrestrial mammals not only from the contaminated habitats but also from nearby uncontaminated habitats. Depending on the effectiveness of the cleanup activities, chronic oil exposure may continue for years in some habitats.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes an unexpected, very low-probability CDE of 75 to 125 thousand bbl lasting 50 to 80 days (Table 4.4.2-2). If a CDE occurs, there is greater potential for more severe effects compared to the risk of effects from an assumed large oil spill. A CDE would result in sustained degradation of water quality, shoreline terrestrial habitats, and, to a lesser extent, air quality that could impact terrestrial mammals from direct contact, inhalation, and ingestion (either directly or indirectly through the consumption of oiled forage or prey species). These effects could be significant, causing a multitude of acute and chronic effects. Additional effects on terrestrial mammals would occur from land and air quality degradation associated with response and cleanup vessels, *in situ* burning of oil, dispersant use, and activities on shorelines associated with cleanup, booming, beach cleaning, and monitoring. A CDE has the potential to alter terrestrial mammal habitats and populations. However, only minor impacts to terrestrial mammals were observed from the *Exxon Valdez* oil spill. No Sitka black-tailed deer were found whose death could be attributed to the *Exxon Valdez* oil spill. However, some deer that fed on kelp in the intertidal areas had slightly elevated concentrations of petroleum hydrocarbons in their tissues (*Exxon Valdez* Oil Spill Trustees 1992). Several river otter carcasses were found following the *Exxon Valdez* oil spill. Analysis showed that they accumulated petroleum hydrocarbons. Also, home ranges in oiled areas were twice that of unoiled areas, suggesting that increased foraging was required to find sufficient food resources. Body lengths, weights, and dietary diversity were also lower in oiled areas (*Exxon Valdez* Oil Spill Trustees 1992). Sellers and Miller (1999) examined the impacts of the *Exxon Valdez* oil spill on Katmai National Park coastal brown bears from 1989 through 1995. Four of the 27 fecal samples from bears captured in 1989 contained hydrocarbons, indicating exposure to crude oil. Many bears remained at higher elevations during May 1989 and, thus, were not present along the coastal areas where most oiled carcasses that bears could have consumed occurred. Oil may have caused the deaths of two yearling brown bears. However, no population-level impacts on the bears of Katmai were indicated (Sellers and Miller 1999).

MMS (2003a) provided an assessment for a low-probability CDE on select terrestrial mammals that occur in the Cook Inlet Planning Area. It was determined that oil from a CDE could cause the loss of up to 50 river otters, 20 brown bears, and 20 Sitka black-tailed deer. River otter habitat could remain contaminated for up to 5 years and brown bear habitat for more than 1 year. If oil contaminated the shorelines of Raspberry, Afognak, and Kodiak Islands, elk and Sitka black-tailed deer could be impacted by direct oiling or by consuming oiled vegetation. No population-level impacts were expected.

Impact Conclusions.

Routine Operations. Up to 120 km (75 mi) of onshore pipeline would be constructed and operated as part of the proposed project; thus impacts to terrestrial mammals would include a minor loss or modification of habitat and behavioral responses associated with occasional helicopter traffic to and from new platforms. Loss or modification of habitat for the pipeline would affect a very minor amount of wildlife habitat within the Cook Inlet area. The disturbance of wildlife by helicopter flights would be short-term in nature and not expected to result in population-level effects. Overall, routine operations associated with the proposed action will have negligible to minor impacts on terrestrial mammals along the shorelines of Cook Inlet.

Expected Accidental Spills. Oil spills may expose terrestrial mammals to oil or its weathering products. In the event of an expected accidental small or large spill, terrestrial mammals may be exposed via ingestion of contaminated food, inhalation of airborne oil droplets, and direct ingestion of oil during grooming, which may result in a variety of lethal and sublethal effects. However, because most spills would be relatively small (<1,000 bbl and most <50 bbl), relatively few individuals would likely be exposed. While some individuals may incur lethal effects, population-level impacts would not be expected. Cleanup activities could temporarily disturb terrestrial mammals, causing those animals to move from preferred to less optimal habitats, which, in turn, could affect overall condition. Such displacement would be limited to those relatively few animals in the vicinity of cleanup activities, and thus would not be expected to result in population-level effects. Overall, accidental oil spills and associated cleanup activities are expected to have negligible to minor impacts to terrestrial mammals. Habitat recovery from small spills would probably require no more than a year.

<u>An Unexpected Catastrophic Discharge Event.</u> In the case of an unexpected, very low-probability CDE, there is greater potential for terrestrial habitats to be impacted compared to an assumed large oil spill. Impacts to terrestrial mammals could be minor to major. The combination of a CDE and cleanup efforts could persist beyond one season, perhaps lasting several years.

4.4.7.1.3 Alaska – Arctic.

Marine Mammals. There are 15 resident or seasonal species of marine mammals in the Arctic region, including 9 species of cetaceans, 5 species of pinnipeds, and 1 fissiped species (Table 3.8.1-4; Section 3.8.1.3.1). All of the species occur in the Chukchi Sea; the Pacific walrus and the bearded and ribbon seals also occur in the western portions of the Beaufort Sea, while the ringed and spotted seals, bowhead and beluga whales, and polar bear occur throughout both seas (Section 3.8.1.3.1). The endangered fin and humpback whales are only occasional transients in the southern portion of the Chukchi Sea during summer. The endangered bowhead whale migrates through the Chukchi and Beaufort Seas between its wintering grounds in the Bering Sea and its summering grounds primarily in the Canadian portion of the Beaufort Sea (Figure 3.8.1-4; Section 3.8.1.3.1). However, some individuals remain in the Alaska portion of the Beaufort Sea and in the Chukchi Sea during summer. Thus, the bowhead whale has the greatest potential of the endangered whale species to occur in areas where OCS-related activities are occurring and be affected by normal operations or oil spills. The potential for this would be most probable during the bowhead whale’s spring and fall migrations that generally occur from March through June and September through November, respectively (Allen and Angliss 2011).

There are at least 9 species of seasonal or resident cetaceans- bowhead, fin, humpback, minke, gray, beluga, and killer whales; harbor porpoise (Suydam and George 1992) occur with rare or observational accounts of narwhals. Bearded seals occur throughout the Beaufort Sea and into the Canadian High Arctic and Greenland. There are more seasonal residents (3,150) than year-long resident bearded seals, but some seals remain in the Beaufort year-round. Spotted seals have small haul-outs east to the Colville River Delta and historically to Prudhoe Bay. Spotted seals are rare past Harrison Bay and are not known to occur throughout the Beaufort Sea. Gray whales occur primarily nearshore and are occasionally found as far east as the Canadian Beaufort Sea. The continental shelf in the Beaufort is much narrower than in the Chukchi, and therefore it can support fewer gray whales. Humpback whales have been observed nearshore in the Chukchi Sea and as far east as the Western Beaufort Sea. Observations of fin whales have occurred in the southern and east central Chukchi Sea. Observations of a few individuals have been more consistent over the last five years during the open water period.

Impacts of Routine Operations. Table 4.4.7-1 (Section 4.4.7.1.1) illustrates how each of the impacting factors associated with OCS oil and gas development may affect marine mammals and their habitats, while Figure 4.4.7-1 (Section 4.4.7.1) presents a conceptual model of potential impacting factors for marine mammals from oil and gas-related activities (including accidental oil spills). The following text presents an overview of potential impacts to marine mammals in and near the Beaufort and Chukchi Sea Planning Areas from the following routine operations (seismic surveys, construction of offshore facilities and pipelines, operations of offshore facilities and drilling rigs, discharges and waste generation, service vessel and helicopter traffic, and decommissioning) and from accidents. NMFS' policy has been to use the 180 dB rms isopleths, where onset Level A harassment from acoustic sources potentially begins for cetaceans and 190 dB rms for pinnipeds. The Level B harassment onset level is 160 dB rms isopleth for impulsive noise and 120 dB rms for non-pulse noise.

Seismic Surveys. During offshore exploration, seismic surveys conducted in offshore areas and in lagoon systems could affect marine mammals. Seismic surveys generally occur during the ice-free periods, normally from July to October (NMFS 2002). In the Beaufort Sea, there are also on-ice seismic surveys, which may impact ice seals and polar bear. Noise generated by seismic surveys may have physical and/or behavioral effects on marine mammals, such as hearing loss, discomfort, and injury; masking of important natural sound signals, including communications among individual whales; behavioral responses such as flight, avoidance, displacement of migration route, and changes in physical or vocal behavior (Richardson et al. 1995; Davis et al. 1998; Gordon et al. 1998; MMS 2003e). It has not been possible to predict the type or magnitude of responses to such surveys (and other oil and gas activities) nor to evaluate the potential effects on populations (NRC 2003a). However, there is no evidence to suggest that routine seismic surveys may result in population-level effects for any of the marine mammal species. Cudahy and Ellison (2002) indicated that tissue damage from exposure to underwater low-frequency sound will occur at a damage threshold on the order of 180 to 190 dB or higher. There have been no documented instances of deaths, physical injuries, or physiological effects on marine mammals from seismic surveys (MMS 2004c).

Noise from airguns and survey vessels could disturb nearby marine mammals that may be foraging in open waters or using floe ice for resting, birthing, and the rearing of young. These disturbances would be largely limited to the immediate area of the survey vessel, although animals within a few kilometers of seismic operations may be affected (Richardson et al. 1986). Because cetaceans and pinnipeds are highly mobile species, they may leave an area when a seismic survey is initiated, thereby greatly reducing their exposure to maximal sound levels and, to a lesser extent, masking frequencies. However, if they surveys occur during the winter or spring when areas of open water are restricted or isolated, young ringed or bearded seals may have some difficulty avoiding the on-ice seismic surveying, and if there are ice breakers, some ringed seal pups could be crushed inside of their lairs. If an animal is able to relocate, would likely resume its normal behavioral patterns. During the open water season, displaced or disturbed individuals may return to the area and/or resume normal behavioral patterns after the survey activities have ceased, but this is not necessarily also true for individuals displaced from on-ice seismic surveys.

Among cetaceans, the odontocetes generally demonstrate relatively poor low-frequency hearing sensitivity, and thus might not be expected to experience hearing loss from seismic surveys (unless they are in close proximity to airgun arrays) (MMS 2004a). The odontocetes in the Arctic region (beluga and killer whales and the less frequently encountered harbor porpoise and rare narwhal) may respond behaviorally to seismic surveys by leaving the areas where seismic surveys are being conducted. Unless the surveyed area is further developed, such displacement would be temporary and not expected to result in long-term impacts to either individual animals or populations of these species.

The mysticetes, which include the endangered bowhead, fin, humpback whales, as well as gray and minke whales, are considered to possess good hearing sensitivity at low frequencies down to approximately 10 Hz, and many of their vocalizations occur in the low tens to a few hundred Hz (Richardson et al. 1995; Crane and Lashkari 1996; Ketten 1998; Stafford et al. 1998). Seismic survey airgun arrays output maximal energy in the region of a few tens of Hz, which overlaps with the expected lower end of the hearing sensitivity of mysticetes. Thus, the mysticetes that occur regularly in the Chukchi and Beaufort Seas may be affected by seismic surveys. Exposure of these whales to maximal airgun output during a seismic survey may result in behavioral changes such as area avoidance or short-term or long-term hearing loss, while less than maximal exposure could result in masking effects (Ljungblad et al. 1988; Malme et al. 1989). It may also alter or deter migration paths and displacement may then result in fewer feeding opportunities where prey are aggregated.

Bowhead whales can detect sounds produced by seismic pulses from 10 to 100 km (6 to 62 mi) away from the source (MMS 2002a). Bowheads have been rarely observed within 20 km (12 mi) of where airguns are operating. However, occurrences of bowheads within 20 km (12 mi) are similar to those outside this radius about 12 to 24 hours after seismic operations cease (MMS 2002a). At seismic pulses as high as 248 dB re 1 μPa-m, bowhead whales respond by orienting away from the seismic vessels at distances up to 7.5 km (4.7 mi) (Richardson et al. 1986). While high-energy noises have the potential to permanently harm cetaceans, there is evidence that some cetaceans may habituate to lower-energy noises. For example, Richardson et al. (1986) found that bowhead whales initially responded to moderate underwater noise levels (110 to 115 dB re 1 μPa-m) by avoiding areas in which seismic exploration activities were occurring, but later became tolerant to prolonged noise exposure. Migrating bowhead whales have also been shown to exhibit avoidance of a 20-km (12-mi) area around seismic surveying where received levels were estimated to be approximately 120 to 130 dB re 1 μPa at 1 m (Richardson et al. 1999). Given their mobility and avoidance reactions to approaching seismic vessels, it is unlikely that whales would occur close to injurious noise levels (MMS 2003e). Some bowhead whales may tolerate noise levels that may reach injury levels when they are engaged or highly motivated during behaviors such as feeding, while others may exhibit more sensitivity, such as females with calves. Quakenbush et al. (2010) documented the interaction of one bowhead whale and a seismic vessel. The whale stayed at least 9.2 km (5.7 mi) from the ship. The seismic activity did not apparently affect overall whale behavior, as the whale remained in the area after seismic activity ceased. Also, the seismic activity did not cause a long-term disruption in feeding or migratory behaviors (Quakenbush et al. 2010).

Todd et al. (1996) found that humpback whales exhibited little behavioral reaction to underwater anthropogenic noises as high as 153 dB re 1 μPa. However, Richardson et al. (1990) observed that bowhead whales in close proximity to underwater anthropogenic noise sources (<1 km [0.6 mi]) reacted to sound levels as low as 122 dB re 1 μPa by ceasing their feeding behaviors and moving away from the noise source. Watkins and Schevill (1975) observed sperm whales cease vocalization behaviors in the presence of underwater anthropogenic sounds at frequencies between 6 and 13 kHz. Anthropogenic underwater noises as low as 180 dB re 1 μPa can elicit startle reactions and avoidance behaviors in sperm whales and gray whales (Malme et al. 1984; Andre et al. 1997). Malme et al. (1984) also observed behavioral reactions (avoidance) in gray whales in response to received levels of around 164 dB re 1 μPa at 1 m (3 ft); and Richardson et al. (1995) reported that individual gray whales that reacted to noise generally slowed, turned away from the noise source, and increased their respiration rates. Humpback whales off the western coast of Australia changed course at 3 to 6 km (1.9 to 3.7 mi) from an operating seismic survey vessel, with most animals maintaining a distance of 3 to 4 km (1.9 to 2.5 mi) from the vessel. Humpback whale groups containing females involved in resting behavior were more sensitive than migrating animals and showed an avoidance response estimated at 7 to 12 km (4.3 to 7.5 mi) from a large seismic source (McCauley et al. 2000).

As discussed for the GOM (Section 4.4.7.1.1), it is assumed that BOEM will continue to require ramp-up of seismic activities coupled with visual monitoring and clearance within an exclusion zone around a seismic array. These actions would reduce the potential for cetaceans to be exposed to sound levels that could affect hearing or behavior. The avoidance reactions of whales to approaching seismic vessels would normally prevent exposure to potentially injurious noise pulses (NMFS 2002). The geographic scale of any potential noise effect is probably relatively small compared to the total habitat used by whales in the Chukchi and Beaufort Seas (MMS 2004c). For example, in the Chukchi Sea, fall migrating bowhead whales are commonly seen from the coast to about 150 km (93 mi) offshore (MMS 2004c), while fall migration in the Beaufort Sea occurs over a 100 km (62 mi) wide corridor (Malme et al. 1989).

Pinnipeds in close proximity to sources of seismic noise may experience intense sound pressure levels that could cause temporary hearing loss by masking ambient noise levels, causing damage to hearing structures and body tissues (Richardson et al. 1995). Generally seals move away from seismic vessels, although some are observed swimming in the bubbles generated by large seismic airgun arrays (MMS 2003e).

Walrus hearing has been reviewed in the Pacific Walrus Status Review (Garlich Miller et al. 2011). If exposed to seismic surveys, some walruses may be temporarily displaced or may even experience temporary threshold shifts in hearing. Seismic surveys occur in open water where walruses may be feeding or passing through but are less likely to be present in large numbers (BOEMRE 2010d).

Noises associated with seismic surveys are less likely to harm fissipeds than cetaceans (MMS 2007e). It is unlikely that polar bears are affected by seismic noise in water, as they swim with their heads above water, reducing the risk of hearing damage. In contrast, on-ice seismic work during the winter is more apt to disturb polar bears. Females with cubs will abandon den sites when a seismic crew is operating nearby (Amstrup 1993; Linnell et al. 2000). Premature den abandonment could lead to an increase in cub mortality. Polar bears are sensitive to noise (Nachtigall et al. 2007), thus bears in the vicinity of a seismic survey may leave the area. Female bears excavate dens in snow on drifting pack ice and on land. Pregnant females and females with newborn cubs in maternity dens are sensitive to noise and may be disturbed by seismic exploration, and have been reported to abandon den sites when seismic crews are operating nearby (Amstrup 1993). Such abandonment of a maternity den, even if short-term, could reduce cub survival. In addition, polar bears encountered along seismic survey lines may be killed in defense of life and property, although regulatory agencies and the oil and gas industry have made serious efforts to minimize interactions with polar bears (NRC 2003a). However, companies are required to search for dens prior to the onset of work and are also required to maintain a 1-mile buffer around the dens, which, so far, appears to be an effective mitigation measure.

For more information on potential effects to marine mammals from seismic exploration, see the MMS Programmatic Environmental Assessment for Arctic Ocean Outer Continental Shelf Seismic Surveys (MMS 2006c). In summary, seismic noise can alter ambient noise levels, damage marine mammal hearing structures, and cause direct physical injury to marine mammals. Potential effects caused by these stressors include:

- Temporary increased susceptibility to injury, mortality, or predation due to noise masking (e.g., communication, predator avoidance);
- Temporary disturbance of normal behavior;
- Temporary avoidance of habitat;
- Increased susceptibility to injury, mortality, or predation due to hearing loss; and
- Reduced survival due to physical injury.

<u>Construction of Offshore Platforms and Pipelines.</u> As part of the proposed action, 6 to 16 exploration wells and 40 to 120 production wells will be drilled in the Beaufort Sea, while 1 to 20 exploration wells and 60 to 280 production wells will be drilled in the Chukchi Sea. There will also be 1 to 4 platforms in the Beaufort Sea and 1 to 5 platforms in the Chukchi Sea. Additional offshore activities planned as part of the proposed action include 10 subsea production wells and 48 to 217 km (30 to 135 mi) of new offshore pipeline in the Beaufort Sea, and between 18 and 82 subsea production wells and 40 to 402 km (25 to 250 mi) of new offshore pipeline in the Chukchi Sea (Table 4.4.1-4).

Noise and human activity associated with construction of offshore facilities and pipelines could disturb marine mammals that may be present in the vicinity of the construction site. Construction activities could disturb normal behaviors (e.g., feeding, social interactions), mask calls from conspecifics, disrupt echolocation capabilities, and mask sounds generated by predators or prey. Generally, the immediate response of disturbed individuals is to leave or avoid the construction area. From a behavioral perspective, increased anthropogenic noise could interfere with communication among cetaceans, such as gray, minke, beluga, and killer whales and harbor porpoise, mask important natural and conspecific sounds, or alter natural behaviors (i.e., displacement from migration routes or feeding areas, disruption of feeding or nursing). Behavioral impacts appear to be affected by the animal’s sex and reproductive status, age, accumulated hearing damage, type of activity engaged in at the time, group size, and/or whether the animal has heard the sound previously (e.g., Olesiuk et al. 2002; Richardson et al. 1995; Johnston 2002; NRC 2003a, 2005a). Toothed whales can be particularly sensitive to high-frequency sounds given their use of high-frequency sound pulses in echolocation, and moderately high-frequency calls for communication. Baleen whales, a group including gray and minke whales, are similarly sensitive to the low frequency noise that is often characteristic of construction, machinery operation, vessel noise, and aircraft noise. Bowhead whales stop feeding and move from within 0.8 km (0.5 mi) of experimental dredge sounds to more than 2 km (1.2 mi) away (MMS 2002a). In addition, some individuals may habituate to dredging and other construction activities (MMS 2002a). Because some marine mammal species exhibit seasonal changes in distribution and are absent or infrequent in the Beaufort and Chukchi Sea Planning Areas in winter, winter construction of offshore platforms would affect relatively few animals. In spring and summer, species present in construction area would be expected to leave the area to other habitats. Displacement could be of short- or long-term duration and could affect survival of young if adults abandon young or are displaced from important foraging areas as well as adults if they are kept from their feeding areas for a long period of time. The construction of new infrastructure in polar bear habitat has the potential to adversely impact these animals through disturbance and displacement.

To date, documented impacts to polar bears in Alaska by oil and gas development activities are few. The potential for adverse impacts is largely associated with increases in industrial activity or expansion of industrial footprints, as well as related increases in human/polar bear interactions. Minimal impacts could result from the potential increase in human/polar bear interactions associated with expanding the onshore facility, installing the offshore and onshore pipelines, and extending the production timeframe within the action area. The USFWS (2008b, 2011) has developed regulations that authorize the nonlethal, incidental take of small numbers of polar bears (and Pacific walruses) during oil and gas industry activities in the Chukchi Sea and Beaufort Sea areas. These regulations include the requirement to maintain a 1.6-km (1.0-mi) exclusion zone around known polar bear dens. The USFWS and USGS have predicted that polar bears may be extirpated throughout much of their range within the next 40 to 75 yr if current trends in sea ice reduction continue (73 FR 28212 [15 May 2008]). Nonetheless, impacts to bears as a direct result of routine, OCS-related oil and gas activities appear to be minimal.

Any activity causing an impulse noise of 160 dB rms or non-pulse noise of 120 dB rms would risk Level B harassment take of whales, and require a take authorization under the MMPA. Additional mitigation measures required to avoid significant adverse impacts would be required by later BOEM and NMFS review processes. Detailed analysis of potential Exploration Plans and Development & Production Plans, along with mitigation measures incorporated into any necessary Incidental Take Authorizations (ITA), would further reduce the potential for any significant adverse impacts. Overall, while development activities may impact whales through masking and avoidance, significant impacts are not expected. Such effects would likely be limited to individuals or small groups, be limited in duration to the construction period, and be sublethal.

Pipeline trenching may also disrupt mammal species (e.g., Pacific walrus, gray whale, bowhead whale). Despite the long, linear nature of pipelines, their construction is a slow-moving, relatively stationary operation. Thus, pipeline construction represents a temporary and avoidable source of disturbance. The extent to which benthic food sources are affected and the subsequent impact to marine mammals depend on the type and amount of benthic habitat that would be disturbed by trenching, the importance of the specific habitats in providing food resources to marine mammals, and the marine mammal species and numbers of individuals that could be affected.

Pipeline construction could cross barrier island and nearshore coastal habitats. Polar bears may be temporarily displaced, or their behavior modified (e.g., by changing direction or speed of travel), by construction activities. As explained in a recent biological opinion, "disturbance from stationary activities could elicit several different responses in polar bears. Noise may act as a deterrent to bears entering the area, or conversely, it could attract bears. Bears attracted to development facilities may result in human–bear encounters, leading to unintentional harassment, or intentional hazing of the bear" (USFWS 2009). Mitigation measures (such as implementation of a human-bear conflict management plan) generally required under MMPA Incidental Take Authorizations (typically a Letter of Authorization) would reduce the potential for these impacts. Any adverse impacts would be localized and negligible.

Because no more than 13.5 ha (33.4 ac) of bottom area would be disturbed by platform construction and no more than 567 ha (1,401 ac) of bottom area would be disturbed by pipeline construction under the proposed action (Table 4.4.1-4), relatively little benthic habitat would be disturbed compared to that present in the Beaufort and Chukchi Sea Planning Areas. Natural recovery of the disturbed benthic habitats would occur within 3 to 10 yr of initial disturbance (Section 4.4.6.2.3). Pipeline trenching is expected to have a limited effect on the overall availability of food sources for marine mammals. Impacts to marine mammal food sources would be localized and would not result in population-level impacts. To avoid or minimize adverse impacts, relevant organizations (i.e., project proponents, BOEMRE, NMFS) will need to develop timing guidelines and operational protocols to govern the specifics of this project. This review would take place at a later stage of review, when more site-specific information would be known.

<u>Construction of Onshore Pipelines.</u> Under the proposed action, 16 to 129 km (10 to 80 mi) of new pipelines onshore of the Beaufort Sea will occur, causing up to 584 ha (1,443 ac) of soil disturbance (Table 4.4.1-4). No other onshore construction will occur under the proposed action (Section 4.4.1.3). Onshore construction activities would not affect most of the marine mammals in the Arctic region because these species typically occur in offshore open-water habitats and ice floes and along pack ice away from coastal areas where construction might occur. Individuals that might be present in nearshore waters adjacent to a construction area would leave the area. Onshore pipeline construction has the potential to directly affect pinnipeds and fissipeds and their habitats through impacts associated with direct contact with construction equipment or infrastructure, as well as indirect impacts associated with perceived habitat loss. Most pinnipeds and fissipeds are alert and mobile enough to be able to avoid areas where construction is occurring. Juveniles are smaller and less mobile than adults; therefore, human disturbances associated with construction activities may have a greater effect on younger pinniped and fissiped individuals.

The activities associated with onshore construction may also indirectly affect pinniped and fissiped species by reducing habitat quality, and thereby affecting the distribution of the species. Pinnipeds and fissipeds may avoid certain areas of human disturbance. Polar bears may be affected by oil and gas development by abandoning dens in close proximity to onshore disturbances, which may lead to range conflicts with other polar bears or greater cub mortality (Amstrup 1993; Linnell et al. 2000). However, there is evidence that some species or individuals of pinnipeds and fissipeds may be capable of habituating to moderate levels of oil and gas exploration and development activities (Moulton et al. 2003; Blackwell et al. 2004; Smith et al. 2007).

The spotted seal, Pacific walrus, and polar bear are the three species of marine mammals in the Beaufort and Chukchi Sea Planning Areas likely to occur in coastal habitats, and therefore to be affected by onshore construction. The spotted seal uses coastal habitats such as beaches and river delta sandbars for sunning and resting, while the polar bear forages along shore ice locations, and may have onshore maternity dens located as much as 8 to 10 km (5 to 6 mi) inland of the coast (Section 3.6.4.2.1). Walrus also haul out in large numbers along the Chukchi Sea Coast and beluga use the near shore areas, such as Kaseguluk Lagoon, in the spring. Foraging bears and resting seals would probably leave or avoid areas where onshore construction is occurring. If an active maternity den is present at or near the construction site, construction may cause the female to abandon the den and her cubs, potentially decreasing cub survival (Linnell et al. 2000); however, there is evidence that denning polar bears can become tolerant of low levels of human activity (Amstrup 1993). This was also recently seen (2011) when a sow with cubs denned on Spy Island next to an offshore facility. As only a small number of individuals of either species might be disturbed, no population-level effects are expected.

Given the small amount of onshore construction that could occur under the proposed action, it is unlikely that onshore construction would have long-term impacts to pinniped and fissiped populations. Onshore construction activities would be sited to avoid areas of known sensitive habitats (e.g., polar bear dens), minimizing the potential for affecting pinniped and fissiped populations.

<u>Operations of Offshore and Onshore Facilities.</u> Noise associated with OCS drilling and production is of relatively low frequency, typically between 4.5 and 30 Hz (Richardson et al. 1995). Potential effects on marine mammals may include disturbance (e.g., changes in behavior, short- or long-term displacement) and masking of calls from conspecifics or other natural sounds (e.g., surf, predators).

Because odontocetes use sounds at frequencies that are generally higher than the dominant sounds generated by offshore drilling and production activities, they may not be sensitive to or affected by these sounds. In contrast, mysticetes (the minke, gray, humpback, fin and bowhead whales) are considered to have good low-frequency hearing and exhibit vocalizations at low frequencies, and thus may be affected by drilling and production noise. Effects would be similar to those identified for exploration and construction activities, namely, behavioral disruption and avoidance of or displacement from the immediate vicinity of the operating facility. For example, bowhead whales have been observed to deflect from their migratory path by 20 km (12 mi) or more in response to drilling noises (MMS 2002a). However, bowhead whales tolerate high levels of continuous drilling noise when necessary to continue with migration (MMS 2002a).

Avoidance or displacement can be of short- or long-term duration, depending on whether or not affected individuals may become acclimated to the operational activities. Because affected individuals would most likely leave the area for other appropriate habitats, neither behavioral disturbance nor the displacement of individuals by normal operations would be expected to result in long-term effects to either individuals or populations. The presence of an operating onshore facility could reduce the suitability of some areas for use by denning female polar bears, while normal operations of offshore facilities could decrease the suitability of offshore areas as pinniped foraging or pup-rearing habitats. Exposure events that elicit a response also may induce stress and further energy expenditure. The frequency that an individual is exposed and reacts to noise levels throughout a given season or lifetime can reach thresholds whereby individual health or reproductive performance could be adversely affected.

Under the Final Rule designating critical habitat for polar bears, terrestrial denning habitat (Critical Habitat Unit 2) was not designated along the U.S. Chukchi Sea coastline (75 FR 76086 [Dec. 7, 2010]). In the Bering and Chukchi Seas, the majority of dens that have been documented occur on Wrangel and Herald islands, and on the Chukotka Peninsula in Russia. In recent years, sea ice formation along the coastline is occurring later in winter, which may preclude access to coastal denning areas along the U.S. Chukchi Sea coastline. While the USFWS has determined that the coastlines of the Chukchi and Bering Seas are not critical habitat, some dens may occur along the coast. Disturbance at den sites from construction or other human activities could result in a female with cubs abandoning the den site, resulting in death from hypothermia or predation to the cubs. Should construction activities be proposed near an active den, mitigation measures (such as den detection and avoidance) generally required under the Letter of Authorization would reduce the potential for these impacts. The raised onshore pipeline would not pose a physical barrier to polar bear movement, and once away from the coast, would not be in polar bear habitat.

<u>Discharges and Wastes.</u> Table 4.4.1-4 presents information on drilling fluids, drill cuttings, and produced waters discharged offshore as a result of the proposed action in the Beaufort and Chukchi Seas. Produced water, drilling muds, and drill cuttings will be discharged into offshore marine waters in compliance with applicable regulations and permits. Compliance with regulations and permits will limit the exposure of marine mammals to waste discharges. In some cases, drilling muds may be recycled and not discharged and cuttings may be transported offsite.

Up to 500 bbl of drill fluids and 600 tons of drill cuttings will be discharged at each exploration and delineation well (Table 4.4.1-4). Heavier components of these muds and cuttings (such as rock) would settle to the bottom, while lighter components could increase turbidity around the drill site. While this increased turbidity could cause marine mammals to avoid the area, any increase in suspended solids associated with the discharge of drilling wastes would be rapidly diluted and dispersed, and thus not be expected to adversely affect marine mammals in the area. Drilling fluids and cuttings associated with development and production wells would be treated and disposed of in the wells, minimizing impacts to marine mammals from these wastes.

Some marine mammals may be exposed to waste fluids (such as bilge water) generated by and discharged from OCS vessels. Discharges of such wastes from OCS service and construction vessels, if allowed, would be regulated under applicable NPDES permits and would also be rapidly diluted and dispersed. Sanitary and domestic wastes would be processed through shipboard waste treatment facilities before being discharged overboard, and deck drainage would also be processed shipboard to remove oil before being discharged. Thus, permitted waste discharges from OCS service and construction vessels would not affect marine mammals.

Ingestion or entanglement with solid debris can adversely impact marine mammals (Marine Mammal Commission 2004). Mammals that have ingested debris, such as plastic, may experience intestinal blockage which, in turn, may lead to starvation, while toxic substances present in the ingested materials (especially in plastics) could lead to a variety of lethal and sublethal toxic effects. Entanglement in plastic debris can result in reduced mobility, starvation, exhaustion, drowning, and constriction of, and subsequent damage to, limbs caused by tightening of the entangling material. The discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by BOEM (30 CFR 250.40) and the USCG (MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]). Thus, entanglement in or ingestion of OCS-related trash and debris by marine mammals would not be expected under the proposed action during normal operations.

Vessel and Aircraft Traffic. There would be up to 12 surface vessels and 12 helicopter trips per week in the Beaufort Sea and up to 15 surface vessels and 15 helicopter trips per week in the Chukchi Sea under the proposed action (Table 4.4.1-4). The majority of vessel traffic in the Beaufort and Chukchi Seas primarily occurs during summer, at which time it could contribute to ambient noise and potential disturbance to marine mammals (MMS 2002a). Which species could be affected by vessel and aircraft traffic, the nature of their response, and the potential consequences of the disturbance, will be a function of a variety of factors, including the specific routes, the number of trips per day, the altitude of the aircraft overflights, the seasonal habitats along the routes, the species using the habitats and the level of their use, and the sensitivity of the mammals to vessel and aircraft traffic. Traffic over heavily used feeding or calving habitats could result in population-level effects for some species, while impacts from traffic over other areas with less sensitive species would likely be limited to a few individuals and not result in population-level effects.

Marine mammals may be affected by this traffic either by disturbance from passing vessels or helicopters or by direct collisions with vessels. Among the cetaceans, the beluga, gray, and bowhead whales are the most abundant in the Beaufort and Chukchi Sea Planning Areas. Thus, these species have the potential to encounter OCS-related vessels. The other cetaceans are present in relatively low numbers (e.g., less than 2,000 throughout the entire planning area), and thus are less likely to encounter OCS-related vessels. During their spring migration (April through June), bowhead whales would likely encounter few, if any, vessels along their migration route, as NMFS (in their IHAs) and FWS (in their LOAs) restrict access to the Chukchi Sea to protect animals in the spring lead system.

Bowheads react to the approach of vessels at greater distances than they react to most other industrial activities. According to Richardson and Malme (1993), most bowheads begin to swim rapidly away when vessels approach rapidly and directly. This avoidance may be related to the historic commercial and continuing subsistence hunting. Avoidance usually begins when a rapidly approaching vessel is 1 to 4 km (0.6 to 2.5 mi) away. A few whales may react at distances from 5 to 7 km (3 to 4 mi), and a few whales may not react until the vessel is <1 km (<0.6 mi) away. Received noise levels as low as 84 dB re 1 μPa (decibels relative to one micropascal) or 6 dB above ambient may result in strong avoidance of an approaching vessel at a distance of 4 km (2.5 mi) (Richardson and Malme 1993). Vessel disturbance has been known to disrupt activities and social groups. Fleeing from a vessel generally stopped within minutes after the vessel passed, but scattering may persist for a longer period. Parks et al. (2011) note for North Atlantic right whales (a species similar to bowhead whales) and Holt et al. (2009) note for killer whales that individuals modified calls in response to increased background and vessel noise, respectively, by increasing the amplitude of their calls. McDonald et al. (2009), however, noted the decline in blue whale song tonal frequencies was not fully explained by the hypothesis of increasing ocean noise. But these authors suggest that post whaling population increase is altering sexually selected trade-offs for singing males between song intensity (ability to be heard at a greater distance) and song frequency (ability to produce songs of lower pitch).

Where vessels approach slowly or indirectly, bowheads are much more tolerant, and reactions are generally less dramatic. The encounter rate of bowhead, humpback, and fin whales with vessels associated with natural gas development would depend on the location of the platform in relation to both shipping routes and areas of heavy use. During their spring migration (April through June), bowheads likely would encounter few, if any, vessels along their migration route, because ice at this time of year typically would be too thick for supply vessels to operate in. Bowheads, as with other “right whales” (family Balaenidae), are among the slowest moving of whales, which may make them particularly susceptible to ship strikes. Despite their likely greatest susceptibility to vessel strikes, records of strikes on bowheads are rare compared with records of strikes on some other large whales (Laist et al. 2001). About 1% of the bowhead whales taken by Alaskan Iñupiat bore scars from ship strikes (George et al. 1994). Until recently, few large ships have passed through most of the Western Arctic bowhead’s range but this situation is changing and the potential for increasing opportunity for vessel strikes may be increasing as northern sea routes become more navigable with the decline in sea ice. At present, bowheads, humpback, and fin whales probably would adjust their individual swimming paths to avoid approaching within several kilometers of vessels attending the production platform, and would also move away from vessels that approached them within a few kilometers (Richardson et al. 1995).

Worldwide, at least 11 species of cetaceans have been documented as being hit by ships (Laist et al. 2001; Jensen and Silber 2003). In most cases, the whales are not seen beforehand or are seen too late to avoid collision. Most lethal or severe injuries involve ships traveling ≥14 knots (26 km/hr or 16 mph) or faster, and collisions with vessels greater than 80 m (262 ft) in length are usually either lethal or result in severe injuries (Laist et al. 2001). Most seismic vessels typically operate around 4–5 knots. Gray whale use of shallow coastal habitat during migration makes ship strikes a potential source of mortality. Only one ship strike mortality has been reported in Alaska when a killer whale hit the prop during a groundfish trawl in the Bering

Sea (MMS 2008b; Allen and Angliss 2011), however, to-date, there have been no vessel strikes reported in the Arctic. Although, harvested bowhead whales have had scarring, indicating they had been hit by the prop of a ship (Rosa 2008). Pinnipeds may also be struck by vessels. There is a possible, but unlikely, potential for polar bears to be struck by vessels (MMS 2009a).

In addition to possible collision-related injuries, cetaceans may be disturbed by the observation of the vessel and the noise it generates. Disturbed individuals would be expected to cease their normal behaviors and likely move away from the vessel. Following passage of the vessel, affected individuals may return and resume normal behaviors. However, high vessel traffic along a consistent route may cause long-term avoidance. If the abandoned areas represent important feeding or calving areas, physical condition and reproductive success may be adversely affected. Of 236 bowhead whales examined between 1976 and 1992, only three ship-strike injuries were documented, indicating that they do not often encounter vessels, avoid interactions with vessels, or that interactions usually result in the death of the animals (Shelden and Rugh 1995; Rosa 2008). Current rates of vessel strikes of bowheads are low, and there are no known fin or humpback strikes in the Alaskan Arctic (BOEMRE 2010d). Bowhead whales do not seem to react to aircraft overflights at altitudes above 300 m (984 ft). Most bowheads do not deflect more than a few kilometers from a single noise disturbance, and behavioral responses last only a few minutes. Most reactions include a change in migration speed and swimming direction to avoid the sound source (Richardson et al. 1991). Bowhead whales typically avoid vessels at distances ranging from 1 to 4 km (0.6 to 2.5 mi); drilling noise may deflect individuals 20 km (12.4 mi) or more from their migratory paths. Schick and Urban (2000) suggest that the spatial pattern of bowhead distribution is highly correlated with distance from drilling rigs, and the presence of drilling rigs results in a temporary loss of available habitat. Miles et al. (1987) suggest icebreakers pushing ice would cause half of the bowheads within 4.6 to 20 km (2.9 to 12.4 mi) of the source to demonstrate an avoidance behavior. Beluga whales are also known to avoid ice breakers by long distances (Erbe 1997, 2000; Cosens and Dueck 1993).

Fixed wing aircraft may be used by whale spotters during pipeline route surveys or pipeline installation activities in the nearshore areas. The use of spotter aircraft could be an important mitigation technique that would reduce the overall potential for gas development to cause adverse impacts to whales. Helicopters are likely to be used to transport crews and supplies in support of modification of the production platform for gas development. Aircraft noise may elicit a response, such as a turn or hasty dive, from a whale or group of whales. But given the altitude at which these aircraft are expected to fly, the potential for adverse reactions is small. Any impacts that did occur would be temporary and minor. To avoid potential disturbance effects on marine mammals, aircraft maintain minimum flight altitudes — human safety will take precedence at all times over this recommendation.

Construction- and operation-related noises that have the greatest potential to impact pinnipeds, including those generated from vessel and aircraft traffic. Noises emitted by shipping vessels range between 140 dB re 1 μPa for smaller vessels to 198 dB re 1 μPa for larger tankers and cargo ships (Heathershaw et al. 2001; Erbe 2002; Hildebrand 2004). Helicopters flying at 150 m (492 ft) altitude are expected to emit noises received at ground level of approximately 80 to 86 dB re 20 μPa (Born et al. 1999). These noises may impact nearby pinniped species, which typically have in-air hearing thresholds between 20 to 80 dB and underwater hearing thresholds between 60 to 120 dB (Kastak and Schusterman 1998; NRC 2005a). Noises associated with approaching vessels and helicopters may cause hauled out pinnipeds to flee to aquatic habitats. For example, ringed, spotted, and bearded seals have also been known to avoid approaching vessels by fleeing from haul out sites into the water (Frost et al. 1993; Born et al. 1999; COSEWIC 2003). During pinniped flight reactions, young pups could be trampled or become isolated from their mothers, leading to injury or making them more susceptible to predators. Despite this, there is evidence that pinnipeds may habituate to moderate levels of human activity (Moulton et al. 2003; Blackwell et al. 2004).

Vessel traffic may disturb pinnipeds in the water and hauled out on ice or terrestrial habitats. Hauled out pinnipeds may exhibit behavioral reactions to the physical disturbance of an approaching vessel or aircraft (sometimes >1 km [0.6 mi] away) by exhibiting startle reactions, escaping the immediate area into the water. Project aircraft has the greatest potential to adversely affect pinnipeds haul out and rookery sites (Frost et al. 1993), where disturbed adults may temporarily cease normal behaviors (such as feeding of young), leave the rookery site, and thereby increase predation risks of unattended pups, or risk of trampling while adults are fleeing. However, pinnipeds may habituate to the presence of project vessels (Moulton et al. 2003; Blackwell et al. 2004), and the escape reactions of hauled out pinnipeds may be minimized over time. At times, many of these species, such as seals, are attracted to moving vessels. Pinnipeds could be injured or killed by ship collisions.

Vessel traffic associated with icebreaking activities in the Alaskan OCS may alter the behaviors of walruses at greater distances (sometimes >2 km [1.2 mi] away) than ordinary ship traffic. In response to icebreaking vessels, female and young walruses typically react more than males do. Hauled out females and young typically responded to approaching icebreaking vessels by fleeing into the water at distances of 0.5 to 1 km (0.3 to 0.6 mi); males responded by entering the water at distances of 0.1 to 0.3 km (0.06 to 0.2 mi) (Johnson et al. 1989, and see MMS 2007d).

Vessel and aircraft traffic may disturb fissipeds in aquatic and terrestrial habitats. It is unlikely for polar bears to be directly impacted by vessel collisions; instead, impacts to polar bears from vessel and aircraft traffic may occur from the physical disturbance associated with such activities. Fissipeds are generally considered to be more tolerant than other marine mammals to noises associated with the construction of offshore oil and gas platforms (MMS 2007e). However, construction-related noises may still affect fissiped populations. Vessel, terrestrial vehicle, and aircraft activities can affect polar bear behavior. Vessel traffic associated with natural gas development activity is not expected to cause impacts to polar bears, because they show little reaction to vessels and generally do not linger in open water where vessels are more likely to travel. As explained in a Biological Opinion (USFWS 2009), "During the open-water season, most polar bears remain offshore on the pack ice. Barges and vessels transporting materials for construction and on-going operations of facilities usually travel in open-water and avoid large ice floes. Therefore, there is some spatial separation between vessels and polar bears." If there is an encounter between a vessel and a bear, it would most likely result in short-term behavioral disturbance only. Polar bear responses to vessels are brief, and generally include walking toward, stopping and watching, and walking/swimming away from the vessel.

Polar bears typically flee from low flying aircraft that are at an altitude of <200 m (656 ft) and a lateral distance of <400 m (<1,312 ft) (Shideler 1993). Extensive or repeated overflights by helicopters travelling to and from offshore facilities could disturb polar bears. Polar bears have been known to run from other sources of noise and the sight of aircraft, especially helicopters. According to a Biological Opinion (USFWS 2009), "Behavioral reactions of polar bears would likely be limited to short-term changes in behavior and have no long-term impact on individuals. In addition, [BOEMRE] requires these types of flights to operate at an altitude of >1,500 ft AGL where possible, which would significantly reduce disturbance." It is expected that flight altitude requirements will minimize disturbances and that adverse impacts from this activity will be temporary and minimal.

The effects of air traffic on pinnipeds in the action area are expected to be localized and transient. Some seals may be disturbed on the ice or at haulouts on land and enter the water, although their responses may be highly variable and brief in nature (Born et al. 1999; Boveng et al. 2008, 2009; Burns and Harbo 1972; Cameron et al. 2010; Kelly et al. 2010). Mitigation measures prohibiting aircraft overflights below 457 m (1,500 ft) will lessen aircraft impacts to these pinnipeds. Results from studies of an existing facility (specifically, the Northstar development) are roughly analogous to what is contemplated under the present natural gas development scenario and suggest that any adverse impacts to phocids would be minor, short-term, and localized, with no measurable consequences to seal populations.

Pacific walrus are particularly vulnerable to disturbance events given their tendency to aggregate in large groups. Reactions to disturbances when on ice are highly variable (Richardson et al. 1995). Reactions at group haulouts (on land) are more consistent; walrus will flee haulout locations in response to disturbance from aircraft and ship traffic, though walrus in the water are thought to be more tolerant. Females with dependent young are considered the least tolerant of disturbances. Walrus are particularly sensitive to helicopters and changes in engine noise, and are more likely to stampede when aircraft turn or bank overhead. Disturbances caused by vessel and air traffic may cause walrus groups to abandon land or ice haulouts. Severe disturbance events could result in trampling injuries or cow-calf separations, both of which are potentially fatal. But while adverse impacts can be severe, they are also to a large extent avoidable. The USFWS has concluded that a minimum altitude of 1000 ft ASL is sufficient in sea ice habitats (see p. 24 of the USFWS Chukchi Sea EA, 2008) with a 0.5-mi (80-m) horizontal buffer. BOEMRE has taken the more precautionary approach of a 1-mi horizontal buffer and 1500-ft AGL or ASL based in part on industry data and on unpublished ADFG and USFWS haulout monitoring data. While BOEMRE does not regulate air space within the project area, direct overflights of terrestrial or sea ice walrus haulouts by industry are strongly discouraged. Typical mitigation measures include flight corridors, a minimum of 1 to 2 mi inland and directly from shore to the exploration site, while maintaining a minimum of 1 horizontal mi from groups of walruses hauled out on ice or land. Overall, the potential for adverse impacts to individuals or groups of walrus do exist, but the probability is minimal in light of mitigation techniques, such as minimum altitude requirements for aircraft.

Decommissioning. Under the proposed action, no platforms will be removed with explosives from the Beaufort and Chukchi Sea Planning Areas. Therefore, potential impacts of decommissioning on marine mammals, as summarized in Figure 4.4.7-4 (Section 4.4.7.1.1), will not occur.

Impacts of Expected Accidental Spills. Accidental oil spills could occur in the Beaufort and Chukchi Sea Planning Areas under the proposed action (Section 4.4.2). Table 4.4.2-1 presents the oil spill assumptions for the proposed action; while Figure 4.4.7-5 (Section 4.4.7.1.1) presents a conceptual model for potential effects of oil spills on marine mammals. It is assumed that 50 to 190 very small oil spills (<50 bbl), between 35 and 70 small oil spills (≥50 bbl but <1,000 bbl), and 1 to 3 large spills (≥1,000 bbl) would be associated with the Program in the Arctic (Section 4.4.2). Small oil spills break up and dissipate within hours to a day (MMS 2009a). Large spills, particularly those that continue to flow for extended periods (i.e., days, weeks, or months), pose an increased likelihood of impacting marine mammal populations (MMS 2008b). Operational discharges such as tank washing with seawater, oil content in ballast water, and fuel oil sludge are among the sources of small oil spills from tankers (Jernelöv 2010). Large oil spills from tankers have decreased significantly in recent years while spills from ageing, ill-maintained, or sabotaged pipelines have increased. The Arctic environment is particularly vulnerable to the effects of oil releases, which are expected to persist longer in the environment because of colder temperatures and difficulty in conducting cleanup operations (e.g., if oil occurs under ice). Nevertheless, recovery from small spills would probably require no more than a year (MMS 2003a).

Oil spills could affect marine mammals in a number of ways, and the magnitude and severity of potential impacts would depend on the location and size of the spill, the type of product spilled, weather conditions, the water quality and environmental conditions at the time of the spill, and the species and habitats exposed to the spill. Marine mammals may be exposed to spilled oil by direct contact, inhalation, and ingestion (directly, or indirectly through the consumption of contaminated prey species). Such exposures may result in a variety of lethal and sublethal effects (Geraci and St. Aubin 1988).

Fresh crude oil releases toxic vapors that when inhaled may irritate or damage respiratory membranes, congest lungs, and cause pneumonia. Following inhalation, volatile hydrocarbons may be absorbed into the bloodstream and accumulate in the brain and liver, leading to neurological disorders and liver damage (Geraci and St. Aubin 1988). Toxic vapor concentrations may occur just above the surface of a fresh oil spill, and thus be available for inhalation by surfacing cetaceans. Inhalation would be a threat only during the first few hours after a spill (Hayes et al. 1992; ADNR 1999). Prolonged exposure to freshly spilled oil could kill some whales (including bowheads, pinnipeds, and polar bear), but the numbers would be small due to a low chance of such contact. This would most likely occur if oil spilled into a lead that bowhead whales could not escape (MMS 2001f).

Direct contact of oil may irritate, inflame, or damage skin and sensitive tissues (such as eyes and other mucous membranes) (Geraci and St. Aubin 1988). Prolonged contact to petroleum products may reduce food intake; foul baleen on mysticete whales, elicit agitated behavior; alter blood parameters, respiration rates, and gas exchange; and depress nervous functions (Lukina et al. 1996). Under less extreme exposures (lower concentrations or shorter durations), oil does not appear to readily adhere to or be absorbed through cetacean skin, which, due to a thick fat layer, may provide a barrier to the uptake of oil-related aromatic hydrocarbons through the body surface (Geraci and St. Aubin 1985, 1988).

Effects of oil spills would depend on how many whales contacted oil, the duration of contact, and the age/degree of weathering of the spilled oil. The number of whales contacting spilled oil would depend on the size, timing, and duration of the spill; how many whales were near the spill; the whales' inclination or ability to avoid contact; and the effectiveness of cleanup activities (MMS 2001, 2004c). Some displacement of bowhead whales may occur in the event of a large oil spill, and avoidance of the contaminated area may last for several years (MMS 2001; NMFS 2002). This indicates that bowhead whales may have some ability to detect an oil spill and would avoid surfacing in the oil by detouring away from the spill area (NMFS 2002). Modeling efforts have indicated that only up to 2% of the Beaufort Sea bowhead whale population would be affected by a large oil spill (NMFS 2002).

An oil spill into ice leads or polynyas in the spring could have devastating effects, trapping bowhead whales where they may encounter fresh crude oil. Calves would be more vulnerable than adults because they need to surface more often to breathe. Feeding bowhead whales are also sometimes observed aggregating in large numbers during the summer open-water season, when they could also be vulnerable to a spill. Beluga whales, that also use the spring lead system to migrate, would be susceptible to a spill that concentrates in these leads (Nuka Research and Planning Group, LLC and Pearson Consulting, LLC 2010).

Pinnipeds and fissipeds may be exposed while coming ashore onto oiled beaches. In addition, adults and juveniles may also be indirectly affected if an accidental spill reduces the quality or quantity of foraging or breeding habitats. Impacts to calving grounds could result in population-level effects. Fouling of fur of some species (e.g., ringed seal pups, polar bear cubs) could affect thermoregulation and reduce survival of the affected young. Ice seals tend to be solitary and would most likely be exposed to oil at sea or on ice. Walruses and spotted seals would most likely be exposed at sea, on ice, or at coastal haulouts. Polar bears would most likely come into contact with spilled oil at sea, on ice, or on shore.

Oil would affect pinnipeds if it were to directly contact individuals, haulouts, or major prey species. For example, bearded seals and walruses are vulnerable to spilled oil from direct exposure and from the indirect effects through the benthic organisms on which they feed (Cameron and Boveng 2009). Although some adult pinnipeds (e.g., walruses) have thick skin that would protect them from absorption of oil, direct contact with oil would affect sensitive tissue areas, causing irritation to eyes, nasal passages, and lungs. Inhalation of hydrocarbon vapors may damage or irritate lung tissue. These injuries may affect already stressed adults and could lead to some fatalities. While adult ice seals depend on a thick fat layer for insulation, seal pups rely on a dense layer of underfur until they are several weeks old. The fouling of this underfur in young pups could reduce its insulating properties, increasing the potential for hypothermia and increasing pup mortality. While there is no conclusive evidence of past oil spills causing a decline in prey species sufficient to result in a decline in any marine mammal population, there is still the possibility of such an effect occurring. Because pinniped species in the Arctic do not congregate in rookeries, the overall effects of accidental oil spills on pinnipeds will be species-specific.

An oil spill that contacts an aggregation of walruses or displaces them from their haulouts may have a severe impact on the population. Walruses could also be impacted by consuming contaminated molluscs and being exposed to oil residues in sediments. As they have a long life span, they could suffer severe effects from the bioaccumulation of oil-derived contaminants (Nuka and Pearson 2010). According to Geraci and St. Aubin (1988), ice seals have the ability to metabolize oil if ingested in low amounts and some researchers believe that the walrus may share this ability (Scholz et al. 1992).

Accidental oil spills could potentially affect polar bears through contamination of prey or reduction of prey availability, fouling of fur, and oiling of ice. Oil contact can cause serious health concerns to polar bears (USFWS 1996). Fouling of fur greatly reduces its ability to insulate, and can result in hypothermia and death. Direct contact with oil or secondary contact with contaminated ice could be fatal. However, in most areas, polar bears occur at low densities; therefore, small numbers of bears would be affected by a single spill. Multiple spills or spills along the ice edge where bear density is greater would potentially increase mortality rate. Ringed seals are the primary prey of polar bears and are, therefore, directly linked to their survival. If seal density is affected by oil spills or cleanup operations, polar bears could experience increased stress and possibly lower survivorship.

Marine mammals may incidentally ingest floating or submerged oil or tar, and may consume oil-contaminated prey (Geraci 1990). Spilled oil may also foul the baleen fibers of mysticete whales, temporarily impairing food-gathering efficiency or resulting in the ingestion of oil or oil-contaminated prey (Geraci and St. Aubin 1988). Ingested oil can remain within the gastrointestinal tract and be absorbed into the bloodstream, thus irritating and/or destroying epithelial cells in the stomach and intestine. Oil ingested during grooming of fouled fur has been reported to result in liver and kidney damage in polar bears and ringed seals (NRC 2003a; Oritsland et al. 1981). It should be noted that ringed seals and likely other ice seals can detoxify their bodies by renal and bilary pathways. Further, seals do not typically orally groom themselves and are therefore less likely to ingest toxins in that way (Kooyman et al. 1976; Geraci and Smith 1976).

Depending on their habitat preferences, feeding styles, and migration patterns, some species may be more vulnerable to exposure than other species. Spills occurring in spring may affect a greater number of individuals due to animals congregating during migration. Spills occurring in or reaching coastal areas, especially sheltered coastal habitats such as bays and estuaries, would be more likely to affect species such as the beluga whale and spotted seal that use coastal habitats for calving and resting. Bowheads are most sensitive to oil contamination during the spring migration when calves are present and their movements are restricted to open leads in the ice (MMS 2002a).

Polar bears may be directly affected by an oil spill, since they spend the majority of their time on ice, through oiling of fur, ingestion of oil from grooming, or by feeding on oiled prey or carcasses. Large oil spills could have a significant impact on polar bear habitat and can result in food chain effects. Spills associated with onshore facilities (and especially any onshore pipelines) would potentially affect polar bears. While it is unlikely that a bear would be directly exposed to an accidental pipeline release, bears could be affected by feeding on contaminated prey. However, because of the relatively low density of bears in the Arctic region, no more than a few individuals would be expected to be affected by an onshore release. Onshore spills that enter a stream system may be carried to coastal areas, where other marine mammals may be exposed.

An accidental oil spill may result in the localized reduction, extirpation, or contamination of prey species. Invertebrate and vertebrate species (such as zooplankton, crustaceans, mollusks, and fishes) may become contaminated and subsequently expose marine mammals that feed on these species. Because benthic organisms (such as crustaceans and mollusks) accumulate oil compounds more readily and to higher levels than pelagic biota, the potential for ingesting oil-contaminated prey is highest for benthic feeding species, such as the gray whale, less so for zooplankton-feeding cetaceans, and least for fish-eating cetaceans (Würsig 1988). Similar differences in exposure via food ingestion may be expected among benthic and fish-eating pinnipeds (i.e., Pacific walrus, spotted seal). Species with a dependence on or preference for offshore areas or habitats for feeding, shelter, or reproduction would be more likely to be affected by a spill than would other marine mammals (Würsig 1988).

Spills occurring in winter may accumulate and may be incorporated into the ice matrix and move with the ice pack. In spring, this oil may be released into ice leads that are used by migrating whales (such as beluga and bowhead whales) and by pinnipeds that use these areas, resulting in the exposure of relatively large numbers of individuals. Spills under ice or associated with leads may affect haulout sites, causing either abandonment or repeated exposure through use of the contaminated haulout. Because some species are relatively restricted to open-water areas associated with ice, individuals may not be able to disperse from spills in these areas, and thus may incur increased exposures. Because polar bears are closely associated with ice edges, spills accumulating along these areas may expose the greatest number of bears to an offshore spill. An oil spill in areas where polar bears congregate (e.g., leads or polynyas and beachcast marine mammal carcasses) could have negative population effects.

Marine mammals that frequently groom, such as polar bears, would be most likely to ingest oil. Feeding on contaminated prey or carcasses also causes ingestion of oil (Fair and Becker 2000). With the exception of bearded seals who may enter the water within hours of being born, newborn seals are more sensitive to oil than adult seals, as they have little fat and rely on a dense layer of fur (lanugo). Loss of this waterproofing by oil could cause hypothermia and death (Fair and Becker 2000).

The magnitude and extent of any adverse effects will also depend on how quickly a spill is contained and how quickly and effectively cleanup is accomplished (USFWS 2004). Arctic conditions (i.e., sea ice, wind, temperature, limited visibility, and sea state) can potentially impact oil spill responses. Other than high sea state (choppy waves), which can enhance the effectiveness of chemical dispersants, most extremes in Arctic conditions hinder spill response activities (Nuka Research and Planning Group 2007a). Lessees are required to have contingency plans to prevent, address, and clean up oil spills (ADNR 1999). Spill cleanup operations could result in short-term disturbance of marine mammals in the vicinity of the cleanup activity, while a collision with a cleanup vessel could injure or kill marine mammals. Disturbance of adults with young during cleanup could reduce survival of the young animals. For example, vessel and human activities associated with cleanup efforts may cause pinnipeds to abandon coastal haulout areas and/or rookeries for an extended period of time. Cleanup operations, including helicopter overflights and vessel traffic, could also potentially increase pup mortality if operations were to occur near rookeries. Aircraft readily disturb pinnipeds and walruses, which can cause adults to stampede into the water, trampling pups in the process. Any increased mortality in a pinniped population could impact the population as a whole, especially for sensitive or declining populations (e.g., Pacific walruses).

An approved oil spill response plan would be required for all exploration and production activities. Oil-containment and cleanup activities would be initiated a short time following an oil spill (MMS 2003e). Oil spill response activities may affect marine mammals through exposure to spill response chemicals (e.g., dispersants or coagulants) or through behavioral disturbance by cleanup operations or habitat disturbance. The chemicals used during a spill response are toxic, but are considered much less so than the constituents of spilled oil (Wells 1989), although there is little information regarding their potential effects on marine mammals. The presence of, and noise generated by, oil spill response equipment and support vessels could temporarily disturb marine mammals in the vicinity of the response action, with affected individuals likely leaving the area. While such displacement may affect only a small number of animals and not result in population-level effects, cleanup operations disturbing adults in pup-rearing areas may decrease pup survival. Oil spill response support vessels may also increase the risk of collisions between these vessels and marine mammals in the vicinity of the spill response. During oil spill cleanup activities, interactions with humans could cause polar bear disturbance, injury, or death. For example, cleanup operations that disturb a den could result in the death of cubs through abandonment and perhaps death of the mother.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes an unexpected, very low-probability CDE of 1.4 to 2.2 million bbl for the Chukchi Sea Planning Area that lasts 40 to 75 days and a CDE of 1.7 to 3.9 million bbl for the Beaufort Sea Planning Area that lasts 60 to 300 days (Table 4.4.2-2). If a CDE occurs, there is greater potential for more severe effects compared to the risk of effects from an assumed large oil spill. A CDE would result in sustained degradation of water quality and, to a lesser extent, air quality that would impact marine mammals from direct contact, inhalation, and ingestion (either directly or indirectly through the consumption of oiled forage or prey species). These effects would be significant, causing a multitude of acute and chronic effects. Additional effects on marine mammals would occur from water and air quality degradation associated with response and cleanup vessels, *in situ* burning of oil, dispersant use, discharges and seafloor disturbances from relief well drilling, and activities on shorelines associated with cleanup, booming, beach cleaning, and monitoring. A CDE has the potential to increase the area and duration of an oil spill, thereby increasing the potential for population-level effects, or at a minimum, an increase in the number of individuals killed. For example, a CDE contaminating ice leads or polynyas in the spring could have devastating effects, trapping bowhead whales where they may encounter fresh crude oil. Beluga whales that also use the spring lead system to migrate would also be susceptible to a spill that concentrates there.

Direct contact with spilled oil from a CDE would have the greatest potential to adversely affect cetaceans when toxic fumes from fresh oil are inhaled at times and places where aggregations of cetaceans may be exposed. In addition, cetaceans would likely avoid oil spill response and cleanup activities. This could cause displacement from preferred feeding habitats, and could deter migration paths for the duration of those activities. Overall, cetaceans would likely be impacted by some loss of seasonal habitat, and by reduction or contamination of prey (BOEMRE 2011k). The potential impacts of a CDE on ice seals would depend on habitat use, densities, season, and spill characteristics. For example, oil from a CDE reaching a polynyas or lead system could have moderate to major impacts on ringed and bearded seals (e.g., could cause the deaths of hundreds to thousands of seals) (BOEMRE 2011k). Significant impacts to the walrus population from a CDE would be most likely to occur if a large-scale contamination of prey and habitat persisted for years (BOEMRE 2011k).

Cleanup of a CDE would have negative consequences as well. Cleanup activities and increased human presence could displace marine mammals from their usual habitats (e.g., alter their migration pathways or avoid areas they normally inhabit).

Impact Conclusions.

Routine Operations. Within Arctic planning areas, noise generated during seismic surveys, exploration and production activities, platform removal, and by OCS-related vessels and aircraft may temporarily disturb some individuals. Contaminants in waste discharges and drilling muds might indirectly affect marine mammals through food-chain biomagnification, although the scope of effects and their magnitude are not known. However, this information is not essential to the determination of a reasoned choice among alternatives. Small numbers of marine mammals could be killed or injured by chance collision with service vessels and by eating indigestible debris, particularly plastic items, lost from service vessels, drilling rigs, and platforms. While vessels may collide with marine mammals, the most likely impact on marine mammals would be changes in behavior (e.g., avoidance responses). Normal behavior is expected to return once a vessel or aircraft has passed. Overall, impacts on marine mammals from routine operations would range from negligible to moderate.

Expected Accidental Spills. The magnitude of effects from expected accidental spills would depend on the location, timing, and volume of the spills; the environmental settings of the spills (e.g., restricted coastal waterway, deepwater pelagic location); and the species (and its ecology) exposed to the spills. Spill cleanup operations could result in short-term disturbance of marine mammals in the vicinity of the cleanup activity, while a collision with a cleanup vessel could injure or kill the affected individual. Overall, oil spills are expected to have minor to moderate impacts to marine mammals, while impacts from oil spill response activities are expected to be minor. Impacts on species that are extralimital to rare are expected to be negligible to minor, but under unusual circumstances could be moderate to major depending on the number of individuals contacted by a spill.

An Unexpected Catastrophic Discharge Event. In the case of an unexpected, very low-probability CDE, there is greater potential for more severe and population-level effects compared to an assumed large oil spill (i.e., impacts could be moderate to major). The combination of a CDE and cleanup efforts could persist beyond one season, perhaps lasting several years.

Terrestrial Mammals. The terrestrial mammal communities present within the Beaufort and Chukchi Sea Planning Areas include a variety of small mammals (e.g., rodents), big game, and furbearer species. Species of particular concern are the caribou, muskoxen, brown bear, and Arctic fox. Section 3.6.4.2.1 provides an overview of these species.

Impacts of Routine Operations. Under routine operations for the proposed action, terrestrial mammals could be affected by the construction and operation of new onshore pipelines and from vehicle traffic and helicopter overflights.

Construction and Operation of Onshore Pipelines. Under the proposed action, 16 to 129 km (10 to 80 mi) of new onshore pipeline would be installed along the Beaufort Sea, which could result in 73 to 584 ha (180 to 1,443 ac) of soil disturbance (Table 4.4.1-4). The areas disturbed represent an extremely small portion of terrestrial wildlife habitat that occurs inshore of the Beaufort and Chukchi Sea Planning Areas.

Caribou. In general, caribou use coastal areas of the North Slope largely in June, July, and August, although a portion of the Western Arctic Herd may overwinter in coastal habitats bordering the Chukchi Sea, and in some years, the Teshekpuk Lake Herd may remain on the Arctic Coastal Plain throughout the winter. Because onshore pipeline construction would likely occur in winter to minimize impacts on the ground surface and vegetation, construction activities would not affect caribou calving or foraging in summer. Construction could, however, disturb caribou in overwintering areas, causing them to vacate preferred overwintering areas and move into less suitable habitats. Such displacement could affect individuals or local populations as a result of increased energy expenditure associated with movement to, and use of, suboptimal habitat, with subsequent mortality and reduced productivity (NRC 2003a).

If construction were to occur in late spring and summer, calving caribou, females with newborn calves, and older foraging calves could be disturbed. Affected individuals would likely leave or avoid habitats in the vicinity of the construction activities and move into potentially less suitable habitats. During the calving season from late May until late June, which includes the actual calving dates and the following 2 to 3 weeks, cows with calves are particularly susceptible to disturbance by human activities, and such displacement could result in population-level effects if calving success and calf survival are reduced (NRC 2003a).

Overall, caribou may be disturbed during construction or affected by the presence of new onshore pipeline. The response of caribou may include the avoidance or abandonment of preferred habitats in the vicinity of the new pipeline, with subsequent displacement to other potentially suboptimal areas. The magnitude of any such effects would be a function of the specific location of the new pipeline relative to preferred habitats (such as calving and foraging grounds and insect-avoidance areas), the location and length of the pipeline, and the number of individuals affected — the greater the length and distance of the new pipeline from existing pipelines (particularly TAPS), the greater the potential for affecting caribou and the greater the number of caribou and caribou herds that could be affected.

While pipelines built lower than 1.5 m (4.9 ft) above the ground surface may act as physical barriers to movement (NRC 2003a), a pipeline constructed to current clearance standards (with a minimum clearance of 1.5 m [4.9 ft]) would not be expected to physically hinder caribou crossings (Curatolo and Murphy 1986). Caribou have been shown to be reluctant in approaching pipelines and to exhibit reduced crossing success of pipelines located in close proximity to roadways with traffic. Thus, the presence of a new pipeline may affect daily or seasonal movements of some individuals and herds.

Muskoxen. Muskoxen are expected to avoid the area where construction of new pipeline is occurring. It is not known how construction disturbance or the presence of a completed pipeline would affect muskoxen habitat use and reproductive success. However, muskoxen may be particularly vulnerable to disturbance in winter because of limited habitat, the length of the Arctic winter, the need to conserve energy throughout the winter, and, for females, the need to maintain good body condition throughout winter and spring for calving (Reynolds et al. 2002). However, because of the small population size of muskoxen, disturbance from pipeline construction could result in population-level effects, especially if this species is disturbed during winter. The limited distribution and small population size of muskoxen in the coastal and inland areas adjacent to the Beaufort and Chukchi Sea Planning Areas would greatly reduce the likelihood for disturbance of this species.

The presence of a completed pipeline may hinder movement by muskoxen if there is insufficient pipeline clearance for this species. However, muskoxen do not exhibit as extensive seasonal or daily movements as caribou. If undisturbed, muskoxen remain in relatively small areas throughout the winter, while in summer they exhibit longer movements that track the emergence of high-quality forage plants (Reynolds et al. 2002). In summer, most daily movements of radio-tracked individuals in the Arctic National Wildlife Refuge (ANWR) were reported to be less than 5 km (3 mi) in length, and many were typically less than 1 km (0.6 mi) in length (Reynolds et al. 2002). Existing pipelines associated with the North Slope oil fields and TAPS do not appear to have hindered the westward expansion of muskoxen from ANWR. For muskoxen to have expanded their range from ANWR to the Colville River, some individuals had to cross the TAPS ROW or travel through the oil fields on the North Slope (BLM 2002). Thus, the presence of a new pipeline is not expected to adversely affect muskoxen populations in onshore areas adjacent to the Beaufort and Chukchi Sea Planning Areas.

Brown Bear. The brown bear uses the coastal environments and/or terrestrial oil transportation routes onshore of the entire Beaufort and Chukchi Sea Planning Areas. Winter construction of onshore pipeline could disrupt individual bear dens. In summer, some individuals may temporarily leave habitats in the vicinity of active construction. However, because bears often habituate to human activities and facilities (Follmann and Hechtel 1990), the presence of new pipeline is not expected to directly adversely affect the brown bear.

Arctic Fox. Arctic foxes occur throughout the Beaufort and Chukchi Sea Planning Areas, using the coastal and shore-fast ice habitats. The Arctic fox would not be adversely affected by the construction or operation of new pipeline. Individuals would likely abandon habitats temporarily in the vicinity of construction activities. Because the completed pipeline could provide increased shelter and den habitat, populations of Arctic fox could increase along the pipeline corridor. An increase in fox abundance could lead to increased outbreak of disease (rabies, canine distemper) among foxes living along the pipeline corridor, as well as increased predation pressures on populations of prey species.

Foxes are highly mobile, and in late autumn and winter, they disperse out onto the sea ice in search of food. Because of this mobility, foxes may visit new offshore facilities (e.g., drilling platforms, ice roads, exploratory seismic trains) in search of food when sea ice is present. Arctic foxes were regularly observed near Seal Island in the Northstar development during the ice-covered season (MMS 2002a). Thus, depending on their number and distance from shore, new offshore platforms may provide additional winter food supplies and increase winter survival of some individuals.

Vehicle Traffic and Helicopter Overflights. Vehicle traffic associated with operations of a pipeline (e.g., pipeline monitoring) could affect wildlife along the new pipeline and any associated access roads. In addition, new access roads may also increase the incidence of vehicles associated with recreation, subsistence hunting, and other activities. Vehicle traffic could disturb wildlife foraging along roadways, causing affected wildlife to temporarily stop normal activities (e.g., foraging, resting) or leave the area. Collision with vehicles could result in mortality, especially in areas with concentrations of wildlife or along migration corridors. Vehicle traffic along any access road associated with the proposed action would likely be light. Thus, the incidence of such collisions would be very low and not expected to result in population-level impacts on wildlife.

Helicopter overflights associated with pipeline monitoring and transport of personnel and supplies may disturb wildlife. The effects of helicopters on wildlife vary by species, populations, habitat type, and environmental variables. Some species may become habituated and experience no adverse effects (e.g., see Harting 1987). Routine overflights by surveillance helicopters would result in a short-term disturbance to animals along the pipeline route, causing them to temporarily alter behaviors, and would not be expected to result in long-term population-level effects.

Caribou. Responses to vehicle and helicopter traffic by caribou can vary from no response to panic behavior. Cow and calf groups appear to be most sensitive (Valkenburg and Davis 1984; MMS 1998). Because caribou tend to avoid transportation corridors (Dau and Cameron 1986; Griffith et al. 2002; Cameron et al. 2002; NRC 2003a), disturbance of caribou by vehicle traffic associated with normal operations of an onshore pipeline would be infrequent. Single passes by helicopters may result in short-term disturbances that should not adversely affect caribou (MMS 1998). Low-flying helicopters are more likely to produce negative responses from caribou than are light, fixed-wing aircraft (Maier et al. 1998). McKechnie and Gladwin (1993) evaluated altitude tolerance thresholds below which aircraft overflights elicit panic and escape responses and determined that the tolerance threshold for a fixed-wing aircraft was 61 m (200 ft), with few or no response reactions observed above 153 m (500 ft). Calef et al. (1976) observed panic or strong escape reactions when aircraft flew at altitudes less than 60 m (200 ft).

Muskoxen. Vehicle traffic along a pipeline access road would likely result in temporary disturbance of muskoxen in the immediate vicinity of the roadway. The response of muskoxen to aircraft overflights has been reported to range from calm to excitable, and the nature of the response depends in part on the altitude of the overflight, terrain, climate, sex, group size, number of calves present in a group, and habituation (Miller and Gunn 1979, 1980). Helicopter and low-flying aircraft overflights can cause muskoxen to stampede and abandon their calves (NRC 2003a). While responses of muskoxen to vehicle traffic and aircraft overflights associated with the proposed action are not expected to adversely affect muskoxen populations, energetic costs associated with forced movements (especially if frequent) in winter could adversely affect spring calving and could result in population-level effects.

Brown Bear. Some brown bears may be injured or killed by collisions with vehicles along access roads, while bears in the vicinity of vehicle traffic may be disturbed and temporarily cease normal behavior or leave the area until the vehicle has passed. Aircraft overflights have been reported to elicit a variety of responses in brown bears, including escape behavior and hiding (Larkin 1996). While vehicle traffic and aircraft overflights associated with the proposed action may on occasion temporarily disturb individual bears, long-term population-level effects would not be expected from normal operations.

Arctic Fox. The Arctic fox may experience temporary disturbance from vehicle traffic and aircraft overflights, resulting in hiding, departure from the immediate area, or cessation of normal behaviors. Some individuals crossing or traveling along access roads may be injured or killed by vehicle traffic. Relatively few individuals are expected to be affected, and population-level impacts would not be expected under normal operations.

Impacts of Expected Accidental Spills. Accidents under the proposed action that could affect terrestrial wildlife would be largely limited to an oil spill from a new pipeline. The impacts on wildlife from an oil spill would depend on such factors as the time of year and volume of the spill, type and extent of habitat affected, and home range or density of the wildlife species. The Arctic environment is particularly vulnerable to the effects of both large and small oil releases, which are expected to persist longer in the environment because of colder temperatures. However, recovery from small spills would probably require no more than a year (MMS 2003a). The potential effects on wildlife from oil spills could occur from direct contamination of individual animals, contamination of habitats, and contamination of food resources. Acute (short-term) effects usually occur from direct oiling of animals (e.g., exposure to toxic hydrocarbons via inhalation and/or by ingestion of oil while grooming contaminated fur), while chronic (long-term) effects generally result from such factors as accumulation of contaminants from food items and environmental media (e.g., water).

Up to two large pipeline spills are assumed to occur over the lifetime of the proposed action (Table 4.4.2-1). Most spills would be small (<1,000 bbl with more than 80% assumed to be <50 bbl). For the most part, the small spills would occur at offshore facilities rather than from the onshore pipeline. Wildlife may be exposed to spilled oil by eating a variety of oiled vegetation, wildlife, and/or contaminated carrion. In addition, animals occurring within a spill area may also be exposed via inhalation of aromatic hydrocarbons. Such exposure would likely result in sublethal or lethal effects. Oil spills could also potentially affect terrestrial mammals by fouling of fur, causing loss of its insulating capacity. Species such as Arctic foxes would be vulnerable to oil ingestion from grooming their fur (Nuka and Pearson 2010). The magnitude of the effect will depend on the level of exposure, the life stage of the exposed animal (e.g., adult, cub), and the condition of the exposed animal (e.g., healthy, injured).

Staging and support activities for cleanup of a large offshore spill could temporarily displace terrestrial mammals. Oil spill cleanup activities on land may displace these animals from not only contaminated habitats but also nearby uncontaminated habitats. This displacement could reduce energy reserves (especially in winter), which in turn could affect body condition and reproductive success.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes an unexpected, very low-probability CDE of 1.4 to 2.2 million bbl lasting 40 to 75 days in the Chukchi Sea Planning Area and a CDE in the Beaufort Sea Planning Area of 1.7- 3.9 million bbl and lasting 60 to 300 days (Table 4.4.2-2). If a CDE occurs, there is greater potential for more severe effects compared to the risk of effects from an assumed large oil spill. A CDE would result in sustained degradation of water quality, shoreline terrestrial habitats, and, to a lesser extent, air quality that could impact terrestrial mammals from direct contact, inhalation, and ingestion (either directly or indirectly through the consumption of oiled forage or prey species). These effects could be severe where persistent, heavy oil makes contact with important habitat and prey base, causing a multitude of acute and chronic effects. Additional effects on terrestrial mammals would occur from land and air quality degradation associated with response and cleanup vessels, *in situ* burning of oil, dispersant use, and activities on shorelines associated with cleanup, booming, beach cleaning, and monitoring. A CDE has the potential to alter terrestrial mammal habitats and populations. The potential for a population-level impact would occur in the unlikely event that a spill occurred in an area where a large number of individual animals are concentrated. For instance, population-level effects to caribou would be most likely from spills occurring in calving areas and along migration corridors. For the muskoxen, the potential for population-level effects would be greatest for a spill occurring in winter when this species remains in small areas, restricted by the availability of forage (Reynolds et al. 2002).

BOEMRE (2011k) concluded that if even several thousand caribou died from oil contamination from a CDE, herd sizes are sufficient to recover within 1 to 2 years. A CDE would probably not impact more than a few brown bears. The home ranges of these bears could be reoccupied within the same season, and population recovery would most likely occur within 1 to 2 years (BOEMRE 2011k). Impacts from a CDE on muskoxen are not anticipated as they spend most of their time inland and away from the Chukchi and Beaufort Sea coasts. Large litters would compensate for any losses of Arctic foxes due to a CDE, and low densities of wolves and wolverines would be expected to prevent more than a few individuals at most from potentially being exposed to oil.

Impact Conclusions.

Routine Operations. The construction and normal operations of new pipeline could result in a variety of short-term and long-term impacts to terrestrial mammals. Short-term impacts would largely be behavioral in nature, with affected animals avoiding or vacating the construction areas. Similarly, vehicle and aircraft traffic associated with the proposed action could temporarily disturb mammals near access roads or under flight paths. While the disturbance of these animals would be short-term in nature, the energetic costs incurred by some of the disturbed biota (especially overwintering muskoxen and pre-calving female caribou) could affect reproductive success. Therefore, disturbances could result in longer term impacts to animal populations. The presence of a new onshore pipeline may result in the displacement from preferred habitats to less suitable habitats for overwintering muskoxen, calving female caribou, and female caribou and their calves. Such displacement may reduce overwinter conditioning or survival as well as calving success. While population-level effects may not be likely for caribou, local population-level effects may occur for muskoxen because of the small population size in Alaska. While vehicle traffic and aircraft overflights associated with the proposed action may on occasion temporarily disturb brown bears and Arctic foxes, long-term population-level effects would not be expected from normal operations. Overall, routine activities associated with the proposed action are not expected to have long-term major impacts on terrestrial mammal species of the North Slope of Alaska. Impacts to terrestrial mammals could range from negligible to moderate.

Expected Accidental Spills. Oil spills may expose terrestrial mammals to oil or its weathering products. In the event of an accidental small or large spill, terrestrial mammals may be exposed via ingestion of contaminated food, inhalation of airborne oil droplets, and direct ingestion of oil during grooming, which may result in a variety of lethal and sublethal effects. However, because most spills would be relatively small (<1,000 bbl with over 80% assumed to be <50 bbl), relatively few individuals would likely be exposed. While some individuals may incur lethal effects, population-level impacts would not be expected. Cleanup activities could temporarily disturb terrestrial mammals, causing those animals to move from preferred to less optimal habitats, which, in turn, could affect their overall condition. Such displacement would be limited to those animals in the vicinity of the cleanup activity, and thus would not be expected to result in population-level effects. Overall, oil spills and associated oil spill response activities are expected to have negligible to minor impacts on terrestrial mammals.

An Unexpected Catastrophic Discharge Event. In the case of a low-probability CDE, there is greater potential for terrestrial mammals and their habitats to be impacted compared to an assumed large oil spill. Impacts to terrestrial mammals would be minor to major. The combination of a CDE and cleanup efforts could persist beyond one season, perhaps lasting several years.

4.4.7.2 Marine and Coastal Birds

Each of the four phases of OCS oil and gas development have associated impact-producing factors (Table 4.1.1-1), some of which may affect marine and coastal birds in the Planning Areas included in the proposed action. Oil and gas development activities that may occur following lease sales under the proposed action and that may affect marine and coastal birds include (1) offshore structure placement and pipeline trenching; (2) offshore structure removal; (3) operational discharges and wastes; (4) OCS vessel and aircraft traffic; (5) construction and operation of onshore infrastructure (including new pipeline landfalls); and (6) noise. Table 4.4.7-2 identifies the impacting factors associated with routine operations that

TABLE 4.4.7-2 Impacting Factors and the Marine and Coastal Bird Resource Components That Could Be Affected with Oil and Gas Development under the Proposed Action

	Resource Component Potentially Affected								
	Habitat[a]			Life Stage[b]			Behavior		
Development Phase and Impacting Factors That May Affect Marine and Coastal Birds	Nesting	Foraging	Overwintering	Nestlings	Juveniles	Adults	Foraging	Courtship/ Nesting	Migration/ Staging
Impacting Factors Common to All Phases									
Helicopter noise	-[c]	-	-	+	+	+	+	+	-
Helicopter traffic	-	-	-	+	+	+	+	+	-
Ship noise	-	-	-	-	-	-	-	-	-
Ship traffic	-	-	-	+	+	+	+	+	+
Hazardous materials	-	-	-	+	+	+	-	-	-
Solid wastes	-	-	-	+	+	+	-	-	-
Offshore lighting	-	-	-	-	+	+	-	-	+
Offshore air emissions	-	-	-	-	-	-	-	-	-
Exploration – Exploratory Drilling									
Seismic noise	-	-	-	-	-	-	+	-	-
Drilling noise	-	-	-	-	+	+	-	-	-
Drilling mud/debris	-	-	-	-	+	+	-	-	-
Offshore Development									
Drilling noise	-	-	-	-	+	+	+	-	-
Trenching noise	-	-	-	+	+	+	+	+	-
Drilling mud/debris	-	-	-	-	+	+	+	-	-
Pipeline trenching	-	+	+	+	+	+	+	-	-
Wellhead and platform placement	-	-	-	-	+	+	+	-	-
Onshore Development									
Site clearing	++	++	-	++	+	+	++	++	+
Construction activity	-	-	-	+	+	+	+	+	+
Construction noise	-	-	-	+	+	+	+	+	+
Production									
Platform collisions	-	-	-	-	+	+	-	-	-
Production noise	-	-	-	-	+	+	-	-	-
Produced water	-	-	-	-	+	+	-	-	-
Drill mud/debris	-	-	-	-	-	-	-	-	-
Decommissioning									
Explosive platform removal	-	-	-	-	+	+	+	-	-
Non-explosive platform removal	-	-	-	-	+	+	+	-	-

[a] Reflects only direct loss or physical degradation of the habitat and not habitat use.

[b] Reflects only injury or mortality of affected life stage.

[c] A dash (-) indicates no effect anticipated; "+" indicates a potential for short-term impacts, "++" indicates a potential for long-term impacts, and "+++" indicates possible population-level effects.

could affect birds and the aspects of marine and coastal birds that could be affected by those factors.

In general, routine operations associated with oil and gas development are not expected to result in population-level effects on marine and coastal birds. Most impacts from routine operations would be localized to the site of the project infrastructure or along support vehicle routes, would for most operations be short term or transient, and would likely affect relatively few individuals or habitats. The greatest potential for longer term and possibly population-level impacts would be associated with very large accidental oil spills. In most areas, small spills would likely affect relatively small numbers of birds and habitats. In contrast, very large spills could affect habitats along extensive areas of coastline and large numbers of birds and important habitats (such as nesting colonies or wintering grounds). Depending on the timing, duration, size, and location of a very large spill, population-level impacts could be incurred by some species.

4.4.7.2.1 Gulf of Mexico.

Impacts of Routine Operations. Routine activities associated with the proposed action that may affect marine and coastal birds in the northern GOM include (1) offshore structure placement and pipeline trenching, (2) offshore structure removal, (3) operational discharges and wastes, (4) OCS vessel and aircraft traffic, (5) construction and operation of onshore infrastructure (including new pipeline landfalls), and (6) noise. Potential impacts associated with these activities may include injury or mortality of birds from collisions with platforms, vessels, and aircraft; exposure to operational discharges; ingestion of trash or debris; loss or degradation of habitat due to construction; and behavioral disturbance due to the presence of, and noise generated by, equipment and human activity (Russell 2005). The nature and magnitude of effects on birds will depend on the specific location of an activity or completed structure (e.g., with greater impacts if a pipeline landfall construction would occur adjacent to a heron rookery), the timing of the activity (e.g., construction that occurs during nesting), and the nature and magnitude of the activity (e.g., the number of miles of trenching through nearshore coastal habitats, the quantity and concentrations of the production water discharges). Consultation with Federal agencies concerning construction and operation of onshore and offshore infrastructure will assure compliance with the Endangered Species Act and the Migratory Bird Treaty Act.

Offshore Structure Placement and Pipeline Trenching. The construction of new offshore infrastructure is not expected to adversely affect marine and coastal birds. Pipeline trenching may affect birds in nearshore coastal areas if trenching occurs in or near foraging or nesting areas. For many species, the effects would be primarily behavioral, namely, the short-term avoidance or abandonment of habitats in the immediate area of trenching. Pipeline trenching near nesting colonies (such as heron rookeries) may disturb adults that are incubating eggs or feeding young, potentially affecting nesting success. Because trenching could result in some long-term loss of coastal habitat (see Section 4.4.6.1.1), habitat loss for some species may also occur. Such impacts could be avoided or minimized by locating pipeline corridors away from nesting aggregations and/or by scheduling trenching activities to avoid the nesting period.

Seabirds such as the brown pelican often use offshore oil and gas production platforms as rest areas or as temporary shelters during inclement weather. In addition, offshore platforms are also used in spring and fall for resting and feeding stopovers by birds migrating to and from more southern wintering areas (Russell 2005). For example, in the fall, many migratory species (including waterfowl, shorebirds, and passerines) arrive at the GOM coast and then fly several hundred miles across the open GOM waters directly for to Central and South America (Lincoln et al. 1998). This route appears to be preferred over the safer but more circuitous land or island routes by way of Texas or Florida. The use of offshore platforms may increase the survivability of individuals using these structures to rest or as shelter during bad weather conditions in the open waters of the GOM (Russell 2005).

Migrating birds may collide with offshore platforms. Annual bird mortality from collisions with offshore platforms has been estimated at 200,000 birds in the northern GOM, with an average of 50 collision deaths per platform per year (Russell 2005). This is probably an underestimate of actual collision mortality incurred by migrating birds, because it is based only on birds recovered from the platforms; birds falling into the water are not reflected in these mortality estimates (Russell 2005). Applying the 50 collision deaths per platform per year estimate, new platforms that could be constructed following lease sales held under the proposed action may result in a total incremental increase of about 10,000 to 22,500 bird collision mortalities. By comparison, hundreds of millions of birds are killed each year colliding with communication towers, windows, electric transmission lines, and other structures (e.g., see Klem 1989, 1990; Dunn 1993). Migrating birds may also be drawn to a lighted platform and circle the platform before moving on or stopping on the platform (Russel 2005). Such circling behavior could increase the potential for a platform collision, and use up valuable energy reserves needed for completing the trans-GOM migration.

Offshore Structure Removal. Under the proposed action, up to 275 existing platforms could be removed from the GOM planning areas. Because many marine birds, as well as migratory birds, are attracted to platforms, there is a potential for some individuals to be affected if they are present during platform removal activities. Typical platform decommissioning involves dismantling many of the above-platform structures, followed by the use of underwater explosives to collapse the platform proper. Birds using a platform undergoing decommissioning would likely leave the platform during dismantling activities. Any remaining birds would be startled by the underwater detonations and quickly leave the collapsing structure. Thus, relatively few individual birds would be affected by decommissioning activities under the proposed action.

Operational Discharges and Wastes. Normal operational wastes may include produced water, drilling muds, and drill cuttings discharged from offshore platforms, waste fluids produced on OCS vessels, and trash and debris generated on platforms and vessels. A number of normal operational discharges and wastes have the potential to affect marine and coastal birds.

The discharge of production wastes into open water is prohibited in coastal waters but permitted in marine waters under the NPDES program (see Section 4.4.3.1). Produced water, drilling muds, and drill cuttings are routinely discharged from production platforms in the GOM into offshore marine waters in compliance with applicable regulations and permits, and would continue to be so discharged with any development following lease sales under the proposed action. The discharged materials may contain a variety of constituents (e.g., trace metals, hydrocarbons) that may be toxic to birds. In marine waters, birds could be exposed to these materials by direct contact or through the ingestion of contaminated food items. Birds most likely to be present at offshore production locations where operational discharges are occurring are those that forage on fish in offshore waters and may frequent offshore facilities; these include pelicans, frigatebirds, gannets, and terns.

Upon discharge in accordance with permit specifications, production wastes would be rapidly diluted in the water column (i.e., to ambient levels within several thousand meters of discharge [see Section 4.4.3.1.1]) and dispersed by currents, thus greatly reducing the magnitude of exposure that a bird might incur. If constituents of the discharged materials bioaccumulate or biomagnify, there is a potential that some birds may be exposed through their food. Field studies have shown that the concentrations of trace metals, hydrocarbons, or NORM in the tissues of fishes collected around production platforms are within background levels (Continental Shelf Associates 1997). Thus, food chain uptake is likely not a major exposure pathway for fish-eating birds at offshore facilities.

Some bird species may also be affected indirectly if the discharges reduce the abundance of prey species (NRC 1983; MMS 1995c). However, because of the rapid dilution that would occur, potential impacts on prey populations inhabiting the water column (e.g., fish, plankton) would likely be limited in extent and not be expected to significantly affect overall prey abundance (see Sections 4.4.7.3.1 and 4.4.7.5.1). While some production-related contaminants may reach sediments and reduce macroinfaunal abundance (Rabalais et al. 1998), the potentially affected macroinvertebrate biota would be at depths beyond the diving limits of birds. Sediment impacts can last for years after the discharge period has ended (Rye et al. 2008) and can cause an overall impoverishment of the benthic community (Daan and Mulder 1996). These sediment changes may affect benthic larval or juvenile stages of species which would eventually become prey for seabirds. However, the relative amount of sediment that could be affected would be very small.

Many species of marine birds (especially gulls) often follow ships and forage in their wake on fish and other prey injured or disoriented by the passing vessel. In doing so, these birds may be affected by discharges of waste fluids (such as bilge water) generated by OCS vessels. Discharges of such wastes from OCS service and construction vessels, when allowed, would be regulated under applicable NPDES permits (see Section 4.4.3.1); any discharged wastes would be quickly diluted and dispersed and thus not be expected to affect marine birds.

Marine and coastal birds may become entangled in or ingest floating, submerged, and beached debris (Heneman and the Center for Environmental Education 1988; Ryan 1987, 1990). Entanglement may result in strangulation, the injury or loss of limbs, entrapment, or the prevention or hindrance of the ability to fly or swim, and all these effects may be considered lethal. Ingestion of debris may irritate, block, or perforate the digestive tract, suppress appetite, impair digestion of food, reduce growth, or release toxic chemicals (Fry et al. 1985; Dickerman and Goelet 1987; Ryan 1988; Derraik 2002). Because the discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by BOEM (30 CFR 250.40) and the USCG (MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]), entanglement in or ingestion of OCS-related trash and debris by marine and coastal birds would not be expected under normal operations.

Vessel and Aircraft Traffic. Under the proposed action, up to 600 vessel and 5,500 helicopter trips may take place weekly within the northern GOM planning areas. Birds may be affected in the following ways by this traffic: (1) they may be induced by vehicle noise to cease a particular activity (such as nesting or feeding) and leave the area, (2) they may incur injury or mortality through collision with a ship or helicopter, or (3) nests may be disturbed by excessive boat wakes.

Disturbance from noise is addressed later in this section. Birds disturbed by the presence of an OCS vessel may flee an area. Displaced birds would move to other habitats and may or may not return. In most cases, such displacement would be short term and transient and would not be expected to result in any lasting effects. However, if the displaced birds were occupying active nests, incubating eggs, or feeding and protecting hatchlings, even a short-term absence of the adult birds could increase predation of eggs or unfledged young, or reduce hatching success. However, because of the heavy commercial and recreational boat traffic in the northern GOM, most birds of the area are likely habituated to ship traffic and may only minimally react to passing OCS support vessels. In addition, OCS vessel traffic would likely occur within designated traffic lanes and not in waterways where birds may be nesting on beaches or other shoreline habitats. For this same reason, wakes from OCS-related vessels are also not expected to affect coastal birds and their nests. In addition, low-wake or wake-free vessel speeds are required while transiting across waterways that have sensitive shoreline resources (such as shorebird nesting colonies). Thus, compliance with such requirements would further minimize potential wake-induced impacts on birds.

A number of studies have examined the responses of birds to low-flying aircraft and atypical noise (see *Noise* discussion below). The results of many of these studies have indicated that although habituation may vary among species (Conomy et al. 1998), many species of birds will habituate to low-flying aircraft and noise and exhibit no effects on reproductive success (Black et al. 1984; Andersen et al. 1989; Delaney et al. 1999).

FAA guidelines for helicopter operations in the GOM request that pilots maintain a minimum altitude of 213 m (600 ft) while in transit offshore, 305 m (1,000 ft) over unpopulated areas or across coastlines, and 610 m (2,000 ft) over populated areas and sensitive habitats such as wildlife refuges and park properties (FAA 2010). Compliance with these guidelines regarding service altitudes for OCS helicopters would minimize disturbance of nesting or roosting birds within coastal areas.

Construction and Operation of Onshore Infrastructure. Loss or alteration of preferred habitat due to new OCS pipeline landfalls could result in the displacement of individuals or groups of birds from the affected area(s), including a possible decrease in nesting activities although relatively few birds and nests are likely to be affected. Some pipelines in the central and western GOM have been brought to shore using a directional drilling process (MMS 2006a, 2008a) in which pipelines pass beneath coastal habitats to emerge inland at an onshore receiving facility, away from coastal habitats. Where used, this process could greatly reduce or avoid impacts on coastal habitats that are important to listed and non-listed marine and coastal birds.

Under the proposed action, up to 12 landfalls would be expected in the Western and Central GOM Planning Areas, with none occurring in the EPA. The location and small number of landfalls that could occur with development associated with the proposed action would greatly limit the amount of coastal bird habitat that might be disturbed. In addition, siting of pipeline landfalls would consider the presence of sensitive habitats and areas, and avoid such areas to the maximum extent possible, further reducing the likelihood of affecting coastal bird habitats and the magnitude and extent of impacts on such habitats.

Noise. Noise generated during facility and pipeline construction, production operations, and platform removal activities, and by OCS ships and helicopters, may affect birds in a variety of ways. Unexpected noise can startle birds and potentially affect feeding, resting, or nesting behavior, and often causes flocks of birds to abandon the immediate area.

Much of the wildlife-related noise effects research has shown that noise may affect territory selection, territorial defense, dispersal, foraging success, fledging success, and song learning (e.g., Anderson et al. 1986; Gladwin et al. 1988; Larkin 1996). In many cases, the effects are temporary, with the birds becoming habituated to the noise. For example, weapons testing noise has been reported to have no significant effect on bald eagle activity or reproductive success, suggesting habituation of the birds to the noise (e.g., Brown et al. 1999). Studies of birds exposed to frequent low-level military jet aircraft overflights and simulated (with mortars, shotguns, and propane cannons) mid- to high-altitude sonic booms have shown aircraft and detonation noise to elicit some short-term behavioral responses but to have little effect on reproductive success (Ellis et al. 1991). Birds of prey have been reported to habituate to low-level helicopter flights and exhibit no effects on their reproductive success (Delaney et al. 1999; Andersen et al. 1989), and low-level (<500 ft AGL) military training flights have been shown to have no effects on the establishment, size, and reproductive success of wading bird colonies in Florida (Black et al. 1984). On the basis of these studies, noise generated during normal operations is expected to have only short-term and transient effects on birds, and would not be expected to result in long-term disturbance or population-level effects.

Potential Effects on ESA-listed Species in the Gulf of Mexico Planning Areas. Normal operations may affect listed bird species in the same manner as non-listed species (i.e., primarily behavioral disturbance). Compliance with ESA regulations and coordination with the NMFS and USFWS would ensure that lease-specific operations would be conducted in a manner that avoids or greatly minimizes the potential for affecting these species.

The threatened Audubon's crested caracara, the endangered Mississippi sandhill crane, the threatened and endangered piping plover, the endangered roseate tern, the endangered whooping crane, the endangered wood stork, and the candidate red knot occur in the GOM planning areas and thus could be affected by oil and gas development in the area. Those species reported from Florida (the Audubon's crested caracara and the roseate tern are exclusive to Florida) would not be expected to be affected by normal OCS oil and gas operations.

The roseate tern, which is known to occur in oceanic waters, occurs within the Florida Keys and southeastern Florida (USFWS 1999; FFWCC 2003). Because these areas are hundreds of kilometers away from the portion of the Eastern GOM Planning Area where oil and gas leasing and development might occur under the proposed action, the roseate tern would not be expected to be exposed to production wastes generated at offshore facilities. The roseate tern is likely to visit offshore platforms during normal foraging activities, but the NMFS has previously evaluated the explosive removal of offshore platforms in the GOM and issued a Biological Opinion that concluded that such structure removal would not jeopardize birds listed under the ESA (NMFS 1988). In addition, BOEM has established guidelines for explosive platform removals (30 CFR Part 250). Compliance with the BOEM guidelines should further reduce the likelihood that offshore structure removal could affect the roseate tern.

Because its distribution is limited to within or near a wildlife refuge in Mississippi, relatively few Mississippi sandhill cranes would be expected to be present in areas where seismic exploration, offshore platform and pipeline construction, or OCS vessel and aircraft traffic is occurring. This species is non-migratory, so collision with offshore platforms is unlikely. While it is possible for daily aircraft traffic to result in the long-term displacement of birds from frequently used flight line locations, the very low number of Mississippi sandhill cranes that could be present along flight lines means that few, if any, birds would be expected to be impacted.

Overwintering flocks of piping plovers could be temporarily disturbed by seismic exploration and by the construction of offshore platforms and pipelines, if those activities were to occur in or near areas where the birds are overwintering. Overwintering birds may also be disturbed by OCS-related vessel and aircraft traffic. If affected, birds would be expected to move away from oncoming vessels and would not be adversely affected. Overwintering birds may be startled by helicopter overflights and may or may not take flight and flee the immediate vicinity. Some birds could be killed or injured as a result of collisions with platforms or OCS-related aircraft; however, piping plovers migrate north for the breeding season and do not travel across the GOM, so collisions with offshore platforms would not be expected.

Overwintering flocks of whooping cranes could be temporarily disturbed by seismic exploration and by the construction of offshore platforms and pipelines, if those activities were to occur in or near areas where the birds are overwintering. Construction would not occur in the Aransas National Wildlife Refuge, but birds occurring outside of the refuge may be disturbed. Overwintering birds may also be disturbed by OCS-related vessel and aircraft traffic. If affected, birds would be expected to move away from oncoming vessels and would not be adversely affected. Overwintering birds may be startled by helicopter overflights and may or may not take flight and flee the immediate vicinity. Some birds could be killed or injured as a result of collisions with OCS-related aircraft; however, whooping cranes migrate north for the breeding season and do not travel through the GOM, so no population-level effects would be expected from collision with offshore platforms.

While the wood stork can be found in the GOM Central and Eastern Planning Areas, the only coastal counties where breeding occurs are located in Florida where normal OCS oil and gas operations will not occur. Non-breeding individuals located in Alabama could be temporarily disturbed by seismic exploration and by the construction of offshore platforms and pipelines, if those activities were to occur in or near areas where the birds are overwintering. Overwintering birds may also be disturbed by OCS-related vessel and aircraft traffic. If affected, birds would be expected to move away from oncoming vessels and would not be adversely affected. Overwintering birds may be startled by helicopter overflights and may or may not take flight and flee the immediate vicinity. Some birds could be killed or injured as a result of collisions with platforms or OCS-related aircraft; however, exposure to routine operations would be expected to be infrequent and localized due to the limited distribution of wood storks in coastal GOM counties outside of Florida.

While the red knot can be found in the GOM planning areas, nesting occurs in mid- and high-Arctic latitudes, so breeding individuals would not be impacted by OCS-related activities. Overwintering flocks of red knots could be disturbed by seismic exploration and by the construction of offshore platforms and pipelines, if those activities were to occur in or near areas where the birds are overwintering. Overwintering birds may also be disturbed by OCS-related vessel and aircraft traffic. If affected, birds would be expected to move away from oncoming vessels and would not be adversely affected. Overwintering birds may be startled by helicopter overflights and may or may not take flight and flee the immediate vicinity. The red knot might visit an offshore platform during spring and fall migrations, but only if stopping to rest on a platform while crossing the GOM. BOEM has established guidelines for explosive platform removals (30 CFR Part 250). Compliance with the BOEM guidelines should further reduce the likelihood that offshore structure removal could affect the red knot. Some birds could be killed or injured as a result of collisions with platforms or OCS-related aircraft, but population-level impacts are not expected. As this species is not an open-water feeder or swimmer, no exposure to operational discharges would be expected.

Impacts of Expected Accidental Events and Spills. The accidental oil spill scenario for the GOM under the proposed action identifies as many as 8 large (≥1,000 bbl) and as many as 470 small (<1,000 bbl) oil spills potentially occurring with development resulting from the lease sales of the proposed action (Table 4.4.2-1). The majority of the expected small accidental spills would be <50 bbl (see Table 4.4.2-1), would quickly dissipate, and would only have the potential to affect a very small amount of habitat and relatively few individuals. Small spills larger than 50 bbl (≤1,000 bbl) would similarly be relatively easy to contain and would only affect small areas of habitat and few individuals. A large spill (≥1,000 bbl), depending on the season and location, would be more difficult to contain and may result in lethal and sublethal effects on relatively large numbers of birds. In the event of an accidental oil spill, birds may be adversely affected through direct contact with the spilled oil, by the fouling of their habitats and contamination of their food by the oil, and as a result of oil spill-response activities. Exposure of eggs, young, and adult birds to oil may result in a variety of lethal and sublethal effects. Fouling of habitats can reduce habitat quality, while contamination of foods may lead to a variety of lethal and sublethal toxic and physiological effects. Finally, oil spill-response activities may disturb birds in nearby habitats that are unaffected by an oil spill.

Adult and young birds may come in direct contact with oil on the water's surface or on oiled beaches, mudflats, and other shore features. Oil may also be physically transferred by nesting adults to eggs or young. Direct contact with oil by young and adult birds may result in the fouling or matting of feathers, which would affect flight and/or diving capabilities, affecting such activities as foraging and fleeing predators. Birds that have been fouled by oil also experience a loss in the insulating properties of their feathers, making them susceptible to hypothermia during cold weather periods. Oil making contact with skin, eyes, or other sensitive tissues may result in an irritation or inflammation of skin or sensitive tissues (Fry and Lowenstine 1985), while oiled eggs would incur reduced gas exchange.

Birds may ingest oil incidentally while foraging and while preening oiled feathers. Ingested oil may depress egg-laying activity or may result in the death or deformities of young (Fry et al. 1985; Leighton 1993). Direct effects of oil contact may be amplified under conditions of environmental stress such as low temperatures, migration movements, and molting. Indirect effects of oil contact include toxic effects from the consumption of contaminated food or starvation from the reduction of food resources (Lee and Socci 1989). The latter effects may hinder the recovery of impacted bird populations after a spill (Hartung 1995; Piatt and Anderson 1996; Piatt and Ford 1996).

Certain species of marine and coastal birds may be more susceptible to contact with spilled oil than others, based on their life histories. For example, diving birds and underwater swimmers such as loons, cormorants, and diving ducks may be the most susceptible to spilled oil because of their relatively long exposure time within the water and at the sea surface (Camphuysen 2007; Williams et al. 1995). Shorebirds and wetland birds may also be susceptible to direct oiling if a spill were to reach the beach intertidal zone or inshore wetland habitats, respectively, where these species forage and raise young (King and Sanger 1979). Oiled birds collected during response actions to the DWH event included seabirds, shorebirds, wetland birds, waterfowl, passerines, and raptors, with the majority of oiled birds being seabirds (see Section 3.8.2.1.5 and Table 3.8.2-6).

The magnitude of the impact would depend on the size, location, and timing of the spill; the species and life stage when exposed; and the size of the local bird population.

Spills in deep water are not likely to affect the listed and candidate bird species identified for the northern GOM (Table 3.8.2-3). Only the roseate tern and the red knot would be expected in areas of the outer inner continental shelf where deepwater spills could occur, and these occurrences would be transient and not expected to result in direct exposure to spilled oil. In contrast, all the listed and candidate species with the exception of the roseate tern could be exposed if a deepwater spill were to move into coastal waters and reach coastal habitats utilized by these species. Even if a deepwater spill were to reach coastal habitats, because of the great distance from shore at which a deepwater spill would originate the oil would be greatly weathered, and therefore reduced in toxicity, by the time it reached the shore (see Section 4.4.3.1.2).

In contrast, a number of non-listed seabird species (e.g., terns, gulls, shearwaters, boobies, frigatebirds) could be exposed to deepwater spills. Some of these species are found only in pelagic areas of the GOM, while others inhabit waters of the continental shelf (see Section 3.1.2.3.2) (Duncan and Havard 1980; Davis et al. 2000). A number of these species forage in deepwater areas, are attracted to offshore platforms, and often follow vessels. These birds may be directly exposed while feeding or resting in spills originating from deepwater platforms or transport tankers and could incur lethal or sublethal effects. Depending on its size, location, and timing, a deepwater spill may affect only a few individuals or, as in the case of aggregations of overwintering gannets, a relatively large number of birds.

A shallow water spill in an offshore or nearshore area that reaches shoreline habitats has the potential to affect a greater number of bird species than a deepwater spill of comparable size that does not reach the coast. Most threatened or endangered avian species are not likely to be affected by a spill unless a hurricane were to occur and spread oil inland to freshwater and terrestrial habitats. However, the piping plover and red knot could be exposed if their beach habitats become fouled by a spill. Because shorebirds tend to be flocking species, spills reaching habitats used by these species could result in the exposure of a relatively large number of individuals. The sandhill crane, wood stork, and whooping crane could be exposed if a spill were to foul their coastal wetland habitats. Because of the very specific and limited winter habitat that supports the majority of whooping cranes, a spill affecting this habitat could result in population-level effects on this species. Audubon's crested caracara, while reported to use coastal dune habitats, is generally more of a terrestrial species and would not be expected to occur along beach and wetland habitats. The roseate tern breeds in scattered colonies along the Florida Keys (see Section 3.8.2.1.2) and could be exposed if a spill were to occur in the extreme southeastern portion of the EPA. Under the proposed action, however, lease sales would be limited to the extreme western portion of this planning area, hundreds of miles from the nearest nesting colony of this tern. Thus, this species would not be expected to be exposed to any accidental spills that might occur in association with a lease sale under the proposed action.

Accidental spills in shallow water could affect a wide variety of non-listed species. In offshore locations, shallow water spills could expose any of a large variety of ducks, cormorants, terns, grebes, and gulls. Spills reaching shoreline habitats such as beaches, mudflats, and wetlands could affect shorebirds (e.g., sandpipers, plovers), wading birds (e.g., herons, bitterns), wetland birds (e.g., rails, coots, blackbirds), and a wide variety of migratory birds. Spills occurring during the fall or spring migrations have the potential to expose large numbers of birds in both nearshore coastal waters and in coastal habitats such as beaches, flats, and wetlands. The magnitude of impacts that could result from an accidental spill in shallow water would depend on the timing, duration, location, and size of the spill; the habitats that came in contact with the spill; and the species and numbers of birds exposed to the spill.

Besides being affected by the spill itself, marine and coastal birds may be affected during spill containment and cleanup activities. Spill response plans will include consultations with Federal and/or State wildlife agencies to minimize potential impacts of response actions on marine and coastal birds. During cleanup, some oiled birds could be successfully cleaned, and cleanup of the affected habitat could be necessary to avoid chronic exposure. Nesting or roosting birds in nearby habitats unaffected by the spill could be disturbed by cleanup of contaminated habitats. Coastal cleanup and remediation activities in coastal habitats may impact local populations of coastal birds, resulting in their temporary displacement from these areas. If the abandoned area is an important nesting habitat (especially during the breeding season), local population-level impacts may be incurred. The application of dispersant chemicals to spilled surface oil could also affect birds. While dispersant chemicals contain constituents that are considered to have low levels of toxicity when compared to toxic constituents of spilled oil (Wells 1989), the effects of these dispersants on seabirds are poorly understood. Because the use of these chemicals and spill cleanup activities would be localized and infrequent, potential impacts from spill response activities would largely be short term (e.g., avoidance of the cleanup area).

The specific nature and magnitude of effects of an oil spill on marine and coastal birds of the GOM will depend on the size, location, timing, and duration of the spill and the birds and habitats exposed to the spill. Small spills may be expected to affect relatively small numbers of birds and habitats and would not be expected to cause population-level impacts.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes a CDE in the GOM with a volume ranging from 900,000 to 7,200,000 bbl and a duration of 30–90 days (Table 4.4.2-2). In the unlikely event that a CDE were to occur in the GOM, the nature and magnitude of impacts to marine and coastal birds would depend on the location, magnitude, and duration of the event, as well as the species, life stages and habitats exposed to the spill. Exposure to oil from a low-probability CDE would have similar types of impacts on bird populations as spills of other magnitudes; however, the area affected and the number of species and individuals likely affected would increase and the degree of impact would be more severe. A much greater number of birds and habitats could be affected, and population-level impacts for some species could be incurred as CDEs can affect extensive areas of shoreline. For example, the Gulf Coast Least Tern Colony (see Section 3.8.2.1.4) on the Mississippi coast has one of the world's largest colonies of least tern. A CDE reaching this colony site during the nesting season could foul several thousand nests and result in the loss of an entire reproductive season, the effects of which may cause long-term population effects.

Exposure to oil can cause pneumonia, kidney damage, reduced immune system function, and anemia in birds. Even low levels of oil can stress birds by interfering with food detection, feeding impulses, predator avoidance, territory definition, homing of migratory species, susceptibility to physiological disorders, disease resistance, growth rates, reproduction, and respiration (MMS 2006b). The GOM acts as an important stopover site for many migratory bird species, and a CDE could impact a bird's ability to consume enough resources to successfully complete its migration. A study of the impact of the 1979 Ixtoc spill on Texas shorebirds found that oil on the beach caused birds to shift their habitat selection to feed in less productive areas (Chapman 1981, 1984). Avoiding oiled habitat may become problematic for species at the edges of their ranges or if a CDE results in widespread oiling of coastlines.

Impact Conclusions.

Routine Operations. The nature and magnitude of effects of routine operations in the GOM on birds would depend on the specific location, the timing, and the nature and magnitude of the operation, as well as the species that would be exposed to the operation. For routine Program activities, the primary effects would be the disturbance of birds (and their normal behaviors) by noise, construction and development equipment, human activity, and habitat loss in areas of infrastructure construction. Birds may also incur injury or mortality as a result of collisions with infrastructure and support vessels.

Birds tend to habituate to human activities and noise, especially in areas like the GOM planning areas, where local bird populations are regularly exposed to noise, construction, and vessel traffic associated with commercial and recreational activities. In most cases, noise disturbances of birds would be short-term or transient, and would be expected to have only minor impacts on marine and coastal birds. Construction of offshore platforms and pipelines could result in short-term avoidance or abandonment of habitats in the immediate area of trenching. However, because of the relatively small amount of habitat that could be disturbed, as well as the limited use of some of the affected habitats (such as deepwater benthic habitat), habitat disturbance or loss is expected to have only minor impacts. Construction of onshore pipelines and landfalls could result in the permanent disturbance of habitat and displacement of individuals within the immediate footprint of the new pipelines and facilities. Because of the relatively small amount of habitat that could be disturbed, habitat disturbance or loss is expected to have only minor impacts on marine and coastal birds. Some mortality may be expected for birds colliding with offshore platforms and, to a lesser extent, with helicopters providing support services to offshore platforms. Impacts from such collisions are anticipated to affect relatively few birds and result in only minor impacts on bird populations, with no population-level effects. Because the discharge of production wastes and other materials generated at offshore platforms and OCS-related vessels is regulated and because permitted production wastes discharged into marine waters would be quickly diluted and dispersed, relatively few birds would be exposed to these waste materials and impacts from such discharges would likely be negligible. The overall impact of all routine operations of the Program is expected to range from negligible to moderate.

Expected Accidental Events and Spills. Accidental oil spills from offshore platforms and pipelines could affect both birds and their habitats. The magnitude and ecological importance of any effects would depend upon the size of the spill, the species and life stages that are exposed, and the size of the local bird population. A shallow water spill in an offshore or nearshore area may impact a greater number of bird species than a deepwater spill, as spills reaching shoreline habitats have the potential to affect shorebirds, wading birds, wetland birds, and migratory birds. Small spills, especially those <50 bbl, would be easily contained and cleaned up. All small spills (≤1,000 bbl) would only impact small areas of habitat and relatively few individuals and are expected to have no more than minor impacts on marine and coastal birds. Large spills (>1,000 bbl), especially those occurring during the fall or spring migrations, may result in lethal and sublethal effects, including reduced reproductive success, on large numbers of birds in both nearshore coastal waters and in coastal habitats. Impacts to marine and coastal birds from a large oil spill in the GOM planning areas are expected to be moderate to major.

An Unexpected Catastrophic Discharge Event. A CDE poses the greatest threat to marine, coastal, and migratory birds, and could affect both birds and their habitats. A CDE would cause similar types of impacts on bird populations as spills of other magnitudes, but the degree of impact would be more severe. Similar to smaller spills, birds that become heavily oiled by direct contact with a spill would likely perish, while lightly oiled birds may experience a variety of lethal or sublethal effects. The GOM acts as an important stopover site for many migratory bird species. An unlikely CDE can foul foraging areas and food resources along extensive areas of shoreline and may impact a bird's ability to refuel for migration. A spill associated with a CDE would affect the greatest number of species, individuals, and habitats, and have the potential to cause moderate to major impacts to affected species.

4.4.7.2.2 Alaska – Cook Inlet.

Impacts of Routine Operations. Oil and gas development that could occur in the Cook Inlet Planning Area following a lease sale under the proposed action would include (1) offshore exploration; (2) construction of offshore platforms and pipelines; (3) construction of onshore pipeline landfalls and pipelines; (4) operations of offshore and onshore facilities; and (5) OCS-related vessel and aircraft traffic (Table 4.4.1-3). While activities supporting this development may be expected to affect marine and coastal birds in the vicinity of the development activities, these impacts would largely be short term, generally affect only a relatively small number of birds at any one time, and not be expected to result in population-level impacts on any species.

Offshore Exploration. Under the proposed action, oil and gas exploration could include the placement of up to 12 exploration and development wells in the Cook Inlet Planning Area. Seismic surveys and placement and operation of the wells could affect some birds. Disturbance of birds during seismic surveys would be limited to the immediate area around survey vessels, be short term, and be largely behavioral (MMS 2005e). For example, noise from airguns and disturbance from survey vessel traffic could displace foraging seabirds in offshore waters, especially if exploration were to occur in areas with high seabird density (such as the open waters adjacent to the Stevenson and Kennedy Entrances to Cook Inlet and off the northwestern coast of Kodiak Island [see Section 3.8.2.2.4]) where seabirds are likely to be encountered. If disturbed, affected birds would likely cease foraging activities and leave the vicinity to feed in other areas. Because the lease sale would occur no closer than 3 NM from shore, offshore exploration activities (including the placement of exploration and development wells) would not be expected to disturb marine or coastal birds or their habitats (such as seabird colonies or wintering grounds) in coastal areas. Thus, normal offshore exploration activities are not expected to result in any population-level effects for local bird populations.

Construction of Offshore Platforms and Pipelines. Under this proposed action, up to three offshore platforms could be constructed in the Cook Inlet Planning Area. These platforms would likely be constructed outside of the planning area and towed to their final location, and marine and coastal birds could be temporarily disturbed during the transportation and placement of the platforms. Disturbance would likely result in affected birds leaving the immediate area of activity (either the platform location or the transportation route). Because of the small number of platforms, the transient nature of their transport and construction, and their offshore locations being well away from coastal habitats and seabird colonies, any impacts on marine and coastal birds may be expected to be short term, affect relatively few birds, and not result in long-term population-level effects for any species.

In addition to the new platforms, up to 241 km (150 mi) of new offshore pipeline could be constructed following leasing under the proposed action. Pipeline trenching could affect birds in nearshore coastal habitats if trenching occurs in or near foraging, overwintering, or staging areas or near seabird colonies. Trenching may also disturb marine species foraging in offshore waters. For many species, disturbance from pipeline trenching would result primarily in a behavioral response, namely, the short-term abandonment or avoidance of habitats in the immediate area of trenching. Pipeline trenching near seabird colonies could cause adults to abandon nests (at least temporarily) and cease incubating eggs or feeding young, and thereby potentially affecting nesting success. If nests are permanently abandoned, some localized population-level effects may be incurred by the affected species if successful nesting habitat is not found elsewhere. Potential impacts could be avoided or minimized by locating pipeline corridors and the landfall away from nesting aggregations (seabird colonies), and by scheduling trenching activities to avoid staging, overwintering, and nesting periods.

Construction of up to 241 km (150 mi) of new offshore pipeline could affect as much as 210 ha (519 ac) of benthic habitat within the Cook Inlet Planning Area and locally affect the availability of foraging habitat for some marine and coastal birds. Because portions of the new pipelines would be in water depths potentially unavailable for most marine and coastal birds, pipeline construction may be expected to have limited effect on the overall availability of foraging habitat for marine and coastal birds. Any impacts on food sources would be localized to the pipeline footprint and are expected to affect relatively few individuals.

Construction of Onshore Pipelines and Landfalls. Under the proposed action, up to 169 km (105 mi) of new pipeline and possibly one new pipeline landfall could be constructed in onshore areas adjacent to the Cook Inlet Planning Area. Construction of new pipelines would likely be located in the general vicinity of existing oil and gas infrastructure, delivering oil to existing refineries in Nikiski and natural gas to existing transmission facilities in the Kenai area (Table 4.4.1-3). Depending on the proximity of the new onshore pipelines or a new pipeline landfall to existing roads, one or more new access roads could be needed to bring in construction equipment and supplies to the construction areas. The construction of new pipelines would result in a long-term loss of a relatively small amount of habitat (about 4.9 ha [12 ac], assuming a 30.5-m [100-ft] construction ROW) along the pipeline routes, while construction camps to support onshore construction activities would affect an additional very small amount of terrestrial habitat. Siting new pipelines and facilities away from coastal areas would reduce the amount of marine or coastal bird habitat that could be affected. Potential habitat impacts could be reduced by locating the new pipelines within existing utility or transportation ROWs. Because there are relatively few nesting colonies along the Kenai Peninsula north of Anchor Point (USGS undated), only a few seabird colonies could be affected by onshore construction activities. The disturbance of birds in these colonies could be reduced or avoided by siting any new onshore infrastructure away from colony sites and by scheduling construction activities to avoid nesting periods. Overall, onshore construction activities are expected to affect only a relatively small number of birds and not to result in population-level effects for any affected species.

Operations of Offshore Facilities. During normal operations, birds may be affected by noise and human activities at onshore and offshore facilities and by the presence of the facilities themselves. Noise and human activities (such as normal maintenance) could affect birds moving through Cook Inlet during spring and fall migration, as well as birds moving into nesting, fall molting, or overwintering habitats in the planning area. Affected birds would likely avoid the platforms and nearby habitats. Although operational noise and human activity may cause birds to avoid areas where platforms are located, affected birds would likely select other suitable areas of the planning area. Because of the small number of new platforms (no more than three), the disturbance of birds in offshore waters by operational noise and human activity would be limited to only a few areas around the platforms and is not expected to adversely affect marine or coastal bird populations.

Offshore platforms may pose a collision hazard to birds, especially during migration and/or periods of low visibility. No information is available regarding bird collisions with platforms and other structures in Cook Inlet or elsewhere in Alaskan waters. However, a reasoned estimate of the potential number of such collisions can be made from information available about potential collisions in the GOM. Annual bird mortality in the northern GOM (a major migratory area with several hundred million migrants estimated to pass through annually) from collisions with offshore platforms has been estimated to average 50 collision deaths per platform per year (Russell 2005). Applying a similar collision mortality rate to development that could occur under the proposed action, about 150 bird collision mortalities might be expected annually for the three new platforms.

Operational Discharges and Wastes. Oil and gas development occurring following a lease sale under the proposed action would result in the generation of drilling fluids and debris (Table 4.4.1-3). Produced water, drilling muds, and drill cuttings generated by development and production wells would be disposed of through down-hole injection. Thus, no impacts on marine and coastal birds from these wastes would be expected under normal operations. In contrast, produced water, drilling muds, and drill cuttings generated by exploration and delineation wells would be discharged at the well sites in compliance with applicable regulations and permits. The discharged materials may contain a variety of constituents (e.g., trace metals, hydrocarbons) that may be toxic to birds. In marine waters, birds could be exposed to these materials by direct contact or through the ingestion of contaminated food items. Birds most likely to be present at well sites are those that forage on invertebrates and fish in offshore waters; these include seabirds such as the alcids (such as the common murre, pigeon guillemot, and ancient murrelet), gulls and terns (such as the mew gull and Arctic tern), and others.

Upon discharge in accordance with permit specifications, production wastes would be rapidly diluted in the water column (i.e., to ambient levels within several thousand meters of discharge [see Section 4.4.3.2.1]) and dispersed by currents, thus greatly reducing the potential for, and the magnitude of, exposure. If constituents of the discharged materials bioaccumulate or biomagnify, there is a potential for some birds to be exposed through their food. Field studies have shown that the concentrations of trace metals, hydrocarbons, or NORM in the tissues of fishes collected around production platforms are within background levels (Continental Shelf Associates 1997).

Normal operations may be expected to generate a variety of operational wastes, such as waste oils, bilge water on support ships, and sanitary wastes. Hazardous waste materials such as lubricating oils, paint, and industrial cleaners would be controlled and disposed of at licensed onshore facilities. Domestic wastewater and sanitary wastes generated on platforms or support vessels would be treated and then discharged to surrounding waters, where they would be quickly diluted (Section 4.4.3.2.1). Many species of marine birds (such as gulls) often follow ships and forage in their wake on fish and other prey injured or disoriented by the passing vessel. Because there would be up to 3 platforms and no more than three weekly vessel trips, only a relatively small volume of operational wastes would be discharged. Any such discharges would be quickly diluted and dispersed and thus not expected to affect marine or coastal birds that could be following the vessels or visiting waters immediately around the production platform.

Marine and coastal birds may become entangled in or ingest floating, submerged, and beached debris (Ryan 1987, 1990). Because the discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by BOEM (30 CFR 250.40) and the USCG (MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]), entanglement in or ingestion of OCS-related trash and debris by marine and coastal birds would not be expected under normal operations.

Vessel and Helicopter Traffic. There could be up to three helicopter trips and three vessel trips each week supporting up to three offshore platforms that could be installed following leasing under the proposed action. Vessel and helicopter traffic could disturb birds in foraging, molting, and staging area habitats as well as in nesting areas (such as seabird colonies) that may occur along the traffic routes. Birds may also be injured as a result of collisions with aircraft. Birds responding to approaching support vessels may be expected to cease normal behaviors and move away from the oncoming vessel; this would have little overall impact on affected birds.

In contrast to ship traffic, helicopter overflights likely have a greater potential for disturbing birds. Both the relatively sudden appearance (compared to an approaching ship) and the noise of helicopter overflights may startle birds, causing them to cease their normal behaviors and flee. The reactions of birds to aircraft overflights will depend on a variety of factors, including the species present, the altitude of the flights, and the frequency of the flights (e.g., see Gladwin et al. 1988; Ellis et al. 1991; Derksen et al. 1992; Miller et al. 1994; Larkin 1996; Delany et al. 1999). Helicopter overflights of open water may startle birds that are resting or foraging on the water surface, causing them to cease normal behavior and possibly try to flee the area. Should birds be disturbed while nesting, nesting success may be affected, especially if the disturbance results in nest abandonment and/or increased nest predation. Alternately, some birds may become habituated to aircraft disturbance. For example, no significant decrease in reproductive success was reported in a thick-billed murre colony located near an airport compared to other thick-billed murres that nested away from the airport (Curry and Murphy 1995). FAA guidelines for helicopter oceanic operations request that pilots maintain a minimum altitude of 213 m (600 ft) while in transit offshore, 305 m (1,000 ft) over unpopulated areas or across coastlines, and 610 m (2,000 ft) over populated areas and sensitive habitats such as wildlife refuges and park properties (FAA 2010).

It is assumed that helicopter support for the new platform would originate from the municipal airport in the Kenai-Nikiski area, north of the Cook Inlet Planning Area, and potential for disturbance of marine and coastal birds would be greatest along the east coast of Cook Inlet in this area and southward into the planning area. This area has several areas that provide important habitat for migrating shorebirds and waterfowl in spring, and some of which provide important overwintering habitat for Steller's eider (Table 3.8.2-2). Although there are no large seabird colonies in this area, small numbers of nesting seabirds could be affected by the overflights. Because of the low amount and transient nature of daily support traffic that might occur under the proposed action, relatively few birds may be expected to be affected by vessel or aircraft traffic. While disturbance of nesting birds has the potential to impact individuals, the number of affected birds would likely be very limited, and if seabird colonies are present, the disturbance of nesting birds could be avoided by using flight paths and vessel routes that avoid the colonies.

Potential Effects on ESA-listed Species in the Cook Inlet Planning Area. Normal operations may affect listed bird species in the same manner as non-listed species (i.e., primarily behavioral disturbance). Compliance with ESA regulations and coordination with the NMFS and USFWS would ensure that lease-specific operations would be conducted in a manner that avoids or greatly minimizes the potential for affecting these species.

The endangered short-tailed albatross, the threatened Steller's eider, and the candidate Kittlitz's murrelet and yellow-billed loon, occur in or near the Cook Inlet Planning Area and thus could be affected by oil and gas development in the area. The short-tailed albatross does not breed in or near the Cook Inlet Planning Area, occurring only as an occasional visitor that forages on the continental shelf edge beyond the southern boundary of the planning area (see Section 3.8.2.2.2). The Steller's eider also does not nest in the Cook Inlet Planning Area, but does overwinter in lower Cook Inlet and in the Shelikof Strait. Thus, normal operations would not be expected to affect nesting habitats or reproductive success of either of these species.

Because of its uncommon occurrence in marine waters in and around the Cook Inlet Planning Area, relatively few short-tailed albatross would be expected to be present in areas where seismic exploration, offshore platform and pipeline construction, or OCS vessel and aircraft traffic is occurring. If present, disturbed individuals would likely move to areas away from the OCS activity and not be adversely affected. While it is possible for a bird to collide with an OCS-related aircraft, the combination of the very low number of short-tailed albatrosses that could be present around platforms or along associated flight lines with the very small amount of aircraft traffic supporting only new platforms means that few, if any, birds would be expected to incur collisions with support aircraft or with a platform. While such collisions would likely result in the mortality of the affected individual, population-level effects would not be expected to result from such collisions.

Overwintering flocks of Steller's eider could be temporarily disturbed by seismic exploration and by the construction of offshore platforms and pipelines, if those activities were to occur in or near areas where the birds are overwintering. Overwintering birds may also be disturbed by OCS-related vessel and aircraft traffic. If affected, birds would be expected to move away from oncoming vessels and would not be adversely affected. Overwintering birds may be startled by helicopter overflights and may or may not take flight and flee the immediate vicinity. Some birds could be killed or injured as a result of collisions with platforms or OCS-related aircraft. Because there would only be no more than three new platforms and three flights per week to the platforms by support aircraft, such collisions are not expected, few if any individuals would be affected, and no population-level effects would be expected.

While Kittlitz's murrelet can be found in the Cook Inlet Planning Area, it is present in a very patchy and clumped distribution, preferring areas of heavy glaciation, high turbidity, and partial ice cover (Day et al. 2000b; Van Pelt and Piatt 2003). This species has been reported to be sensitive to excessive noise and human activity (Day and Nigro 1999). Offshore platform or pipeline construction activities occurring near concentrations of this species could result in the short- or long-term displacement of birds from the construction areas. Construction of onshore pipelines and facilities could disturb nesting birds and affect nest sites, although it is unlikely that more than a few individuals would be affected. This species nests on cliffs and scree slopes, in a terrain typically avoided when pipelines are being sited. Long-term platform operations and daily vessel and aircraft traffic may also result in the long-term displacement of birds from surrounding platform locations and along frequently used flight line locations. In addition, some individuals could collide with OCS-related aircraft. Because of the disjunct distribution of this species, exposure to routine operations would be expected to be infrequent and localized.

Lower Cook Inlet is used by overwintering yellow-billed loons and by immature and possibly nonbreeding adults throughout the year. This species could be temporarily disturbed by seismic exploration and by the construction of offshore platforms and pipelines, if those activities occurred in or near areas where the birds are present. Birds also may be disturbed by OCS-related vessel and aircraft traffic. Birds may be startled by helicopter overflights and may or may not take flight and flee the immediate vicinity. Some birds could be killed or injured as a result of collisions with platforms or OCS-related aircraft; however, there would be no more than three new platforms and three flights per week to the platforms by support aircraft, so no population -level effects would be expected.

Impacts of Expected Accidental Events and Spills. Under the proposed action, no more than one large spill (between 1,700 and 5,000 bbl from either a platform or a pipeline), and as many as 18 small spills (<1,000 bbl) may be expected over the lifetime of the lease. The magnitude and extent of impacts on marine and coastal birds from such spills will be a function of a variety of factors, including (1) the time of year of the spill, (2) the volume of the spill, (3) the habitats exposed to the spill, and (4) the species exposed to the spill or that utilize the impacted habitats. The majority of expected accidental spills would be small (<50 bbl) (see Table 4.4.2-1), would quickly dissipate, and would only have the potential to affect a very small amount of habitat and relatively few individuals. Small spills larger than 50 bbl (≤1,000 bbl) would similarly be relatively easy to contain and would only affect small areas of habitat and few individuals. A large spill (≥1,000 bbl), depending on the season and location, would be more difficult to contain and may result in lethal and sublethal effects on relatively large numbers of birds. Oil spills from onshore pipelines may affect terrestrial habitats and birds. Because of the lower number of species and individual birds that would be present in winter, as well as their more limited winter distribution, a greater number of species and individuals may be expected to be affected by an accidental oil spill during spring and fall migration and during the summer. However, some species overwinter in Cook Inlet, in relatively large numbers, and these could be affected by an accidental spill. Birds in areas near habitats that have been affected by oil may also be disturbed during spill cleanup operations. Spill cleanup activities may displace birds from nearby habitats, which, depending on the nature of those habitats (e.g., nesting, molting, staging), could result in reduced reproductive success or survival. In addition, the duration of cleanup activities may preclude birds from using the area for quite some time.

Exposure of eggs and young and adult birds to oil may result in a variety of lethal and sublethal effects, while oil may foul habitats, reducing habitat quality and contaminating foods; these potential effects apply to both non-listed and listed bird species of the Cook Inlet Planning Area. The short-tailed albatross, Steller's eider, and Kittlitz's murrelet may be directly affected by an accidental oil release in the same manner as described for non-listed birds, namely, via direct contact and through the ingestion of contaminated foods. These three species may also be indirectly affected as a result of spill-related impacts on their habitats, which may also be affected during oil spill cleanup activities. Direct exposure of birds or their habitats could result in a variety of lethal and nonlethal effects that may affect survival and reproductive success, potentially resulting in population-level effects on the exposed species (e.g., see Hartung 1995; Piatt and Anderson 1996; Day et al. 1997a, b; Esler et al. 2000; Lance et al. 2001; Golet et al. 2002; Esler et al. 2002). The types of effects that exposed birds could incur are discussed in Section 4.4.7.1.

During ice-free conditions (i.e., summer), accidental spills (especially small ones) may be expected to be quickly diluted (see Section 4.4.3.2.2). In contrast, spills occurring under ice may persist for a longer period of time and be transported by currents to areas more distant from the site of the accidental spill. Previous modeling of similar size oil spills in Cook Inlet indicate that land segments with the highest chance of contact with an offshore platform or pipeline spill are generally along the western shore of lower Cook Inlet in Kamishak Bay and Shelikof Strait (MMS 2003a). Several areas that provide important habitat to migrating and overwintering birds (see Figure 3.8.2-8 and Table 3.8.2-8), as well as a number of seabird colonies, occur in these areas (USGS undated).

Offshore spills that reach coastal areas may expose species that forage or nest in coastal habitats along Cook Inlet and Shelikof Strait. As discussed in Section 3.8.2.2, these areas support thousands of migrating shorebirds and waterfowl, provide important wintering habitat for Steller's eider, and include numerous seabird colonies. Spills reaching these areas could directly or indirectly expose adults, eggs, young, and food resources. Because of the large number of Steller's eider that overwinter in coastal areas of Cook Inlet (in the vicinity of Homer Spit and Kamishak Bay) (Larned 2005), an accidental spill reaching wintering areas could expose a large number of birds. This species concentrates in shallow, vegetated nearshore habitats, and spills contacting such areas could locally reduce foraging habitat and food resources and contaminate potential prey. The number of birds affected would depend on the size and location of the spill, the number of birds directly exposed to the spill, and the amount of habitat affected.

Offshore spills in marine waters may also expose migrating seabirds and waterfowl, as well as pelagic seabirds that forage in areas such as the offshore marine waters of Cook Inlet near the Barren Islands (Figure 3.8.2.2-1). The short-tailed albatross is considered to be highly vulnerable to the impacts of oil pollution (King and Sanger 1979). Because this species does not breed in the planning area, accidental spills would not be expected to affect nesting colonies. This species is widely dispersed and is only an irregular visitor to the marine waters of the planning area. Few individuals would be expected to be exposed to an accidental spill, and few individuals would be expected to be disturbed during spill cleanup activities. The exposure of a very small number of short-tailed albatross would not be expected to result in population-level impacts on the species. This species forages in open marine waters, and no specific foraging habitat type or location has been identified as being of prime importance for this species. In the event of an accidental spill, members of this species would likely relocate their foraging activities, with no resulting significant impacts expected. Thus, accidental spills would not be expected to adversely affect foraging habitats and associated prey items available to the short-tailed albatross in the Cook Inlet Planning Area.

Spills may also indirectly affect bird populations by reducing food resources and prey availability in affected habitats. These indirect effects could reduce foraging success and energy assimilation, which may affect growth, survival, and reproductive success. Depending on the species affected, these effects could result in population-level effects. Because of the small number and size of spills assumed for routine operations that might occur under the proposed action (Table 4.4.2-1), widespread exposure and impacts such as those observed for the *Exxon Valdez* oil spill in Prince William Sound are not expected for this alternative.

Because of the preference of Kittlitz's murrelet for glacially influenced habitats and its patchy and disjunct distribution among coastal areas, accidental oil spills would generally not be expected to affect more than a few individuals. A moderate to large spill in a high-use area could, however, result in the oiling of a relatively large number of birds. While the chronic effects of long-term exposure of this species are not known, studies on the effects of the *Exxon Valdez* oil spill on marine birds indicate that while murrelets as a whole are especially vulnerable to and adversely affected by large oil spills, this group recovers within a relatively short time following the initial spill and exposure (Day et al. 1997a, b; Murphy et al. 1997). The greatest potential for population-level impacts would be associated with offshore spills occurring in spring and summer and affecting breeding adults. Because this species nests in terrestrial habitats up to 129 km (80 mi) inland (see Section 3.8.2.2.2), nest sites would not be expected to be affected by offshore spills but could be affected by spills from onshore pipelines. However, because this species nests in habitats such as coastal cliffs, scree slopes, and talus above timberline, which are typically considered unsuitable and thus are avoided when a pipeline is being sited, nest sites are unlikely to be affected by an onshore oil spill.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes a CDE in the Cook Inlet Planning Area with a volume ranging from 75,000 to 125,000 bbl and with a duration of 50–80 days (Table 4.4.2-2). A low-probability CDE would have similar impacts on bird populations as spills of other magnitudes. However, the area affected would increase and the degree of impact would be more severe depending on the location, magnitude, and timing of the event, climate conditions (winter, ice cover), and on the species, life stages, and habitats exposed to the spill. A much greater number of species, individuals, and habitats could be affected, and population-level impacts for some species could be incurred if the CDE affects extensive areas of shoreline. Such a spill contacting important migratory staging areas for waterfowl and shorebirds could have adverse effects on a variety of species. The Cook Inlet is characterized by the sudden and rapid occurrence of very large numbers of birds in early May as many species of birds use this region as important stopover habitats during their spring migrations. If a CDE were to occur during this time, a larger number of species and individual birds would be impacted by the spill, either by direct mortality or indirectly through loss of habitat or food. Similarly, a CDE reaching wintering areas for waterfowl could have population-level effects, especially with the increased difficulty in addressing spills under winter conditions.

A study of the *Exxon Valdez* oil spill in the Northern Gulf of Alaska reported populations of loons, grebes, cormorants, and sea ducks declining by 44–84% (Piatt et al. 1990). The immediate impact of the spill was a reduction in the size of local breeding populations. Populations may continue to be impacted in the future as both production and recruitment are reduced. In addition to immediate mortality, a CDE can impact bird populations through ingestion of oil or contamination of nest sites (Piatt et al. 1990). Nine years after the *Exxon Valdez* oil spill, most of the diving bird species studied still exhibited negative impacts, while only one surface-feeding species showed a negative effect. The difference in impacts may be due to behavioral differences that result in diving birds spending more time at rest on the water and in contact with any remaining oil on the surface of the water (Irons et al. 2000).

Impact Conclusions.

Routine Operations. The nature and magnitude of effects of routine operations in Cook Inlet on birds would depend on the specific location, the timing, and the nature and magnitude of the operation, as well as the species that would be exposed to the operation. For routine Program activities, the primary effects would be the disturbance of birds (and their normal behaviors) by construction and development equipment and human activity, and habitat loss in areas of infrastructure construction. Birds may also incur injury or mortality as a result of collisions with infrastructure and support vessels.

Offshore exploration activities such as seismic surveys and well placement could displace foraging seabirds. However, activities would occur far enough from shore that only negligible or minor impacts are expected on marine and coastal birds. Construction of offshore platforms and pipelines has the potential to affect the foraging habitat of some marine and coastal birds, but impacts to food sources would be limited to the pipeline footprint, and the overall impact is expected to be no more than negligible or minor. Construction of onshore pipelines and landfalls would result in the long-term disturbance of habitat within the immediate footprint of the new facilities. Because of the relatively small amount of habitat that could be disturbed, only minor impacts are expected on marine and coastal birds. Some mortality may be expected for birds colliding with offshore platforms and, to a lesser extent, with helicopters providing support services to offshore platforms. Impacts from such collisions are anticipated to affect relatively few birds and result in only negligible or minor impacts on bird populations, with no population-level effects. Because the discharge of production wastes and other materials generated at offshore platforms and OCS-related vessels is regulated and because permitted production wastes discharged into marine waters would be quickly diluted and dispersed, relatively few birds would be exposed to these waste materials and impacts from such discharges would likely be negligible. The overall impact of all routine operations for the Program could range from negligible to moderate.

Expected Accidental Events and Spills. Accidental oil spills in the Cook Inlet Planning Area could affect birds through direct contact or through indirect contamination of their food resources and their habitats. The magnitude and ecological importance of any effects would depend upon the size of the spill, the species and life stages that are exposed, the size of the local bird population, and the time of year that the spill occurs. Cook Inlet and Shelikof Strait support large numbers of migrating shorebirds and waterfowl and provide important wintering habitat. Spills reaching these areas could impact large numbers of birds and their habitats. Small spills, especially those <50 bbl, may be expected to quickly dilute during ice-free conditions, but spills occurring under ice may persist. The effects of all small spills (≤1,000 bbl) would be localized and the impacts are expected to be minor. Large spills (>1,000 bbl), especially those occurring under ice and those that reach important wintering habitats, may result in lethal and sublethal effects on large numbers of birds. Impacts to marine and coastal birds from a large spill in the Cook Inlet Planning Area are expected to be moderate to major.

An Unexpected Catastrophic Discharge Event. A CDE poses the greatest threat to marine, coastal, and migratory birds, and could affect both birds and their habitats. A CDE would cause similar types of impacts on bird populations as spills of other magnitudes, but the degree of impact would be more severe. Cook Inlet contains important migratory staging areas for waterfowl and shorebirds. An unexpected CDE occurring in May or winter months would be expected to have a higher impact on bird populations due to the rapid occurrence of large numbers of migratory birds and the difficulties associated with spill cleanup in ice conditions. The impacts of a CDE on coastal and marine birds in the Cook Inlet Planning Area are expected to range from moderate to major.

4.4.7.2.3 Alaska – Arctic.

Impacts of Routine Operations. Under the proposed action, a number of facilities could be constructed and operated in offshore and onshore portions of the Beaufort Sea and Chukchi Sea Planning Areas (Table 4.4.1-4). Under the exploration and development scenarios for these two planning areas, it is assumed that development would be limited to the shelf areas of both planning areas and to water depths less than 91 m (300 ft). Because the shelf is relatively narrow in the Beaufort Sea, ranging from 90 km (about 60 mi) in the west to 50 km (30 mi) in the east, oil and gas activities would occur within 200 km (100 mi) of shore. In contrast, the Chukchi Sea Planning Area has a very wide shelf area with water depths less than 91 m (300 ft), and oil and gas activities may occur in areas 200 km (120 mi) or more from shore. Figure 4.4.1-2 shows the locations of historic lease sales in the Beaufort Sea and Chukchi Sea Planning Areas; future lease sales and development may be expected to occur in similar areas. Thus, coastal birds are more likely to be affected by development in the Beaufort Sea Planning Area than in the Chukchi Sea Planning Area following lease sales under the proposed action. Marine and coastal birds could be affected during routine operations at these locations by (1) offshore exploration, (2) construction of offshore platforms and pipelines, (3) construction of onshore pipelines, (4) operation of offshore platforms, (5) operational discharges and wastes, and (6) vessel and aircraft traffic.

Offshore Exploration. During offshore exploration, seismic surveys conducted in offshore areas could affect primarily seabirds, because these are the species most likely to be foraging or otherwise using pelagic open waters areas of the two planning areas. Potentially affected birds may include puffins, murres, auklets, gulls and terns. Noise from airguns and disturbance from survey vessel traffic could displace birds from nearby habitats. These disturbances would be limited to the immediate area around survey vessels, would be short term, and would not be expected to result in adverse impacts on local bird populations.

Construction of Offshore Platforms and Pipelines. Under the proposed action, one to four offshore platforms could be constructed in the Beaufort Sea Planning Area, and one to five in the Chukchi Sea Planning Area (Table 4.4.1-4). Construction of offshore platforms would likely involve the construction of gravel islands to support drilling operations, and seabirds and waterfowl that utilize offshore waters could be affected by construction of these islands. However, construction of these offshore islands would occur in winter when most species are absent. Thus, construction of offshore platforms would not be expected to affect seabirds or waterfowl.

The exploration and development scenario for the proposed action identifies the construction of many miles of new offshore pipeline in the two planning areas: 48 to 2,422 km (30 to 1,505 mi) for the Beaufort Sea and 40 to 402 km (25 to 250 mi) for the Chukchi Sea. Because pipeline construction would also occur in winter when most species have left the area, few birds would be affected by this construction.

Construction of the offshore gravel islands to support drilling operations would likely use gravel mined from the vicinity of the offshore islands. On the North Slope, gravel is generally extracted from the floodplains of large rivers (Pamplin 1979; BLM 2002). Because the mining of gravel would occur in winter along with other construction activities, gravel mining would not be expected to disturb seabirds, waterfowl, or shorebirds, because these would normally be absent during that time. The winter excavation of gravel could result in the conversion of some riverine floodplain habitats into open water habitats, potentially affecting the local distribution and availability of nesting and foraging habitats for some species arriving the following spring after gravel excavation has occurred.

A variety of waterfowl and shorebird species nest in floodplain habitats along the Arctic coast. The extent to which some of these species could be affected by gravel excavation will depend on the specific habitats excavated, the extent of habitat disturbance, and the level of nesting use that the affected area typically supported. Because gravel excavation would occur in winter, active nests would not be disturbed. Instead, birds arriving in spring searching for suitable nesting habitat would simply search for other nesting locations. Because the relatively small number of offshore facilities that could be constructed under the proposed action (no more than nine platforms total for the two planning areas) would require a relatively limited amount of gravel, excavation activities (and associated habitat impacts) would likely be limited to a few locations.

Although pipeline trenching would also be carried out in winter when most seabird and waterfowl species are not present, seafloor trenching could locally disrupt benthic invertebrate communities that may serve as food sources for waterfowl during other seasons. The extent to which benthic food sources could be affected and the subsequent impact on waterfowl will depend on the type and amount of benthic habitat that would experience long-term disturbance from trenching, the importance of the specific habitats in providing food resources to waterfowl, and the number of waterfowl that could be affected.

Pipeline trenching could disturb as much as 13.5 ha (33 ac) and 567 ha (1,400 ac) of benthic habitat in the Beaufort Sea and Chukchi Sea Planning Areas, respectively. Much of this disturbance would occur in water depths of 30 m (100 ft) or more and thus affect benthic habitats that are largely inaccessible by seabirds and diving ducks. Trenching could, however, affect the egg or larval survival/development (through direct mortality and increased turbidity) of fish species that will eventually become prey for seabirds (SAFMC 2005). The environmental changes caused by trenching would be temporary and would only affect more sensitive prey species. Thus, pipeline trenching is expected to have very limited effects on the overall availability of waterfowl food sources, and any impacts on food sources would be very localized and would not be expected to result in population-level impacts on local seabird and waterfowl populations.

The winter construction would also utilize ice roads to build and access gravel island construction sites during the winter. Ice roads may be constructed over both tundra habitats and frozen ocean habitats. During the construction of ice roads, water from local rivers and lakes would be pumped onto the desired area to build up a rigid surface. Ice roads over frozen ocean habitats would have little effect on most bird species because few species would be present in this season. However, species that do overwinter (such as ptarmigan and snowy owl) may temporarily leave the construction area and move to similar habitats in nearby locations.

Construction of Onshore Pipelines. Under the proposed action, up to 129 km (80 mi) of new onshore pipeline could be constructed in onshore areas adjacent to the Beaufort Sea Planning Area; no onshore pipelines would be constructed in support of new development in the Chukchi Sea Planning Area (Table 4.4.1-4). The construction and operation of up to 129 km (80 mi) of new overland pipelines could disturb coastal and tundra species; it could degrade or eliminate as much as 390 ha (970 acres; assumes 30.5-m [100-ft] pipeline ROW) of potential nesting or post-molting habitat within the footprint of the new pipelines, causing birds to select habitats in other locations. Construction camps to support onshore construction activities would temporarily disturb some areas and limit use by birds; this disturbance would be short- or long-term, depending on the nature and effectiveness of camp abandonment and restoration activities following completion of construction activities. The impacts on potential habitat would be temporary and localized, and birds would likely respond by selecting other areas for nesting or post-molting. Regardless of the duration of the effect, the amount of habitat that would be disturbed would be relatively small and not be expected to affect more than a few birds. Careful pipeline ROW siting to avoid important nesting or post-molting habitats, and avoiding construction during post-molting and staging periods near such habitats, would further reduce the magnitude of any potential effects on local bird populations.

Operations of Offshore Platforms. During normal operations, birds may be affected by noise and human activities at the platforms, as well as by the presence of the platforms themselves. Noise generated during drilling and production activities could affect the use of surrounding waters by birds arriving during spring migration, foraging in surrounding waters during nesting season, and later in the year during fall molting and staging periods. Some species may react by avoiding areas immediately in the vicinity of the platforms, other species may show little avoidance or become acclimated, and still others may be attracted to the offshore platforms. Because of the small number of offshore platforms (no more than nine for both planning areas), the disturbance of birds by operational noise and activity would likely be limited to relatively few individuals and would not be expected to result in population-level effects for any species.

Operational platforms may pose collision threats to migrating and nesting birds alike. Many coastal nesting species travel out to open waters of the shelf to forage, while many species of waterfowl and seabirds migrate along the shelf in spring and summer (Section 3.8.2.3). While little information is available regarding bird collisions with platforms in the Arctic, annual bird mortality from collisions with offshore platforms in the northern GOM has been estimated to average 50 collision deaths per platform per year (Russell 2005). By applying a similar collision mortality rate to the platforms that would be developed in the Beaufort Sea and Chukchi Sea Planning Areas, a total of 200 annual bird collision mortalities might be expected for the four new platforms in the Beaufort Sea Planning Area, and 250 total annual collision mortalities for the five new platforms in the Chukchi Sea Planning Area. The incidence of bird collisions in the GOM may be much greater than the incidence that could occur in the two Arctic planning areas because of the much greater number of migrants in the GOM. However, some Arctic species such as the murres and puffins) are present in very large numbers (Section 3.8.2.3.1) in some locations along the Arctic coast and exhibit daily migrations between coastal nesting areas and foraging areas as far as 80 km (50 mi) or more offshore, which could increase the potential for encountering offshore platforms.

Operational Discharges and Wastes. Produced water, drilling muds, and drill cuttings generated by development and production wells would be disposed of through down-hole injection. Thus, no impacts on marine and coastal birds from these wastes would be expected under routine operations. In contrast, produced water, drilling muds, and drill cuttings generated by exploration and delineation wells would be discharged at the well sites in compliance with applicable regulations and permits. In marine waters, birds could be exposed to these materials by direct contact or through the ingestion of contaminated food items. Birds most likely to be present at well sites are those that forage on invertebrates and fish in offshore waters; these include seabirds such as the murres and puffins, gulls, and jaegers.

Many species of marine birds (especially gulls) often follow ships and forage in their wake on fish and other prey injured or disoriented by the passing vessel. In doing so, these birds may be affected by discharges of waste fluids (such as bilge water) generated by OCS vessels. The discharge of such wastes from OCS service and construction vessels, if allowed, would be regulated under applicable NPDES permits, and any discharged wastes would be quickly diluted and dispersed and thus not be expected to affect marine birds.

Marine and coastal birds may become entangled in or ingest floating, submerged, and beached debris (Heneman and the Center for Environmental Education 1988; Ryan 1987, 1990).

Entanglement may result in strangulation, the injury or loss of limbs, entrapment, or the prevention or hindrance of the ability to fly or swim, and all these effects may be considered lethal. Ingestion of debris may irritate, block, or perforate the digestive tract, suppress appetite, impair digestion of food, reduce growth, or release toxic chemicals (Fry et al. 1985; Dickerman and Goelet 1987; Ryan 1988; Derraik 2002). Because the discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by BOEM (30 CFR 250.40) and the USCG (MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]), entanglement in or ingestion of OCS-related trash and debris by marine and coastal birds would not be expected under routine operations.

Vessel and Aircraft Traffic. Development occurring under the proposed action could include up to 12 weekly vessel and helicopter trips in the Beaufort Sea Planning Area and as many as 15 weekly helicopter and vessel trips in the Chukchi Sea Planning Area. The presence of ships and helicopters, as well as noise associated with their passage, can disturb birds and potentially affect feeding, resting, or nesting behavior, and may cause affected birds to abandon the immediate area. Which birds could be affected, the nature of their response, and the potential consequences of the disturbance will be a function of a variety of factors, including the specific routes, the number of trips per day, the altitude of the flights, the seasonal habitats along the routes, the species using the habitats and the level of their use, and the sensitivity of the birds to vessel and aircraft traffic. Traffic near or over heavily utilized feeding or nesting habitats of sensitive species could result in population-level effects, while impacts from traffic in other areas with less sensitive species would largely be limited to a few individuals and would not result in population-level effects. The use of shipping lanes and aircraft routes avoiding sensitive bird areas would greatly reduce or eliminate the potential for vessel and aircraft traffic to cause population-level effects in marine and coastal birds.

Helicopter overflights are generally conducted at low altitudes and have the potential for disturbing birds in onshore and offshore locations (Ward and Stein 1989; Ward et al. 1994; Miller 1994; Miller et al. 1994). FAA guidelines for helicopter oceanic operations request that pilots maintain a minimum altitude of 213 m (600 ft) while in transit offshore, 305 m (1,000 ft) over unpopulated areas or across coastlines, and 610 m (2,000 ft) over populated areas and sensitive habitats such as wildlife refuges and park properties (FAA 2010). The type of response elicited from the birds and the potential effect on the birds will depend in large part on the time of year for the overflights and the species disturbed. Helicopter overflights during spring breakup of pack ice may disturb marine species feeding in open water leads and waterfowl in open coastal waters, causing birds to leave the area. Similarly, overflights in summer could displace waterfowl and seabirds from preferred foraging areas and from coastal nesting or brood-rearing areas such as seabird colonies and the lagoon systems of the Beaufort and Chukchi Seas. Molting and staging waterfowl may temporarily leave an area experiencing helicopter overflights (Derksen et al. 1992), while geese have been reported to exhibit alert behavior and flight in response to helicopter overflights (Ward and Stein 1989; Ward et al. 1994).

While bird strikes are possible, any such events would affect only an occasional individual and not result in any population-level effects. However, the increased energy demand associated with birds leaving foraging or staging areas for other, potentially less favorable areas could result in a lowered fitness of the affected birds. While birds disturbed from nesting or brood-rearing habitats by occasional overflights would be expected to return, birds experiencing frequent overflights may relocate to less favorable habitats for a longer period of time (MMS 2002b). In addition, the temporary absence of adult birds may increase the potential for predation of unguarded nests and young (NRC 2003a).

Potential Effects on ESA-listed Species in the Arctic Planning Areas. Normal operations may affect listed bird species in the same manner as non-listed species (i.e., primarily behavioral disturbance). Compliance with ESA regulations and coordination with the NMFS and USFWS would ensure that lease-specific operations would be conducted in a manner that avoids or greatly minimizes the potential for affecting these species.

The threatened spectacled eider and Alaska breeding population of the Steller’s eider occur in the Beaufort and Chukchi Seas, while the Federal candidate Kittlitz’s murrelet and yellow-billed loon only occur in the coastal and inland waters of the Chukchi Sea Planning Area. These species could be affected by oil and gas development in the area. None of these species would be disturbed by offshore platform or pipeline construction because these activities would occur in winter when these species have left the area for wintering grounds.

Important molting and staging areas for the spectacled eider occur in both the Beaufort and Chukchi Sea Planning Areas. OCS-related vessel and aircraft traffic may disturb nesting or molting spectacled eiders, as well as those present at staging areas. This species has exhibited noise avoidance behavior during nesting (Anderson et al. 1992). If affected, birds would be expected to move away from oncoming vessels and would not be adversely affected. Some individuals could collide with OCS-related aircraft. Injury or mortality could occur due to the collisions, but the limited traffic that is expected makes collision unlikely and population-level effects are not expected.

Nesting Steller’s eiders may be disturbed by OCS-related vessel and aircraft traffic. If affected, birds would be expected to move away from oncoming vessels and would not be adversely affected. Birds may be startled by helicopter overflights and may or may not take flight and flee the immediate vicinity. Some birds could be killed or injured as a result of collisions with platforms or OCS-related aircraft, but the limited traffic that is expected makes collision unlikely and population-level effects are not expected.

While Kittlitz’s murrelet can be found in the Chukchi Sea Planning Area during the nesting season, it is not believed to nest east of Cape Beaufort because of an absence of suitable habitat (Day et al. 1999). This species has been reported to be sensitive to excessive noise and human activity (Day and Nigro 1999). This species nests on cliffs and scree slopes, in terrain typically avoided when pipelines are being sited. Long-term platform operations and daily vessel and aircraft traffic may result in the long-term displacement of birds from platform locations and along frequently used flight line locations. In addition, some individuals could collide with OCS-related aircraft. Because of the limited distribution of this species, exposure to routine operations would be expected to be infrequent.

During nesting, the yellow-billed loon may be disturbed by OCS-related vessel and aircraft traffic in the Chukchi Sea Planning Area. This species utilizes nearshore and offshore marine waters adjacent to its breeding areas for foraging during the summer. The yellow-billed loon may also be disturbed during migration, which occurs along the coastlines of both the Beaufort and Chukchi Seas. If affected, birds would be expected to move away from oncoming vessels and would not be adversely affected. In addition, some individuals could collide with OCS-related aircraft, but population-level effects are not expected.

Impacts of Expected Accidental Events and Spills. Marine and coastal birds could be affected by accidental oil spills from offshore platforms and pipelines, as well as from onshore processing facilities and pipelines. The magnitude and extent of impacts will be a function of a variety of factors, including (1) the time of year of the spill, (2) the volume of the spill, (3) the habitats exposed to the spill, and (4) the species exposed to the spill or that utilize the exposed habitats. The majority of expected accidental spills would be small (<50 bbl) (see Table 4.4.2-1), would quickly dissipate, and would only have the potential to affect a very small amount of habitat and relatively few individuals. Small spills larger than 50 bbl but ≤1,000 bbl would similarly be relatively easy to contain and would only affect small areas of habitat and few individuals. A large spill (≥1,000 bbl), depending on the season and location, would be more difficult to contain and may result in lethal and sublethal effects on relatively large numbers of birds. Exposure of eggs and young and adult birds to oil may result in a variety of lethal and sublethal effects. Oil moving into coastal and inshore areas may foul habitats, reducing habitat quality and contaminating vegetation and invertebrate foods. Ingestion of contaminated foods may lead to a variety of lethal and sublethal toxic and physiological effects. Finally, oil spill-response activities may disturb birds in nearby habitats that are unaffected by an oil spill.

Certain species of marine and coastal birds may be more susceptible to contact with spilled oil than others, based on their life histories. For example, diving seabirds and underwater swimmers such as loons and diving ducks may be the most susceptible to offshore spills because of their extensive use of such areas and their relatively long exposure time on the sea surface. In contrast, shorebirds and waterfowl may be most susceptible to spills that reach the beach intertidal zone, coastal lagoons, or inshore wetland habitats where these species forage and raise young. The magnitude of the impact will depend on the size of the spill, the species and life stage when exposed, and the size of the local bird population.

Offshore spills in spring that reach coastal barrier islands and mainland coastal wetland areas may expose common eiders, gulls, and other birds that nest in these habitats along the Beaufort and Chukchi Seas. Some of these areas support large nesting colonies, and direct and indirect exposure of adults, eggs, young, and food resources may adversely affect reproductive success and result in population-level effects on some species.

Offshore spills in spring may also expose migrating seabirds and waterfowl. Exposed individuals may experience lethal or sublethal effects from the exposure. Depending on the species, mortality or subsequent impacts on reproduction could result in population-level impacts on some species. Species with naturally low reproductive rates, such as the long-tailed duck and red-throated loon, may be especially vulnerable to population-level impacts. Because these species have a low reproductive rate that limits natural population growth, the loss of comparatively few individuals could result in more substantive population impacts.

Spring spills contacting shoreline areas have the potential to expose thousands of migrating shorebirds, as well as contaminating nesting and foraging habitats and oiling nests and eggs. Exposure of individuals could result in lethal or sublethal effects, while oiling of nests and/or eggs would reduce reproductive success.

Spills occurring in late summer through autumn and that enter coastal lagoons and delta areas could expose large numbers of waterfowl (loons, tundra swans, king eiders, long-tailed duck) that use these habitats for molting and staging, and potentially result in adverse population-level effects. For example, mortality estimates of long-tailed ducks in the central Beaufort Sea from a hypothetical spill ranged as high as 35%, depending on the amount of oil spilled and the number of birds present (MMS 2003a). A winter spill under the ice could contaminate ice leads that develop during spring breakup, exposing eiders and other waterfowl that use these features while migrating.

Oil spills from onshore pipelines would likely be limited to a much smaller area than would a spill in an offshore location. Those birds exposed could incur a variety of lethal or sublethal effects; however, because relatively few individuals or nests would be expected to be exposed, no population-level impacts would be expected. However, an oil spill from an onshore pipeline that reaches an aquatic habitat such as a stream, wetland, or lake on the Arctic coastal plain may have greater impacts on shorebirds and waterfowl. Many such aquatic habitats are used by a variety of waterfowl and shorebirds for brood rearing, molting, and staging. Thus, a terrestrial spill reaching such habitats could expose a much larger number of birds than a spill restricted to a terrestrial environment.

Spill cleanup activities may disturb and displace birds from nearby habitats. Depending on the use of those habitats (e.g., nesting, molting, staging), displaced birds could incur reduced reproductive success or survival. In addition, the duration of cleanup activities may not only displace birds currently present but also preclude birds using the area for quite some time. For example, cleanup activities associated with a large spill may involve hundreds of workers and numerous boats, aircraft, and onshore vehicles, operating in the affected area for a year or more. During this time, migrating birds arriving in spring would be expected to bypass habitats that are near areas undergoing active cleanup operations.

Potential impacts of accidental spills apply to both non-listed and listed bird species of the Beaufort Sea and Chukchi Sea Planning Areas. Because the Kittlitz's murrelet is only present in the Chukchi Sea Planning Area during the nesting season, and because this species nests in terrestrial habitats that are typically considered unsuitable and thus avoided when a pipeline is being sited, this species is unlikely to be affected by an accidental oil spill. Steller's eiders nest in terrestrial environments, but they spend the majority of their time in shallow marine waters and may be impacted by offshore spills in spring that reach mainland coastal habitats. Spectacled eiders may be impacted if offshore spills reach coastal habitats of the Beaufort Sea and Chukchi Sea Planning Areas that are utilized as important molting and staging areas. This species would be impacted by a loss of habitat, as well as ingestion of contaminated food, as it prepares for fall migration. The yellow-billed loon may be more susceptible to contact with spilled oil than other bird species because its diving method of feeding provides a relatively long exposure time on the sea surface.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes CDEs for the Chukchi Sea and Beaufort Sea Planning Areas with volumes ranging from 1,400,000 to 2,200,000 bbl and 1,700,000 to 3,900,000 bbl, and durations of 40 to 75 days and 60 to 300 days, respectively (Table 4.4.2-2). A low-probability CDE would have similar impacts on bird populations as spills of other magnitudes. However, the area affected would increase and the degree of impact would be more severe, and could result in population-level effects depending on the location, magnitude, and timing of the event; climate conditions (winter, ice cover); and on the species, life stages, and habitats exposed to the spill. A much greater number of birds and habitats could be affected, and population-level impacts for some species could be incurred as impacts of CDEs in this region are prolonged by the cold water and cold air temperatures. Many bird species found in Arctic regions are at the edge of their geographic range and may not be as capable of tolerating additional stress from direct oiling or reduction in habitat or resources as species found in more moderate climates (Levy 1980, 1983). A CDE in the harsh environmental conditions of the Arctic may have serious impacts on colonial seabirds of the Arctic (Levy 1980).

A CDE has the potential to affect large numbers of birds due to its toxicity to individuals and their prey and the amount of time birds spend on the surface of marine and coastal waters. Those species that congregate in potentially affected areas are most susceptible to significant impacts. Areas within the Beaufort Sea and Chukchi Sea Planning Areas provide important nesting, molting, and migration habitat to a variety of seabirds, waterfowl, and shorebirds. A CDE during periods of peak use could affect large numbers of marine and coastal birds, seabirds, and waterfowl. If marine and coastal birds come into contact with oil from a CDE, they could experience a loss of thermoregulatory ability, loss of buoyancy, an inability to fly or forage, or organ damage due to ingestion of oil. For example, up to 45% of the estimated Pacific Flyway population of Pacific brant could be affected if an oil spill reaches Kasegaluk Lagoon in the Chukchi Sea Planning Area. Effects could range from direct mortality of approximately 60,000 brant to sublethal effects on an equal or smaller number of brant. The loss of up to 45% of the Pacific Flyway population would have population-level effects. The situation with brant is similar to a wide variety of waterfowl and shorebirds that use similar areas of the Chukchi and Beaufort Seas. Mortality from a CDE could result in population-level effects for most marine and coastal bird species, recovery from which would take more than three generations (BOEM 2011).

Impact Conclusions.

Routine Operations. Routine operations may be expected to affect some birds in each of the Arctic planning areas included in the proposed action. Coastal birds are more likely to be affected by development in the Beaufort Sea Planning Area, because oil and gas activities are more likely to occur closer to shore than in the Chukchi Sea Planning Area. The nature and magnitude of effects on birds would depend on the specific location, the timing, and the nature and magnitude of the operation, as well as the species that would be exposed to the operation. For routine Program activities, the primary effects would be the disturbance of birds (and their normal behaviors) by construction and development equipment, human activity, and habitat loss in areas of infrastructure construction. Birds may also incur injury or mortality as a result of collisions with infrastructure and support vessels.

Offshore exploration activities such as noise from airguns and disturbances from survey vessel traffic may affect seabirds using open water areas of the two planning areas. However, disturbances would be limited to the immediate area around survey vessels and only negligible or minor effects are expected on marine and coastal birds. Construction of offshore platforms and pipelines would involve the construction of gravel islands which could affect seabirds and waterfowl that utilize offshore waters. However, construction would occur in winter when most species are absent, so the impact on marine and coastal birds is expected to be negligible or minor. Construction of onshore pipelines and landfalls would result in the permanent disturbance of habitat within the immediate footprint of the new pipelines and facilities. Because of the relatively small amount of habitat that could be disturbed, habitat disturbance or loss is expected to have only minor impacts on marine and coastal birds. Some mortality may be expected for birds colliding with offshore platforms and, to a lesser extent, with helicopters providing support services to offshore platforms. Impacts from such collisions are anticipated to affect relatively few birds and result in only negligible or minor impacts on bird populations, with no population-level effects. Because the discharge of production wastes and other materials generated at offshore platforms and OCS-related vessels is regulated and because permitted production wastes discharged into marine waters would be quickly diluted and dispersed, relatively few birds would be exposed to these waste materials and impacts from such discharges would likely be negligible. The overall impact of all routine operations for the Program could range from negligible to moderate.

Expected Accidental Events and Spills. Accidental oil spills from offshore platforms and pipelines could affect both birds and their habitats. The magnitude and ecological importance of any effects would depend upon the size of the spill, the species and life stages that are exposed, and the size of the local bird population. A winter spill under ice would increase cleanup difficulties and could result in greater impacts than a spill in ice-free conditions. Small spills, especially those <50 bbl, would be more likely to be contained and cleaned up. All small spills (≤1,000 bbl) would only impact small areas of habitat and relatively few individuals and are expected to have minor impacts on marine and coastal birds. Large spills (>1,000 bbl), especially those that enter coastal lagoons and delta areas, may result in lethal and sublethal effects, including reduced reproductive success, on birds using those habitats for molting and staging. Impacts to marine and coastal birds from a large oil spill in the Arctic planning areas are expected to be moderate to major.

An Unexpected Catastrophic Discharge Event. The Beaufort Sea and Chukchi Sea Planning Areas provide important nesting, molting, and stopover habitat for many species of coastal and marine birds. An unexpected CDE in the Arctic has the potential to affect large numbers of birds that are already at the edge of their geographic range and are sensitive to additional stress. Spill cleanup in ice conditions would be more difficult and the cleanup process itself could displace birds from nearby habitats. Impacts to marine and coastal birds from a CDE in the Arctic planning areas are expected to be moderate to major.

4.4.7.3 Fish

4.4.7.3.1 Gulf of Mexico.

Impacts of Routine Operations. See individual habitat sections for detailed discussions of the impacts of oil and gas activities on fish habitat in the GOM. Potential OCS oil and gas development impacting factors for fish in the GOM are shown by phase in Table 4.4.7-3. Impacting factors common to all phases include platform lighting, increased ship traffic, vessel discharges (bilge and ballast water), and miscellaneous discharges (deck washing, sanitary waste). Impacts from waste discharges would be localized and temporary and are not expected to have population-level impacts on fish populations. Many of these waste streams are disposed of on land, and all vessel and platform wastes that are discharged into surface waters must meet USEPA and/or USCG regulatory requirements. Studies conducted in the northern GOM suggest that platform lighting could alter predator-prey dynamics by enhancing phytoplankton productivity around the platform, potentially improving food availability and the visual foraging environment for fishes (Keenan et al. 2007). Potential impacts from platform lighting would be localized but long term and are expected to have minimal impacts on fish populations.

Exploration and Site Development. During the OCS oil and gas exploration and development phase, fish could be affected by noise from seismic surveys and noise and bottom disturbance from drilling, platform placement, and pipeline trenching and placement activities. Releases of drilling muds and cuttings could also affect fish by contaminating food resources in sediments and surrounding surface waters (Table 4.4.7-3).

All fish species in the GOM are presumed to be able to hear with varying degrees of sensitivity and within the frequency range of sound produced by exploration site development activities. Noises generated during platform and pipeline placement, vessel traffic, and seismic surveys are all potential sources of disturbance to fish communities. Noise could kill or injure fish, induce behavioral alterations, produce generalized stress, and interfere with communication (Smith et al. 2004; Vasconcelos et. al. 2007; see Popper and Hastings 2009 for a recent review). A primary source of noise during exploration and site development would be airguns used during seismic surveys. There is some experimental evidence that noise generated by seismic surveys could kill or injure organisms typically within a few meters of the noise source, but other studies found no injury or mortality even for sensitive, early life stages (Dalen and Knutsen 1986; Holliday et al. 1987; reviewed in NSF and USGS 2010). Several researchers have also documented startle responses or temporary avoidance of areas exposed airgun noise, but these effects are not found consistently (Skalski et al. 1992; Turnpenny and Nedwell 1994; Engås et al. 1996; Wardel et al. 2001; reviewed in Popper and Hastings 2009 and NSF and USGS 2010). Continuous long-term exposure to high-pressure sound waves has been shown to cause damage to the hair cells of the ears of some fishes under some circumstances (Popper 2003). Several studies have found that species with gas bladders, which includes many of the pelagic and demersal fish species in the GOM, are more vulnerable to injury or mortality from explosions than species without gas bladders such as flatfish (MMS 2004a). For adult fishes, continuous exposures to high noise levels is unlikely under natural circumstances as fish could move from the area. However, fish larvae may suffer greater mortality because of their

TABLE 4.4.7-3 Impacting Factors on Fish and Their Habitat in the GOM Planning Areas

Development Phase and Impacting Factor	Life Stage Affected[a] Eggs	Larvae	Adults
Impacting Factors Common to All Phases			
Vessel noise	X	X	X
Vessel traffic	X	X	X
Hazardous materials	X	X	X
Solid wastes	X	X	X
Offshore lighting	X	X	X
Aircraft noise			
Offshore air emissions			
Onshore air emissions			
Aircraft traffic			
Miscellaneous platform discharges	X	X	X
Vessel discharges	X	X	X
Bottom disturbance from vessel anchors	X	X	X
Exploration and Development			
Seismic noise	X	X	X
Noise from drilling and construction	X	X	X
Bottom disturbance from platform placement, drilling, and pipeline placement and trenching	X	X	X
Discharge of drilling muds and cuttings	X	X	X
Production			
Production noise	X	X	X
Produced water discharge	X	X	X
Artificial reef	X	X	X
Decommissioning			
Platform removal (non-explosive)	X	X	X
Platform removal (explosive)	X	X	X

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

small size and relative lack of mobility, especially within a short distance of the airgun (NSF and USGS 2010). The severity and duration of noise impacts would vary with site and development scenario, but overall the impacts would be temporary and localized. A recent review of seismic survey noise on marine fish concluded that although data were limited, there would be no significant impacts on marine fish populations from seismic surveys (NSF and USGS 2010).

Bottom-disturbing activities such as coring and drilling, platform placement and mooring, and pipeline trenching and placement would displace fish in the vicinity of the activities. Bottom disturbance would result in temporary sedimentation and increased turbidity, which could damage fish gills and bury benthic invertebrate prey resources within some distance of the disturbance. Fish mortality may also be greater if bottom disturbance occurs in areas of high larval and juvenile fish density such as estuaries and nearshore areas. In addition, the physical changes to benthic habitat resulting from drilling could affect food resources for benthic fishes by altering benthic invertebrate community composition. Soft sediment fishes, particularly in shallow water, are subject to frequent bottom disturbance from human activities such as trawling and natural occurrences such as storms and are presumably well adapted to such conditions.

The discharge of drilling muds and cuttings (including synthetic drilling fluids adhering to the cuttings) can affect fish in several ways. Section 4.4.3.1 describes the various categories of drilling fluids. Impacts from turbidity would be similar to those described above and could damage respiratory structures, cause fish to temporarily move from the area, and disrupt food acquisition. Drilling muds and cuttings released near the sediment surface or in shallow water would bury benthic food resources in the release area although conditions would eventually recover. Trace metal and hydrocarbon constituents in drilling fluids can be toxic to all life stages of fishes if exposed to high enough concentrations. Planktonic eggs and larvae that contact the mixing zone would be at greatest risk (e.g., Kingsford 1996), while juveniles and adults passing through a discharge are not likely to be adversely affected. The disturbance would be short, and based on the assumption of a relatively widespread distribution of eggs, larvae, and prey, only a very small proportion of the population of a given fish species is likely to be affected. In addition, all discharges must comply with NPDES permit requirements regarding the discharge amount, rate, and toxicity, which would greatly reduce the impact on fish communities. BOEM-sponsored research on the biological effects of drilling fluids on marine communities in the GOM (Continental Shelf Associates, Inc. 2004a, 2006) found that fish densities were elevated near the platforms compared to control locations and certain classes of benthic invertebrate food sources were also more abundant within 300 m (984 ft) of the well compared to control areas (Continental Shelf Associates, Inc. 2006).

There are several protective measures in place to protect sensitive fish habitat from oil and gas activities. Impacts on hard-bottom areas from bottom-disturbing activities would be minimized by the Topographic Features Stipulation that establishes No Activity Zones, where no operations, anchoring, or structures are allowed. There is also a lease stipulation that requires avoidance of low-relief live-bottom and pinnacle features. In deep water, there are stipulations requiring the avoidance of chemosynthetic communities and deepwater corals.

Based on the discussion above, the site development and exploration represent a short-term disturbance, primarily affecting demersal fishes, with the severity of the impacts generally decreasing dramatically with distance from bottom-disturbing activities. No population-level effects on fish communities would be expected.

Production. Production activities that could affect soft sediment habitat include operational noise, bottom disturbance, and the release of process water. In addition, the platform would replace existing featureless soft sediments and serve as an artificial reef (Table 4.4.7-3).

Chronic bottom disturbance could result from the movement of anchors and chains associated with support vessels and floating platform moorings. Bottom disturbance would affect fish and their food resources in a manner similar to that described above for the exploration and site development phase. Some of the disturbance could be episodic and temporary, but others would last for the lifetime of the platform.

Sessile epifaunal invertebrates requiring hard substrate (i.e., barnacles and corals) as well as small motile invertebrates (amphipods and worms) would colonize fixed or floating platform structures, creating an artificial reef. Pipelines not buried would also provide hard substrate for sessile and structure-oriented fish species. Reef fish and epipelagic fishes such as tunas, dolphin fish, and jacks would be attracted to these platforms in concentrations greater than those of surrounding soft sediments and even natural reefs (Wilson et al. 2003). The platforms could possibly enhance feeding of predators by attracting and concentrating smaller prey species. However, concerns have been expressed that highly migratory species could be diverted from normal migratory routes and consequently from normal spawning or feeding areas because of attraction to structures such as oil platforms (Brickhill et al. 2005). Similarly, platforms may attract reef fish from natural hard-bottom areas. Thus platforms may simply attract fish rather than increasing fish production and at the same time make them easier to harvest by commercial and recreational fisheries (Brickhill et al. 2005). Because of the wide distribution of reef and epipelagic species and the great number and spatial extent of production platforms, such effects could extend to the regional scale. Ultimately, the benefit or detriment of artificial reefs as habitat depends on how fisheries are managed on the reef and the individual life histories and habitat requirements of the species present (Bohnsack 1989; Macreadie et al. 2011).

Produced water contains several toxic elements (Continental Shelf Associates Inc. 1997), and direct and continuous exposure to produced waters can be lethal to all life stages of fishes. Because more chemicals are required to maintain adequate flow in deep waterwells, produced water from deepwater wells is expected to contain more chemical contaminants than wells in shallow water. Direct exposure would occur only in the water column near the discharge point; thus pelagic adults and planktonic eggs and larvae would be most susceptible. Higher impacts would be realized if eggs and larvae were unusually concentrated. Thus, local circulation patterns greatly influence the degree of potential impact. Nevertheless, population-level effects on fishes are not likely, as contaminants are not expected to reach toxic levels in the sediment and water column because of dilution and NPDES permitting requirements regarding discharge rate, contaminant concentration, and toxicity. In studies of the potential long-term ecological effect of oil and gas development, no significant bioaccumulations of hydrocarbons or metals were observed in fish collected near platforms, and histopathological evaluations of fish found no damage to liver tissue (Peterson et al. 1996). In addition, benthic invertebrate food sources collected in sediments near platforms do not appear to bioaccumulate the common contaminants in produced water, and their tissues did not exceed USEPA-specified concentrations considered harmful (Continental Shelf Associates, Inc. 1997). Organisms attached to oil platforms have not been found to accumulate metals, although they have been found to bioaccumulate organic contaminants (Continental Shelf Associates, Inc. 1997). Produced water discharge has also not been found to contribute significantly to hypoxia in the GOM (Rabalais 2005; Bierman et al. 2007). Thus, production activities are expected to result in short-term impacts on fish communities and no population-level effects on fish communities are anticipated.

Decommissioning. Platform removal in general would temporarily affect fish by displacing resident fishes, disturbing sediments, and increasing noise and turbidity for some length of the water column. In addition, it is assumed that up to 275 platforms would be removed using explosives, which could kill or cause sublethal injury to many of the fishes associated with the structures. Small fish and fish with swimbladders are most susceptible to injury and mortality from underwater blasts. In a study of 792 explosive platform removals in the GOM, an average of 567 dead fish were observed floating at the surface, although the actual number dead is likely to be higher (Continental Shelf Associates, Inc. 2004b). Mark and recapture studies conducted at platform removal sites in the central and western GOM (Gitschlag 2000) estimated that between 2,000 and 5,000 fishes greater than 8 cm (3 in.) in length and more than 6,200 fish less than 8 cm (3 in.) were killed during explosive removals in water depths ranging from 14 to 32 m (46 to 105 ft). Sheepshead, spadefish, red snapper, and blue runner accounted for 89% of the mortality estimated by these studies. Mortality estimates of red snapper associated with the platform ranged from 57 to 90%. Assuming 275 explosive removals, a large number of fish could potentially be killed during the Program. Displaced fish would repopulate the area over a short period of time, although the species composition would likely shift to soft sediment species and away from reef and migratory pelagic species of fish. Overall, decommissioning activities are expected to result in short-term impacts on fish communities and no population-level effects are anticipated.

If fixed platforms are toppled and left in place, the platform would continue to serve as an artificial reef, although the density and composition of fish may change. For example, the high vertical relief of the platform is important in attracting fish; thus fish density may decline once the platform is toppled (Wilson et al. 2003). Pipelines not buried, in both shallow and deepwater would provide hard substrate and habitat for structure-oriented fishes. As discussed above, the ability of artificial reefs to enhance fish production is controversial. In addition, artificial reefs may allow the spread of non-native fish species across the GOM, especially as waters warm due to climate change (Hickerson et al. 2008). For example, lionfish (*Pterois volitans*) have spread from the reefs of the West Florida shelf to the central and western GOM, where they are often found associated with oil platforms (http://www.lsu.edu/seagrantfish/biological/invasive/redlionfish.htm). In the future, other species could become established through range expansion or human introductions. Ultimately, the benefit or detriment of artificial reefs as habitat depends on how fisheries are managed on the reef and the individual life histories and habitat requirements of the species present (Bohnsack 1989; Macreadie et al. 2011).

Impacts of Expected Accidental Events and Spills. It is assumed that up to 8 large spills (≥1,000 bbl), up to 70 spills between 50 and 999 bbl, and up to 400 smaller spills between 1 and 50 bbl could occur during the lease period under the proposed action (Table 4.4.2-1). Impacts to individual fish and their habitat would generally increase with the size of the spill. Most spills would be small and are expected to be short-term and affect relatively few individuals. Larger areas and numbers of individuals may be affected by large spills greater than 1,000 bbl. Toxic fractions of PAHs in spilled oil can cause lethal or sublethal effects in adult fishes. Less is known about the impacts of natural gas on fish, but natural gas could have lethal or sublethal impacts as well, depending on concentration. Impacts of hydrocarbons differ among various life stages of fishes. For example, pelagic eggs and larval stages of fish, whose movements are largely controlled by water currents, could be killed if they came into contact with surface oil spills (Patin 1999). Conversely, oil and gas would typically rise above the seafloor, which would limit direct contact with demersal fishes. Evidence also indicates that the majority of adult pelagic fish can likely detect and avoid heavily oiled waters in the open sea, thereby avoiding acute effects (Patin 1999; Roth and Baltz 2009). However, adult fish could still be exposed to sublethal hydrocarbon concentrations through direct contact with gills or through ingestion of spilled oil. In addition, oil could ultimately enter the benthic food web as oil-contaminated pelagic organic matter and biota settled to the seafloor. The size and location of the spill, habitat preference of the fish, and the season in which the spill occurred would be important determinants of the impact magnitude of the spill. Hydrocarbons released during the spill would be diluted and broken down by natural processes.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes a CDE in the GOM with a volume of 0.9-7.2 million bbl and a duration of 30–90 days that could result from pipeline ruptures, a loss of well control, and from tanker spills associated with an FPSO system (Table 4.4.2-2). At the population level, hydrocarbon spills could affect fish by causing high mortality of eggs, larvae, juveniles, or adults; triggering abnormal development; impeding the access of migratory fishes to spawning habitat; displacing individuals from preferred habitat; reducing or eliminating prey populations available for consumption; impairing feeding, growth, or reproduction; causing adverse physiological responses; increasing susceptibility to predation, parasitism, diseases, or other environmental perturbations; and increasing or introducing genetic abnormalities. Lethal and sublethal impacts can also result from cleanup methods involving burning, skimming, and dispersants (if used). Dispersant toxicity varies by species and dispersant used, although newer dispersant formulations, such as COREXIT® 2500, do not appear to be more toxic to fish than oil alone (Hemmer et al. 2011). However, few species have been tested; additive toxicity from oil-dispersant mixtures may be significant for some species (Hemmer et al. 2011).

Most of the fishes inhabiting shelf or oceanic waters of the GOM have planktonic eggs and larvae (Ditty et al. 1988; Richards et al. 1993). Catastrophic spills occurring during recruitment periods or spills that affect areas with high larval fish concentrations such as estuaries could result in population-level impacts. Because of the wide dispersal of early life history stages of most fishes in the GOM, it is anticipated that only a relatively small proportion of early life stages present at a given time would be affected by a particular oil spill event, and this would limit the potential for population-level effects. For example, an evaluation of the response of coastal fishes to the DWH event suggests that large-scale losses of 2010 cohorts were largely avoided and that there were no discernible shifts in species composition following the spill (Fodrie et al. 2011). However, the impact magnitude would also depend on the temporal and spatial scope of the oil spill. Since some species of fish spawn in a limited geographic area(s) during a small temporal window, a spill could have population-level impacts if the spill coincided in time and space with spawning activity. In addition, individual fish species that currently have depressed populations and critical spawning grounds in the GOM such as tuna, swordfish, and other billfish could suffer lethal or sublethal effects from the spill.

In addition to effects on individuals and species, impacts to fish can result in ecosystem-level effects if the population impacts are significant. For example, fish in the GOM can occupy a number of trophic levels ranging from herbivore to top-level carnivore. Therefore, fish are critical to energy flow within nearshore and marine food webs. They are also seasonally important food sources to transient carnivores. Consequently, impacts to fish can propagate throughout the food web, affecting sea turtles, birds, and marine mammals. In addition, many GOM fishes migrate between and within marine, estuarine, and freshwater habitats. In doing so, they transfer nutrients and carbon over a broad area, thereby connecting offshore and coastal ecosystems (Deegan et al. 2002; Kneib 2002; Haertel-Borer et al. 2004). Significant impacts to fish populations could reduce this transfer, resulting in local changes in productivity. As with large spills, the size and location of the spill, habitat preference of the fish, and the season in which the spill occurred would be important determinants of the impact magnitude of the spill.

Species Listed under the Endangered Species Act: Gulf Sturgeon.

***Impacts of Routine Operations*.**

Exploration and Site Development. No information is available on the hearing or acoustic biology of Gulf sturgeon from which to assess effects. The only noise sources strong enough to produce impacts other than behavioral disruption are seismic surveys. Since the seismic sources (airguns) are fired in the upper water column, Gulf sturgeon are unlikely to be injured, but the noise could have behavioral effects such as disruption of feeding and movement behaviors. Adult Gulf sturgeon wintering in shelf waters of the GOM may be affected by sounds emanating from working platforms and their attendant operations. However, the most likely effects would be short-term behavioral disruption or avoidance of certain areas.

The placement of bottom-founded structures during the exploratory drilling phase may affect adult Gulf sturgeon and their designated critical habitat (50 CFR 226.214) directly and indirectly. As with all fish, the drilling platform and pipeline placement could injure or displace Gulf sturgeon and reduce or eliminate their benthic food resources. These disturbances could affect adult Gulf sturgeon during cooler months, which is their primary feeding period of the year when they move from coastal rivers into inner shelf waters of the eastern and central GOM (Ross et al. 2009). However, most new oil and gas production activities would not occur in the shallow coastal waters less than 10 m (33 ft) in depth (67 FR 39106–39199) preferred by Gulf sturgeon. Consequently, only a small proportion of the areas of bottom disturbance would potentially be used by Gulf sturgeon.

Drilling muds and cuttings can be released at or near the sea surface or the seafloor. Muds and cuttings are diluted and dispersed rapidly in the ocean; therefore, cuttings released at the surface are unlikely to have measurable impacts on Gulf sturgeon. However, food resources for Gulf sturgeon may be buried by muds and cuttings released near the seafloor or settling in thick accumulations in shallow water. Gulf sturgeon are known not to have an affinity for structured habitat, and they occur in water shallower than that typically used for drill sites. Thus, accumulations of drilling muds and cuttings are not likely to affect Gulf sturgeon or their habitat.

Production. Produced water discharges dilute rapidly in the open ocean, and direct exposure would occur only in the water column near the discharge point where adult sturgeon are not likely to be located. Vulnerable early life stages of Gulf sturgeon exist only in rivers far removed from produced water discharges, making exposure unlikely. The discharge of produced water is not thought to contribute to significantly increasing the size or severity of the hypoxic zone in the GOM (Rabalais 2005). Consequently, it is believed that discharges resulting from the proposed action will not affect dissolved oxygen levels in areas used by Gulf sturgeon.

Decommissioning. Under the proposed action, it is assumed that explosives would be used to remove up to 275 platforms in the entire GOM. Explosive blasts can be lethal to fishes that may be present near the structure (Gitschlag 2000). However, the Gulf sturgeon are known not to have an affinity for offshore structures; thus, they are not likely to be affected.

Impacts of Expected Accidental Events and Spills. Hydrocarbons released by small (1 to 1,000 bbl) and large (>1,000 bbl) accidental spills could affect adult sturgeon by direct contact with gills or via direct ingestion. Adult and juvenile fishes would likely avoid oil from a spill. Fish eggs and larvae could die or become deformed if exposed to certain toxic fractions of spilled oil (Kingsford 1996). However, contact with early life stages of Gulf sturgeon is unlikely because floating oil is not likely to penetrate to the middle reaches of most rivers where eggs are deposited and because oil would float on the freshwater outflow and never reach or settle directly on demersal eggs (Fox et al. 2000).

Impacts of an Unexpected Catastrophic Discharge Event. Although each spill is unique, existing sediment and water quality data collected after the DWH event suggest that even after a CDE, hydrocarbon contamination of the water column would be short-lived and localized (OSAT 2010; OSAT 2 2011). Sediment contamination would also be localized but could be significant in heavily oiled areas (see Sections 4.4.6.1 and 4.4.6.2). Therefore, CDE impacts would be greatest if the spill were to contact critical habitats for Gulf sturgeon; such habitats have been designated in coastal, riverine, and estuarine areas from Louisiana to Florida. Studies of the persistence of hydrocarbons in nearshore habitats following the DWH event are ongoing. All of these habitats are potentially affected by oil spills, depending on the size and location of the spill. See Section 4.4.6.1 for a discussion of the potential impacts of oil spills on coastal habitats.

Species Listed under the Endangered Species Act: Smalltooth Sawfish.

Routine Operations.

Exploration and Site Development. Smalltooth sawfish are considered rare from Texas to the Florida panhandle (NMFS 2009) and are not likely to be present in the Central and Western Planning Areas where exploration and site development, production, and decommissioning activities occur. In addition, smalltooth sawfish are livebearers; therefore sensitive egg and larval life stages are not present in the water column, which makes them less susceptible to impacts from exploration and production activities.

Noise from underwater construction and seismic surveys could produce impacts ranging from lethal to sublethal and behavioral (Popper and Hastings 2009). Since the seismic sources (airguns) are fired in the upper water column, smalltooth sawfish are unlikely to be affected. Juvenile smalltooth sawfish occupy shallow estuaries and nearshore areas away from noise-generating oil and gas exploration and development activities. Adult smalltooth sawfish are found in waters up to 122 m (400 ft) or deeper and could be affected by exploration and production noises. However, the most likely effects would be short-term behavioral disruption or avoidance of certain areas.

The placement of bottom-founded structures during the exploratory drilling phase may affect adult smalltooth sawfish and their designated critical habitat (50 CFR 226.214) directly and indirectly. As with all fish, the drilling platform and pipeline placement could injure or displace smalltooth sawfish and reduce or eliminate their benthic food resources. Small juveniles typically occupy shallow estuarine waters and would not be located in the vicinity of most bottom disturbance. However, most new platform and drilling activity would occur at the depth range occupied by large juveniles and adults. Given their size, most adults would likely be able to swim away from bottom-disturbing activities, thereby avoiding injuries. However, foraging habitat would be temporarily eliminated and food resources in the disturbed area may be reduced.

Drilling muds and cuttings can be released at or near the sea surface or the seafloor. Muds and cuttings are diluted and dispersed rapidly in the ocean; therefore, cuttings released at the surface are unlikely to have measurable impacts on smalltooth sawfish. However, food resources for smalltooth sawfish may be buried by muds and cuttings released near the seafloor or settling in thick accumulations in shallow water. Small juvenile smalltooth sawfish occur in water shallower than that typically used for drill sites and are not likely to be affected.

Production. Vulnerable early life stages of smalltooth sawfish exist only in shallow estuarine areas far removed from produced water discharges, making exposure unlikely. Adults and larger juveniles do occupy coastal waters where produced water discharge would occur. Produced water discharges dilute rapidly in the open ocean, and direct exposure would occur only in the water column near the discharge point where adult sawfish are not likely to be located. The discharge of produced water is not thought to contribute to significantly increasing the size or severity of the hypoxic zone in the GOM (Rabalais 2005). Consequently, it is believed that discharges resulting from the proposed action will not affect dissolved oxygen levels in areas used by smalltooth sawfish.

Decommissioning. Under the proposed action, it is assumed that explosives would be used to remove up to 700 platforms in the entire GOM. Explosive blasts can be lethal to fishes that may be present near the structure (Gitschlag 2000). However, smalltooth sawfish are known not to have an affinity for offshore structures; thus, they are not likely to be affected.

Impacts of Expected Accidental Events and Spills. Smalltooth sawfish are considered rare from Texas to the Florida panhandle and are not likely to be present in the Central and Western Planning Areas where accidental oil spills would occur. Adult and juvenile fishes would likely avoid oil from a spill, although they could be exposed to sublethal concentrations through aqueous or dietary routes. Smalltooth sawfish are livebearers and the exposure of eggs to hydrocarbons would occur only by adult exposure. Contact with small juvenile smalltooth sawfish is unlikely unless oil penetrates shallow estuarine areas. However, actively reproducing populations are thought to exist only in south Florida (NMFS 2009), and therefore small juveniles are not likely to be exposed to oil spills.

Impacts of an Unexpected Catastrophic Discharge Event. Existing sediment and water quality data collected after the DWH event suggest that even after a CDE, hydrocarbon contamination of the water column would be short-lived and localized (OSAT 2010; OSAT 2 2011). Sediment contamination would also be localized but could be significant in heavily oiled areas (see Sections 4.4.6.1 and 4.4.6.2). Studies of the persistence of hydrocarbons in nearshore habitats following the DWH event are ongoing. See Sections 4.4.6.1 and 4.4.6.2 for discussions of the potential impacts of oil spills on coastal habitats. As described above, adults would be able to avoid lethal concentrations of oil and contact with small juvenile smalltooth sawfish is unlikely unless oil penetrates shallow estuarine areas. Actively reproducing smalltooth sawfish populations are thought to exist only in south Florida (NMFS 2009), therefore small juveniles are not likely to be exposed to oil spills.

Impact Conclusions.

Routine Operations. Routine oil and gas activities would be temporary, and no population-level impacts on fish are expected. The primary potential impacts on fish communities from Program activities could result from seismic surveys and bottom-disturbing activities such as drilling, platform placement and mooring, and pipeline trenching and placement, which could displace, injure, or kill fish in the vicinity of the activity. Displaced fish and invertebrate food sources would repopulate the area over a short period of time. Fixed platforms, particularly the large number projected for the GOM, would also serve as artificial reefs that would attract substantial numbers of fish. The effects of drilling muds and produced water discharge on fish would be localized, and no population-level effects are expected. Overall, impacts to fish from routine Program activities are expected to range from negligible to minor, and only negligible impacts on threatened or endangered fish species are expected.

Expected Accidental Events and Spills. Small spills would be localized and are unlikely to affect a substantial number of fish before dilution and weathering would reduce concentrations of toxic fractions to nontoxic levels. Large spills would affect a wider area, with the magnitude of the impacts depending on the location, timing, and volume of spills, distribution and ecology of affected fish species, and other environmental factors. Most adult fish are highly mobile and would likely avoid lethal hydrocarbon exposures, although they may be subjected to sublethal concentrations. Smaller species and egg and larval life stages are more likely to suffer lethal or sublethal exposures from oil contact because of their relative lack of mobility. Overall, impacts to fish (including Gulf sturgeon) from small spills would range from negligible for spill less than 50 bbl, minor for spills up to 1,000 bbl, and from minor to moderate for large spills (≥1,000 bbl). Impacts to smalltooth sawfish are expected to range up to minor.

An Unexpected Catastrophic Discharge Event. Under most circumstances, a CDE would affect only a small proportion of a given fish population; therefore, overall population levels for individual species may not be affected. However, fish species that currently have depressed populations or have critical spawning grounds present in the affected area could experience population-level impacts. In addition, oil contacting shoreline areas used for spawning or providing habitat for early life stages of fish could result in large-scale lethal and long-term sublethal effects on fish. Coastal oiling could measurably depress some fish populations for several years. Overall, the impacts to fish (including Gulf sturgeon) in the case of a CDE could range up to moderate. Impacts to smalltooth sawfish are expected to range up to minor.

4.4.7.3.2 Alaska – Cook Inlet.

Impacts of Routine Operations. Potential OCS oil and gas development impacting factors for fish in the Cook Inlet Planning Area are shown by phase in Table 4.4.7-4. Impacting factors common to all phases include vessel traffic, platform lighting, vessel discharges (bilge and ballast water), and miscellaneous discharges (deck washing, sanitary waste). Impacts from waste discharges would be localized and temporary and are not expected to have population-level impacts on fish populations. Many of these waste streams are disposed of on land, and those that are discharged must meet USEPA and/or USCG regulatory requirements that minimize environmental impacts. Studies of platform lighting suggest the lights could alter predator-prey dynamics by enhancing phytoplankton productivity around the platform, potentially improving food availability and the visual foraging environment for fishes (Keenan et al. 2007). Potential impacts from platform lighting would be localized but long term and expected to have minimal impacts on fish populations.

Exploration and Site Development. During the OCS oil and gas exploration and development phase, fish could be affected by noise from seismic surveys and noise and bottom disturbance from drilling, platform placement, and pipeline trenching and placement activities (Table 4.4.7-4).

Noise disturbance from drilling, construction, and seismic surveys could potentially kill, injure, or displace fish depending on the magnitude of the noise, fish size, and distance from the noise source. Seismic survey data are usually collected by discharging compressed air from arrays of airguns towed behind ships. All fish species in Cook Inlet are presumed to be able to hear, with varying degrees of sensitivity, within the frequency range of sound produced by exploration and site development activities. The effects of airgun discharges on fishes depend on the fish life history stage and biology, distance to and type of the sound source, and the magnitude of the explosion. Noise generated by seismic surveys could kill or injure organisms typically within 1 to 5 m (3 to 16 ft) of the airgun or cause some species to temporarily avoid the area (Turnpenny and Nedwell 1994; Popper and Hastings 2009). Noise might also produce generalized stress (Smith et al. 2004) and interfere with communication (Vasconcelos et al. 2007). Several studies have found that species with gas bladders (e.g., salmonids, coregonids, and gadids) are more vulnerable to injury or mortality from explosions than species without gas bladders such as flatfish (MMS 2004a). The juvenile and adult fish in Cook Inlet likely to be affected by the noise generated from seismic surveys include salmon, cod, whitefishes, and herring. Continuous, long-term exposure to high-pressure sound waves has also been shown to cause damage to the hair cells of the ears of some fishes under some circumstances (Popper and Hastings 2009). For adult fishes, continuous exposures would not exist under natural circumstances, as fish could move from the area. However, fish larvae may suffer greater mortality because of their small size and relative lack of mobility, especially if they are within a few meters of the airgun (NSF and USGS 2010). In a confined area such as Cook Inlet, noise from seismic surveys can also alter fish behavior. For example, disruption of

TABLE 4.4.7-4 Impacting Factors on Fish and Their Habitat in the Cook Inlet Planning Area

	Life Stage Affected[a]		
Development Phase and Impacting Factor	Eggs	Larvae	Adults
Impacting Factors Common to All Phases			
Vessel noise	X	X	X
Vessel traffic	X	X	X
Hazardous materials	X	X	X
Solid wastes	X	X	X
Offshore lighting	X	X	X
Aircraft noise			
Offshore air emissions			
Onshore air emissions			
Aircraft traffic			
Miscellaneous platform discharges	X	X	X
Vessel discharges	X	X	X
Bottom disturbance from vessel anchors	X	X	X
Exploration and Development			
Seismic noise	X	X	X
Noise from drilling and construction	X	X	X
Bottom disturbance from platform placement, drilling, and pipeline placement and trenching	X	X	X
Discharge of drilling muds and cuttings	X	X	X
Production			
Production noise	X	X	X
Produced water discharge	X	X	X
Artificial reef	X	X	X
Decommissioning			
Platform removal (non-explosive)	X	X	X

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

normal behaviors during critical spawning and feeding periods in spring and summer has the potential to adversely affect survival and reproduction. The severity and duration of noise impacts would vary with site and development scenario, but overall the impacts would be temporary. Recent reviews of seismic survey noise on marine fish concluded that although data were limited, significant impacts on marine fish populations from seismic surveys were not likely (BOEMRE 2010b; NSF and USGS 2010).

Bottom-disturbing activities such as coring and drilling, platform placement and mooring, and pipeline trenching and placement would displace fish in the vicinity of the activities and result in temporary sedimentation and turbidity, which could damage fish gills and bury benthic invertebrate prey resources within some distance of the disturbance. Fish mortality may be greater if bottom disturbance occurred in areas of high larval and juvenile fish density such as estuaries and nearshore areas. The migrations of anadromous species common in Cook Inlet such as Pacific salmon and eulachon could also be disrupted. Soft sediments in Cook Inlet are subject to frequent bottom disturbance from high discharge and storms and Cook Inlet waters are naturally high in suspended sediments. Thus, fish communities in Cook Inlet are presumably well adapted to such conditions.

It is assumed that drilling muds and cuttings would be discharged into Cook Inlet for exploration wells only, while drilling wastes from development and production wells would be reinjected into the wells. The discharge of drilling muds and cuttings (including synthetic drilling fluids adhering to the cuttings) can adversely affect fish in several ways. Impacts from turbidity associated with drilling waste discharge would be similar to those described above and could damage respiratory structures, cause fish to temporarily move from the area, and disrupt food acquisition. Drilling wastes released near the sediment surface or in shallow water would bury benthic food resources in the release area, although conditions would eventually recover. Trace metal and hydrocarbon constituents in drilling fluids can be toxic to fish at all life stages if they are exposed to high enough concentrations. Impacts would be greatest for planktonic eggs and larvae that contact the mixing zone, while juveniles and adults passing through a discharge are not likely to be adversely affected. Based on the assumption of a relatively widespread distribution of eggs, larvae, and prey in Cook Inlet, drilling waste discharge is not likely to alter the population dynamics of fisheries resources in Cook Inlet or the Gulf of Alaska. In addition, drilling discharges must comply with NPDES permit requirements regarding the discharge amount, rate, and toxicity, which would greatly reduce the impact on fish communities.

While an exact route cannot be determined at this time, any onshore pipeline route would be required to comply with various Alaska Coastal Management Program policies. As a consequence, construction activities in sensitive aquatic habitat would be minimized. Specifically, the route for onshore pipeline facilities would be sited inland from shorelines and beaches, and crossings of anadromous fish streams would be minimized and consolidated with other utility and road crossings of such streams. In addition, onshore pipelines would be designed, constructed, and maintained to minimize risk to fish habitats from a spill, pipeline break, or construction activities.

Overall, site development and exploration activities represent temporary disturbance primarily affecting demersal fishes, with the severity of the impacts generally decreasing dramatically with distance from the disturbance. No population-level effects are anticipated.

Production. Production activities that could affect fish communities in Cook Inlet include operational noise, bottom disturbance from anchors and the release of process water. In addition, the platform would replace existing featureless soft sediments and serve as an artificial reef (Table 4.4.7-4).

Chronic disturbance to demersal fish communities could result from the movement of pipelines and anchors and chains associated with support vessels. Bottom disturbance would affect fish in a manner similar to that described above for the exploration and site development phase. The disturbance would be episodic and temporary, but would last for the lifetime of the platform.

Produced water contains metals, hydrocarbons, salts, and radionuclides, and their discharge could contaminate habitat, resulting in lethal and sublethal effects on fish, particularly early life stages. However, NPDES permitting requirements regarding discharge rate, contaminant concentration, and toxicity would greatly reduce the potential for impacts on fish. It is assumed that all produced water would be disposed of by injection into permitted disposal wells. Therefore, the effects of produced water discharges on fish are expected to be minimal.

Platforms would add a hard substrate to the marine environment, providing additional habitat for marine plants and animals (e.g., kelp and mussels) that require a hard substrate. Fish species in Cook Inlet that prefer hard substrate, such as rockfish, may be attracted to platforms. The platform would likely increase shell material and organic matter in the sediments surrounding the platform, potentially resulting in a shift in benthic invertebrate food sources.

A two-year (1997–1998) study of contaminant levels in the sediments of the Shelikof Strait and Cook Inlet provide information on potential effects of oil and gas development in the Cook Inlet Planning Area (MMS 2001a). Samples of sediment from depositional areas (where sediment contamination is expected to be greatest) suggested that metals and PAHs in sediments derived primarily from natural sources rather than past oil and gas developments (MMS 2001a). In addition, sediment concentrations of metals and organic contaminants in outermost Cook Inlet and Shelikof Strait (1) have not increased significantly since offshore oil exploration and production began in Cook Inlet (circa 1963) and (2) posed only a small risk to benthic biota or fish (MMS 2001a).

Decommissioning. No explosive platform removals are anticipated under the proposed action. Nonexplosive removals (e.g., abrasive, mechanical, or diver cutters) would have no long-term impacts to fish populations, although individuals associated with the platform would experience a loss of habitat. Pipelines installed and anchored on the seafloor would be capped and left in place, although there is the potential for chronic sediment disturbance from pipeline movement. If fixed platforms are left in place, the changes to fish communities resulting from the initial platform installation would be long-term.

Impacts of Expected Accidental Events and Spills. It is assumed that 1 to 3 small spills between 50 and 999 bbl and 7 to 15 smaller spills between 1 and <50 bbl, and large spills (≥1,000 bbl) could occur under the proposed action (Table 4.4.2-1). Impacts to individual fish and their habitat would generally increase with the size of the spill. It is anticipated that only a small amount of water column and shoreline would be affected by smaller oil spills and would not, therefore, present a substantial risk to fish populations. Consequently, the effects of small spills on fish and their habitat are expected to be localized, short-term, and affect relatively few individuals. Larger areas and numbers of individuals may be affected by large spills (spills >1,000 bbl). Accidental large hydrocarbon releases in Alaska may have greater ecological consequences than in temperate areas because oil is likely to persist in the environment due to the colder temperatures. Hydrocarbons can have a range of effects on fish depending on the concentration, the length of exposure, and the life history stage of the fish involved

(Starr et al. 1981; Malins 1977). Prolonged exposure to elevated levels of petroleum hydrocarbons can result in lethal or sublethal (reproduction, recruitment, physiology, growth, development, and behavior) impacts at the level of the individual.

Impacts from spills would be greatest if a large spill occurred during a reproductive period or contacted a location important for spawning or growth such as intertidal and nearshore subtidal habitats. Because pelagic species of fishes in Cook Inlet are relatively abundant and widely distributed in waters across much of the central Gulf of Alaska, even a large oil spill is not likely to cause population-level impacts on most fish populations inhabiting the central Gulf of Alaska (i.e., South Alaskan Peninsula, Kodiak Archipelago, Shelikof Strait, Cook Inlet, and Prince William Sound).

An Unexpected Catastrophic Discharge Event. The PEIS analyzes a CDE in the Cook inlet Planning Area with a volume of 75-125 thousand bbl and a duration of 50–80 days. The likelihood of oil from a CDE (Table 4.4.2-2) contacting part of the shoreline is relatively high because the Cook Inlet Planning Area is located within a relatively confined estuary. Spilled oil affecting nearshore and intertidal areas would likely result in the greatest impacts on fisheries resources. Oil may persist for years in intertidal areas and could represent a persistent source of exposure for fish such as herrings that generally spawn near shorelines. In addition to impacts to individual fishes, a CDE could result in population-level effects in some cases (Peterson et al. 2003). Fishes most likely to be affected by an oil spill would be those that migrate extensively (e.g., salmon), those with high fidelity to natal streams (e.g., Dolly Varden), and those confined to nearshore environments (e.g. rainbow smelt). Gas and particularly oil releases in Cook Inlet could affect fish populations by causing mortality of eggs, larvae, juveniles, or adults; triggering abnormal development; impeding the access of migratory fishes (e.g., salmon and herring) to spawning habitat; altering behaviors; displacing individuals from preferred habitat; reducing or eliminating prey populations available for consumption; impairing feeding, growth, or reproduction; causing adverse physiological responses; increasing susceptibility to predation, parasitism, diseases or other environmental perturbations; and increasing or introducing genetic abnormalities. It is anticipated that pelagic eggs and larval stages of fish, whose movements are largely controlled by water currents, would be killed if they came into contact with surface oil spills (Patin 1999). Conversely, evidence indicates that the majority of adult pelagic fish can likely detect and avoid heavily oiled waters in the open sea, thereby avoiding acute effects (Patin 1999).

Lethal and sublethal impacts can also result from cleanup methods involving burning, skimming, and dispersants (if used). Dispersant toxicity varies by species and dispersant used, although newer dispersant formulations, such as COREXIT® 2500, do not appear to be more toxic to fish than oil alone (Hemmer et al. 2011). However, few species have been tested; additive toxicity from oil-dispersant mixtures may be significant for some species (Hemmer et al. 2011).

Oil spills in intertidal areas also have the potential to contaminate or alter the composition and abundance of the benthic food resources consumed by fish. For example, evidence from the *Exxon Valdez* oil spill suggests stress-tolerant invertebrates such as polychaetes and snails would not suffer long-term population declines in oiled areas, but clams and mussels could be contaminated and reduced in abundance for several years (*Exxon Valdez* Oil Spill Trustee Council 2010a).

A CDE could result in a decline in local abundances of fish stocks or subpopulations, with recovery potentially requiring multiple generations. Some stocks are already in decline due to non-OCS anthropogenic and natural impact-producing factors (e.g., pollution, habitat loss, and climatic shifts). Impacts to fish can result in ecosystem-level effects if the population impacts are significant. For example, fish can occupy a number of trophic levels ranging from herbivore to top-level carnivore. As such, fish are critical to energy flow within nearshore and marine food webs. They are also seasonally important food sources to transient carnivores. Consequently, impacts to fish can propagate throughout the food web affecting birds and marine mammals. In addition, many Alaskan fishes, particularly salmon, migrate between and within marine, estuarine, and freshwater habitats. In doing so, they transfer nutrients and carbon over a broad area and connect offshore and coastal ecosystems (Naiman et al. 2002). Therefore, significant impacts to fish populations could reduce this transfer resulting in local changes in productivity.

Some of the potential effects that a CDE in Cook Inlet could have on fish resources can be inferred based upon the impacts of the 1989 *Exxon Valdez* oil spill, which released approximately 257,000 bbl of oil into nearby Prince William Sound. The potential effects of the Valdez spill are best known for salmon and Pacific herring. Adult salmon were able to return to natal streams and hatcheries even under very large oil spill conditions (Brannon et al. 1986; Nakatani and Nevissi 1991), as evidenced by the return of pink and sockeye salmon to Prince William Sound and sockeye salmon to Cook Inlet during and after the *Exxon Valdez* oil spill. Population-level effects on salmon were primarily through exposure of eggs and larvae to oil in sediments. Because of their long incubation period in intertidal gravel and because salmon embryos have a large lipid-rich yolk that can accumulate hydrocarbons from low-level exposures, salmon embryos are vulnerable to contamination from oil spills that reach intertidal areas (Peterson et al. 2003). For example, pink salmon embryos in oiled intertidal streams of Prince William Sound continued to show higher mortality than those in non-oiled streams until 1993 (Bue et al. 1998), and from 1989 to 1990, the growth rates of cutthroat trout and Dolly Varden in oiled streams were lower than those in clean streams (Hepler et al. 1993). However, salmonid populations appeared to recover within 15 years. Pink and sockeye salmon populations were considered to have recovered in 1999 and 2002, respectively (*Exxon Valdez* Oil Spill Trustee Council 2010a). Dolly Varden char were considered recovered in 2002, and cutthroat trout are considered to have very likely recovered (*Exxon Valdez* Oil Spill Trustee Council 2010a).

Although the *Exxon Valdez* oil spill occurred a few weeks before Pacific herring spawned in Prince William Sound, adult herring appeared to be relatively unaffected by the spill. About half of the herring egg biomass was deposited within the oil trajectory, and toxicity tests suggested egg-larval mortality in the oiled areas was twice as great as in the non-oiled areas and that larval growth rates in oiled areas were depressed compared to those in areas unaffected by the spill (Brown et al. 1996; McGurk and Brown 1996). After a record harvest in 1992 (following the *Exxon Valdez* spill), the Pacific herring population in Prince William Sound collapsed and has remained depressed, with reduced or no commercial harvest allowed. The Pacific herring stock of Prince William Sound is still classified as “not recovered” from the

Exxon Valdez oil spill (*Exxon Valdez* Oil Spill Trustee Council 2010a). However, because of natural variability in population and confounding environmental factors, there has not been full consensus among researchers that the currently low herring numbers are fully attributable to the effects of spilled oil. Pathogens, rather than lingering effects of the Valdez spill, may be primarily responsible for the lack of recovery (*Exxon Valdez* Oil Spill Trustee Council 2010a).

Although the effects of the spill on rockfish, a common demersal fish in Cook Inlet, were never well understood, their populations and habitat are considered recovered from the *Exxon Valdez* spill (*Exxon Valdez* Oil Spill Trustee Council 2010a). In general, adult demersal fishes are believed to avoid oil slicks, although individuals in coastal shallow waters with slow water exchange could be exposed to sublethal hydrocarbon concentrations (Patin 1999). A large or catastrophic spill could adversely affect hundreds of millions of eggs and juvenile stages, especially spills that reach nearshore areas, which are important to many species of demersal fishes as juveniles (Moles and Norcross 1998). Adult demersal and bentho-pelagic fish, including pollock, sablefish, Pacific cod, eulachon, and Pacific sand lance, would probably not be harmed by spilled oil at the surface. However, many demersal fishes such as walleye pollock, halibut, and cod all have buoyant eggs and larvae that float near the surface where they could be exposed to spilled oil (NPFMC 2010a).

Impact Conclusions.

***Routine Operations*.** The primary potential impacts on fish communities from Program activities could result from seismic surveys and bottom-disturbing activities such as drilling, platform placement and mooring, and pipeline trenching and placement, which could displace, injure, or kill fish in the vicinity of the activity. Displaced fish and invertebrate food sources would repopulate the area over a short period of time. Oil and gas activities would be temporary, and no population-level impacts on fish are expected. The effects of drilling muds and produced water discharge on fish would be localized, and no population-level effects are expected. Drilling waste and produced water discharge would be far less in Alaska because fewer wells would be drilled in Alaska and because it is assumed that drilling muds and cuttings from production wells and all produced water would be reinjected into the wells. Overall, impacts to fish from routine Program activities are expected to range from negligible to minor.

Expected Accidental Events and Spills. Small spills would be localized and are unlikely to affect a substantial number of fish before dilution and weathering would reduce concentrations of toxic fractions to nontoxic levels. Large spills would affect a wider area, with the magnitude of the impacts depending on the location, timing, and volume of spills, distribution and ecology of affected fish species, and other environmental factors. Most adult fish are highly mobile and would likely avoid lethal hydrocarbon exposures, although they may be subjected to sublethal concentrations. Smaller species and egg and larval life stages are more likely to suffer lethal or sublethal exposures from oil contact because of their relative lack of mobility. Overall, impacts from small spills would range from negligible for spill less than 50 bbl, minor for spills up to 1,000 bbl, and from minor to moderate for large spills (≥1,000 bbl).

***An Unexpected Catastrophic Discharge Event*.** A CDE would affect a wider area, with the magnitude of the impacts depending on the location, timing, and volume of spills, distribution and ecology of affected fish species, and other environmental factors. Most adult fish are highly mobile and would likely avoid lethal hydrocarbon exposures, although they may be subjected to sublethal concentrations. Smaller species and egg and larval life stages are more likely to suffer lethal or sublethal exposures from oil contact because of their relative lack of mobility. Under most circumstances, a CDE would affect only a small proportion of a given fish population; therefore, the overall population levels of a given species may not be affected. However, oil contacting shoreline areas used for spawning or providing habitat for early life stages of fish could result in large-scale lethal and long-term sublethal effects on fish. In Alaskan waters, where oil may be slow to break down, coastal oiling could measurably depress some fish populations for several years. Overall, the impacts to fish from a CDE could range up to moderate.

4.4.7.3.3 Alaska – Arctic.

Impacts of Routine Operations. Potential OCS oil and gas development impacting factors for fish are shown by phase in Table 4.4.7-5. Impacting factors common to all phases include vessel traffic, platform lighting, vessel discharges (bilge and ballast water), and miscellaneous discharges (deck washing, sanitary waste). Impacts from waste discharges would be localized and temporary and are not expected to have population-level impacts on fish populations. Many of these waste streams are disposed of on land, and any discharges into surface waters must meet USEPA and/or USCG regulatory requirements before discharge. Studies of platform lighting suggest that the lights could alter predator-prey dynamics by enhancing phytoplankton productivity around the platform, potentially improving food availability and the visual foraging environment for fishes (Keenan et al. 2007). Potential impacts from platform lighting would be localized but long term and are expected to have minimal impacts on fish populations.

Exploration and Site Development. During the OCS oil and gas exploration and development phase, fish could be affected by noise from seismic surveys and noise and bottom disturbance from drilling, subsea well, gravel island and ice road construction, platform placement, and pipeline trenching and placement activities (Table 4.4.7-5). Section 5 of a report recently released by BOEM contains additional information about the sound produced by fish and invertebrates in the Arctic region (Normandeau Associates, Inc. 2012). The effects of these activities on fish communities are described in detail in Section 4.4.7.3.2.

Fish in the Beaufort Sea and Chukchi Sea Planning Areas most likely to be affected by the noise generated from drilling, vessel traffic, and seismic surveys include salmon, cod, whitefishes, and herring. The effect on the overall fish population are not expected to result in population-level impacts since fishes are distributed over wide geographic areas and airgun operations are localized (Section 4.4.7.3.2). While it is anticipated that there would be no long-term population-level effects on managed species from seismic surveys, individual fish, especially egg and larval life stages in close proximity (1 to 5 m [3 to 16 ft]) to airgun arrays (Dalen and Knutsen 1986; Holliday et al. 1987; Turnpenny and Nedwell 1994), could suffer mortality or injury, and adult fishes more distant from the noise could exhibit short-term avoidance and behavioral alteration. A recent review of seismic survey noise on marine

TABLE 4.4.7-5 Impacting Factors on Fish and Their Habitat in the Beaufort Sea and Chukchi Sea Planning Areas

	Life Stage Affected[a]		
Development Phase and Impacting Factor	Eggs	Larvae	Adults
Impacting Factors Common to All Phases			
Vessel noise	X	X	X
Vessel traffic	X	X	X
Hazardous materials	X	X	X
Solid wastes	X	X	X
Offshore lighting	X	X	X
Aircraft noise			
Offshore air emissions			
Onshore air emissions			
Aircraft traffic			
Miscellaneous platform discharges	X	X	X
Vessel discharges	X	X	X
Bottom disturbance from vessel anchors	X	X	X
Exploration and Development			
Seismic noise	X	X	X
Noise from drilling and construction	X	X	X
Bottom disturbance from drilling and placement of subsea wells, platforms, and pipelines	X	X	X
Discharge of drilling muds and cuttings	X	X	X
Production			
Production noise	X	X	X
Produced water discharge	X	X	X
Artificial reef	X	X	X
Decommissioning			
Platform removal (non-explosive)	X	X	X

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

fish concluded that although data were limited, there would be no significant impacts on marine fish populations from seismic surveys (BOEMRE 2010b; NSF and USGS 2010).

Development and construction activities that could affect fish in the Beaufort and Chukchi Sea Planning Areas include drilling, installation of pipelines and construction of subsea wells, platforms, artificial islands, and ice roads. Bottom disturbance would result in temporary sedimentation and turbidity, which could damage fish gills and bury benthic invertebrate prey resources within some distance of the disturbance. Individual fish would likely temporarily move away from affected areas (Section 4.4.7.3.2). The total area affected by seafloor disturbance under the proposed action would be relatively small compared to the availability of similar seafloor habitat in surrounding areas.

Onshore, up to 129 km (80 mi) of oil pipeline could be constructed. While an exact route cannot be determined at this time, the pipeline route would be required to comply with various Alaska Coastal Management Program policies. As a consequence, construction activities in sensitive aquatic habitats would be minimized. Specifically, the route for onshore pipeline facilities would be sited inland from shorelines and beaches, and crossings of anadromous fish streams would be minimized and consolidated with other utility and road crossings of such streams. In addition, onshore pipelines would be designed, constructed, and maintained to minimize risk to fish habitats from a spill, pipeline break, or construction activities.

Gravel island and ice road construction may affect freshwater fish and fish habitats. Gravel for island construction is mined from river bars, and water for construction of ice roads is pumped from local rivers and lakes to desired areas to build a rigid surface. Removal of gravel could increase turbidity and reduce the water quality in affected rivers. Water withdrawal for ice road construction could potentially remove a large number of fish from the water body and reduce dissolved oxygen concentrations in the remaining lake water (Cott et al. 2008). For ice roads that traverse lakes, long-term impacts to fish populations could result from traffic-related noise disturbance. Truck noise is not expected to be great enough to result in injury to fish even in the vicinity of the road noise (Stewart 2003). However, fish may temporarily avoid the areas of noise and vibrational disturbance (Stewart 2003). The potential for entrainment can be reduced by using mitigative intake screens and by taking water from lakes with groundfast ice; such lakes are less likely to contain significant fish populations. Impacts to water quality can be minimized by avoiding excessive water removal. For example, Cott et al. (2008) found that water withdrawals of 10% of under-ice water volume did not significantly reduce oxygen concentration, while a 20% withdrawal reduced both dissolved oxygen and the amount of suitable fish habitat. Impact to fish will also be reduced by the ADFG, which requires reviews of gravel extraction and water withdrawal activities to assess potential impacts on salmon and other fish species and requires permits to be issued before activities can be initiated.

Artificial islands would increase the diversity of habitats available on an otherwise homogeneous ocean. Specifically, construction of such islands would introduce an artificial hard substrate that opportunistic benthic species, especially those that prefer gravel substrate, could colonize. Fishes may be attracted to the newly formed habitat complex, and fish population numbers in the immediate vicinity of the platforms are likely to be higher than in surrounding waters away from the structures. The overall change in habitat could result in changes in local community assemblage and diversity (NMFS 2011d). The number of platforms projected for the Beaufort Sea and Chukchi Sea Planning Areas under the proposed action (up to nine) would create a small amount of hard substrate habitat and would likely have little effect on overall fish populations.

It is assumed that drilling muds and cuttings would be discharged into the Beaufort and Chukchi Sea Planning Areas for exploration wells only and that drilling wastes from development and production wells would be reinjected into the wells. The discharge of drilling muds and cuttings (including synthetic drilling fluids adhering to the cuttings) can adversely affect fish in several ways. Impacts from turbidity associated with drilling waste discharge would be similar to those described above and could damage respiratory structures, cause fish to temporarily move from the area, and disrupt food acquisition. Drilling wastes released near the sediment surface or in shallow water would bury benthic food resources in the release area, although conditions would eventually recover. Trace metal and hydrocarbon constituents in drilling fluids can be toxic to fish at all life stages if they are exposed to high enough concentrations. Impacts would be greatest for planktonic eggs and larvae that contact the mixing zone, while juveniles and adults passing through a discharge are not likely to be adversely affected. Assuming a relatively widespread distribution of eggs, larvae, and prey in the Beaufort and Chukchi Seas, drilling waste discharge is not likely to alter the population dynamics of fisheries resources. In addition, drilling discharges must comply with NPDES permit requirements regarding the discharge amount, rate, and toxicity, which would greatly reduce the impact on fish communities.

Overall, site development and exploration activities represent temporary disturbance primarily affecting demersal fishes, with the severity of the impacts generally decreasing dramatically with distance from the disturbance. No population-level effects are anticipated.

Production. Production activities that could affect fish communities in the Beaufort and Chukchi Seas include operational noise, bottom disturbance from anchors and the release of process water. In addition, the platform would replace existing featureless soft sediments and serve as an artificial reef (Table 4.4.7-5). Chronic disturbance to demersal fish communities would result from the movement of anchors and chains associated with support vessels. Pipelines not buried would be anchored in place which would minimize their movement and potential to disturb fish habitat. Bottom disturbance would affect similar to that described above for the exploration and site development phase. The disturbance would be episodic and temporary, but would last for the lifetime of the platform.

Produced water contains metals, hydrocarbons, salts, and radionuclides, and their discharge could contaminate habitat, resulting in lethal and sublethal effects on fish, particularly early life stages. It is assumed that all produced water would be disposed of by injection into permitted disposal wells. Therefore, the effects of miscellaneous and produced water discharges on fish communities are expected to be minimal.

The results of the Arctic Nearshore Impacts Monitoring in the Development Area study funded by BOEM provide a good summary of the long-term changes to benthic communities resulting from oil and gas development in the Arctic. Hydrocarbons are primarily derived from river inputs rather than oil and gas development (Brown 2004; Neff & Associates, LLC 2010). Tissue hydrocarbon and metals concentrations in fish and their invertebrate food sources sampled near the Northstar development and Liberty prospect area were similar to or lower than invertebrate tissue levels found elsewhere in the world. No increase in hydrocarbons and metals in fish or invertebrate tissues was attributable to oil and gas production (Neff & Associates, LLC 2010).

Decommissioning. No explosive platform removals are anticipated under the proposed action. Nonexplosive removals (e.g., abrasive, mechanical, or diver cutters) are not expected to have long-term impacts to fish populations, although fish associated with the platform would experience a loss of habitat. Pipelines installed and anchored on the seafloor would be capped and left in place, although there is the potential for chronic sediment disturbance from pipeline movement. Impacts on fish populations associated with decommissioning activities are expected to be temporary.

Impacts of Expected Accidental Events and Spills. It is assumed that large spills (≥1,000 bbl), up to 35 small spills (50 to 999 bbl), and up to 190 smaller spills (>1 and <50 bbl) could occur during the lease period under the proposed action (Table 4.4.2-2). Impacts to individual fish and their habitat would generally increase with the size of the spill. Most accidental hydrocarbon releases would be small and would primarily affect fish in the water column, as most oil and gas would float above the sediment surface. It is anticipated that in most cases only a small amount of the water column and shoreline would be affected by these smaller oil spills and would not, therefore, present a substantial risk to fish populations. Consequently, the effects of small spills on fish and their habitat are expected to be short-term and affect relatively few individuals.

Larger areas and numbers of individuals may be affected by large spills (>1,000 bbl). As described in Section 4.4.7.3.2, accidental hydrocarbon releases in the Beaufort Sea and Chukchi Sea Planning Areas could affect fish populations by causing mortality of eggs, larvae, juveniles, or adults; triggering abnormal development; impeding the access of migratory fishes (e.g., salmon and herring) to spawning habitat; altering behaviors; displacing individuals from preferred habitat; reducing or eliminating prey populations available for consumption; impairing feeding, growth, or reproduction; causing adverse physiological responses; increasing susceptibility to predation, parasitism, diseases, or other environmental perturbations; and increasing or introducing genetic abnormalities. It is anticipated that pelagic eggs and larval stages of fish, whose movements are largely controlled by water currents, would be killed if they came into contact with surface oil spills (Patin 1999; Peterson et al. 2003). Conversely, evidence indicates that the majority of adult pelagic fish can likely detect and avoid heavily oiled waters in the open sea, thereby avoiding acute effects (Patin 1999).

Impacts from large spills would be greatest if a large spill occurred during a reproductive period or contacted a location important for spawning or growth such as intertidal and nearshore subtidal habitats. Because pelagic species of fishes in the Beaufort Sea and Chukchi Sea Planning Areas are widely distributed, even a large oil spill is not likely to cause population-level impacts on most fish populations.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes a CDE in the Chukchi Sea Planning Area with a volume of 1.4-2.2 million bbl and a duration of 40–75 days, and a CDE in the Beaufort Sea Planning Area with a volume of 1.7-3.9 million bbl and a duration of 60–300 days (Table 4.4.2-2). See Section 4.4.7.3.2 for a detailed discussion of the effects of oil spills on fish following the catastrophic *Exxon Valdez* spill. A CDE (Table 4.4.2-2) has the potential to affect multiple species in the Arctic Planning Areas. Such spills can have a range of effects on fish depending on the concentration, the length of exposure, and the life history stage of the fish involved (Starr et al. 1981; Malins 1977; NMFS 2011d). During the spill, adult and juvenile fish may be temporarily displaced, which could interfere with movements to feeding, overwintering, or spawning areas. Fish eggs, larvae, and juveniles are the most sensitive life history stages (Section 4.4.7.3.2). Spilled petroleum hydrocarbons may persist for years (NMFS 2011d), especially in sediments of cold waters, making it likely that some fish species would be exposed to low levels of hydrocarbons for an extended time after an oil spill. Similarly, petroleum hydrocarbons could remain available for uptake and bioaccumulation by benthic food sources for years following a spill (NMFS 2011d). Lethal and sublethal impacts can also result from cleanup methods involving burning, skimming, and dispersants (if used). Dispersant toxicity varies by species and dispersant used, although newer dispersant formulations, such as COREXIT® 2500, do not appear to be more toxic to fish than oil alone (Hemmer et al. 2011). However, few species have been tested; additive toxicity from oil-dispersant mixtures may be significant for some species (Hemmer et al. 2011).

Among the most abundant marine fish in the Beaufort Sea and Chukchi Sea Planning Areas are Arctic cod, sculpin, eelpout, pricklebacks, and flatfish. Of these, the Arctic cod may be the most susceptible to spills under ice because they spawn in winter under ice when cleanup would be most difficult. In addition, the larvae are pelagic and most likely to come into contact with oil and gas, which tend to float on the surface. Arctic cod are also susceptible because they are dependent on algal production in open water and under sea ice, which could be affected by oil and gas exposure. Among the most abundant anadromous species are the Arctic and least cisco, broad whitefish, Dolly Varden, and rainbow smelt. Fishes most likely to be affected by an oil spill would be those that migrate extensively (e.g., Arctic cisco), those with high fidelity to natal streams (e.g., Dolly Varden), and those confined to nearshore environments (e.g., broad whitefish and rainbow smelt). Some pelagic species (e.g., Pacific herring; capelin) spawn in intertidal zones where their eggs may be susceptible to oil (Rice et al. 1984). Herring generally spawn near shorelines over 3–4 week periods, and oil driven onshore could contact spawning adults and developing eggs (MMS 1996a). Larval herring are also susceptible after moving into deeper water because they rise diurnally to feed on plankton and could be exposed to surface oil repeatedly if a spill occurs. Demersal fishes such as walleye pollock, halibut, and cod all have buoyant eggs and larvae that float near the surface where they could be exposed to spilled oil (MMS 1996).

A CDE spill could have population-level consequences if vital habitat areas were affected or if it occurred in spawning areas or juvenile feeding grounds when fish populations are highly concentrated (e.g., the Arctic cisco population concentrated near the Colville River). In such cases, catastrophic spills could cause substantial reductions in population levels for one or more years.

In addition to effects on individuals and species, impacts to fish can result in ecosystem-level effects if the population impacts are significant. For example, fish can occupy a number of trophic levels ranging from herbivore to top-level carnivore. Therefore, fish are critical to energy flow within nearshore and marine food webs. They are also seasonally important food sources to transient carnivores. Consequently, impacts to fish can propagate throughout the food web, affecting birds and marine mammals. In addition, many Alaskan fishes, particularly salmonids, migrate between and within marine, estuarine, and freshwater habitats. In doing so, they transfer nutrients and carbon over a broad area and connect offshore and coastal ecosystems (Naiman et al. 2002). Significant impacts to fish populations could reduce this transfer, resulting in local changes in productivity. In addition, Arctic cod are keystone species in the Arctic, and significant impact to this species could have broad ecosystem effects.

Impact Conclusions.

Routine Operations. The primary potential impacts on fish communities from Program activities could result from seismic surveys and bottom-disturbing activities such as drilling, platform placement and mooring, and pipeline trenching and placement, which could displace, injure, or kill fish in the vicinity of the activity. Oil and gas activities would be temporary, and no population-level impacts on fish are expected. Displaced fish and invertebrate food sources would repopulate the area over a short period of time, but certain fish habitat recovery may be long-term. The effects of drilling muds and produced water discharge on fish would be localized, and no population-level effects are expected. Drilling waste and produced water discharge would be far less in Alaska because fewer wells would be drilled in Alaska and because it is assumed that drilling muds and cuttings from production wells and all produced water would be reinjected into the wells. Overall, impacts to fish from routine Program activities are expected to range from negligible to minor, and no impacts on threatened or endangered fish species are expected.

Expected Accidental Events and Spills. Small spills would be localized and are unlikely to affect a substantial number of fish before dilution and weathering would reduce concentrations of toxic fractions to nontoxic levels. Large spills would affect a wider area, with the magnitude of the impacts depending on the location, timing, and volume of spills, distribution and ecology of affected fish species, and other environmental factors. Most adult fish are highly mobile and would likely avoid lethal hydrocarbon exposures, although they may be subjected to sublethal concentrations. Smaller species and egg and larval life stages are more likely to suffer lethal or sublethal exposures from oil contact because of their relative lack of mobility. Overall, impacts from small spills would range from negligible for spill less than 50 bbl, minor for spills up to 1,000 bbl, and from minor to moderate for large spills (≥ 1,000 bbl).

An Unexpected Catastrophic Discharge Event. A CDE would affect a wider area, with the magnitude of the impacts depending on the location, timing, and volume of spills, distribution and ecology of affected fish species, and other environmental factors. Most adult fish are highly mobile and would likely avoid lethal hydrocarbon exposures, although they may be subjected to sublethal concentrations. Smaller species and egg and larval life stages are more likely to suffer lethal or sublethal exposures from oil contact because of their relative lack of mobility. Under most circumstances, a CDE would affect only a small proportion of a given fish population; therefore, overall population levels may not be affected. Oil contacting shoreline areas used for spawning or providing habitat for early life stages of fish could result in large-scale lethal and long-term sublethal effects on fish. In Alaskan waters, where oil may be slow to break down, coastal oiling could measurably depress some fish populations for several years. Overall, the impacts to fish from a CDE could range from minor to moderate.

4.4.7.4 Reptiles

Impacts of Routine Operations. The discussion of impacts to reptile species from OCS oil and gas development is primarily focused on sea turtles that may occur throughout the GOM. There is the potential for other reptile species to be affected from a small number of impacting factors related to OCS oil and gas development. Additional reptile species (e.g., American crocodile, Alabama red-belly turtle, and gopher tortoise) will be identified as impacting factors are discussed in this PEIS.

There are five species of sea turtle that may be encountered in the GOM OCS Planning Areas: green, hawksbill, Kemp's ridley, leatherback, and loggerhead. All of these species have the potential to occur throughout the planning areas as hatchlings, juveniles, and adults. All but the hawksbill have been reported to nest on beaches within the GOM Planning Areas, and the number and distribution of nests differ dramatically among these species across bordering States (Section 3.8.3; Figure 3.8.3-1). Sea turtles may be affected in all phases of OCS oil and gas development. Under the proposed action, one or more of the sea turtle life stages could be affected under routine operations due to (1) airborne and underwater noise, (2) offshore structure placement and pipeline trenching, (3) removal of offshore structures, (4) OCS vessel traffic, (5) construction and operation of onshore infrastructure, and (6) exposure to operational discharges and wastes. In addition, reptiles may be affected by unexpected and accidental spills of oil and other contaminants. Table 4.4.7-6 illustrates how each of the various impact factors associated with OCS oil and gas development may affect sea turtles and their habitats in the GOM. Many of these impacting factors could occur during multiple project phases. Conceptual models illustrated in Figures 4.4.7-6 through 4.4.7-10 show how various activities associated with seismic surveys, onshore and offshore construction, normal O&G operations, decommissioning, and accidental oil releases may impact sea turtles. While OCS O&G projects have the potential to affect sea turtles of all life stages, it has been determined that impacts to later life stages (large juveniles and adults) result in greater population-level impacts (Crouse et al. 1987).

As discussed in Section 3.3.1, climate change in the GOM is expected to affect coastal systems through processes such as warming temperatures, changes in precipitation, sea level rise, and more frequent intense storms. Rising water temperatures, increased sea levels, and intense storms may affect the availability and suitability of foraging and nesting habitats for coastal and marine reptiles (Hawkes et al. 2009). For reptiles that rely on temperature to determine the gender of offspring in incubating eggs (referred to as temperature-dependent sex determination), including sea turtles and crocodilians, subtle increases in atmospheric temperatures could skew sex ratios of hatchlings, which could have future population implications (Walther et al. 2002). It is also predicted that global warming and increased precipitation rates associated with climate change will cause sea levels to rise (Church et al. 2001). This phenomenon could alter sea turtle coastal habitat in many areas (Hawkes et al. 2009). For example, a study in Hawaii predicted that as much as 40% of green sea turtle nesting habitat could be affected with a 0.9 m (2.7 ft) sea level rise (Baker et al. 2006).

TABLE 4.4.7-6 Potential OCS Oil and Gas Development Impacting Factors for Reptiles in the GOM

	O&G Impacting Factor								
	Noise								
Resource Receptor Category Potentially Affected	Seismic Exploration	Construction, Operation, and Decommissioning	Collisions with OCS Vessels	Presence of OCS Vessels	Construction and Decommissioning of Onshore and Offshore Infrastructure	Offshore and Onshore Lighting	Produced Water, Drill Cuttings and Mud, Liquid Wastes, Hazardous Materials	Solid Wastes and Debris	Accidental Oil Spills
Sea turtle nest sites – individual nests and nesting beaches	–	–	–	–	Destruction of nests; degradation or loss of nesting beaches	–	–	–	Physical disturbance and reduced quality from fouling
Sea turtle hatchlings	Injury; disruption of normal behavior (feeding, nesting)	Disruption of normal behavior (feeding, nesting)	Injury of mortality from ship strikes	Disruption of normal behavior (feeding, nesting)	Injury; disruption of normal behavior	Attraction of reproductive adults to low quality nesting habitats	Toxicity	Ingestion and/or entanglement	Fouling, toxicity
Sea turtle juveniles					Injury; disruption of normal behavior	Attraction of reproductive adults to low quality nesting habitats			Fouling, toxicity
Sea turtle adults					Injury; disruption of normal behavior	Attraction of reproductive adults to low quality nesting habitats			Fouling, toxicity
Sea turtle migration	Displacement or impediment	Displacement or impediment	–	Displacement or impediment	Displacement or impediment	Attraction of reproductive adults to low quality nesting habitats	–	–	Displacement or impediment
Sea turtle juvenile foraging habitats	–	–	–	–	Temporary habitat disturbance during construction; possible long-term increase in habitat	Attraction of reproductive adults to low quality nesting habitats	Reduced habitat quality	–	Physical disturbance; reduced habitat quality
Sea turtle adult foraging habitats	–	–	–	–	Temporary habitat disturbance during construction; possible long-term increase in habitat	Attraction of reproductive adults to low quality nesting habitats	Reduced habitat quality	–	Physical disturbance; reduced habitat quality

TABLE 4.4.7-6 (Cont.)

	O&G Impacting Factor								
	Noise								
Resource Receptor Category Potentially Affected	Seismic Exploration	Construction, Operation, and Decommissioning	Collisions with OCS Vessels	Presence of OCS Vessels	Construction and Decommissioning of Onshore and Offshore Infrastructure	Offshore and Onshore Lighting	Produced Water, Drill Cuttings and Mud, Liquid Wastes, Hazardous Materials	Solid Wastes and Debris	Accidental Oil Spills
Sea turtle wintering grounds	–	–	–	–	Temporary habitat disturbance; possible long-term increase in habitat	Attraction of reproductive adults to low quality nesting habitats	Reduced quality	–	Physical disturbance; reduced quality
American crocodile nest sites, adults, juveniles, hatchlings, and their habitat	–	–	–	–	Destruction of nests; degradation or loss of nesting or foraging habitat	–	–	–	Fouling, toxicity; physical disturbance; reduced habitat quality
Alabama red-belly turtle nest sites, adults, juveniles, hatchlings, and their habitat	–	–	–	–	Destruction of nests; degradation or loss of nesting or foraging habitat	–	–	–	Fouling, toxicity; physical disturbances; reduced habitat quality
Gopher tortoise nest sites, adults, juveniles, hatchlings, and their habitat	–	–	–	–	Destruction of nests; degradation or loss of nesting or foraging habitat	–	–	–	–

[a] – = No impact anticipated.

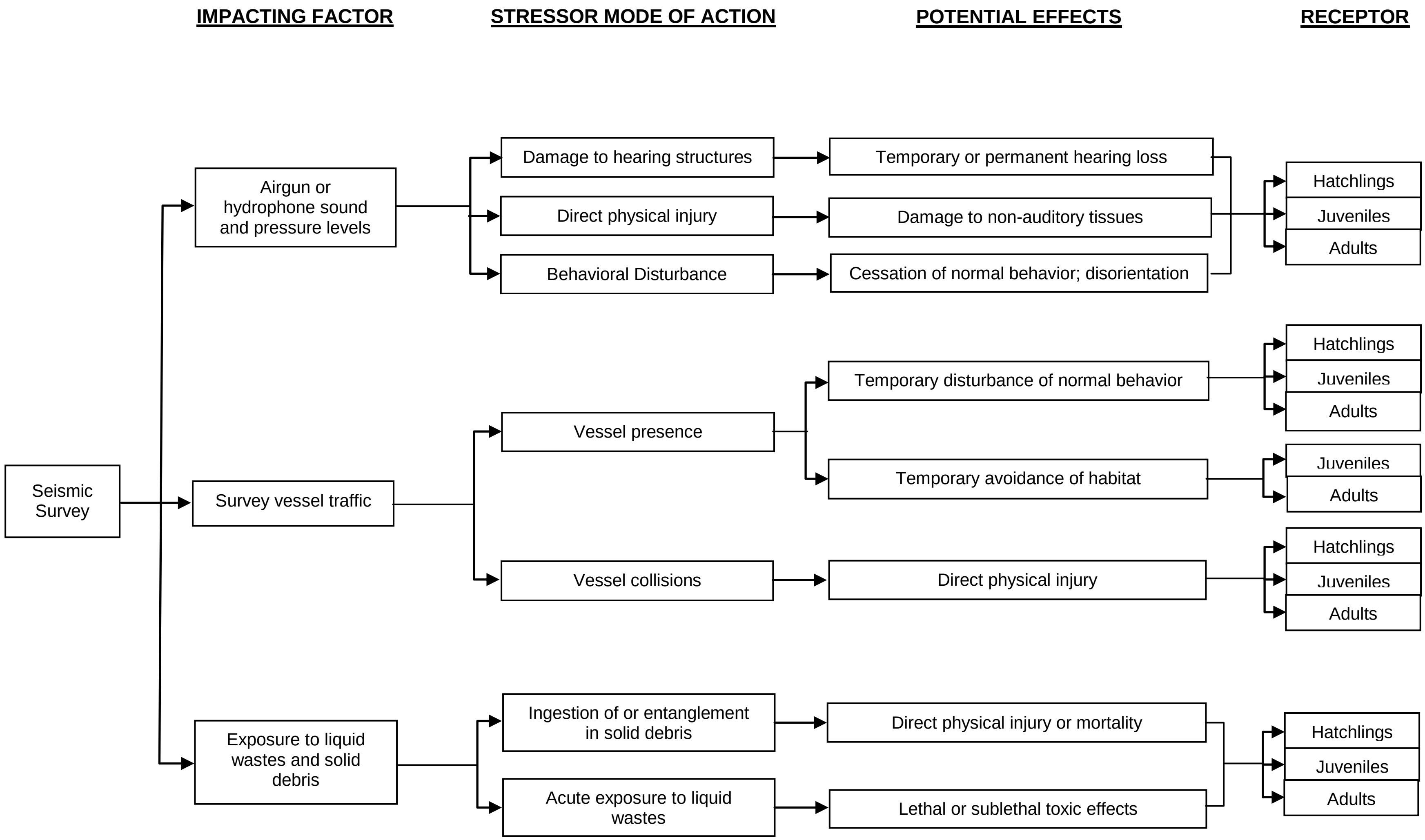

FIGURE 4.4.7-6 Conceptual Model for Potential Effects of Seismic Survey Activities on Turtles in the GOM

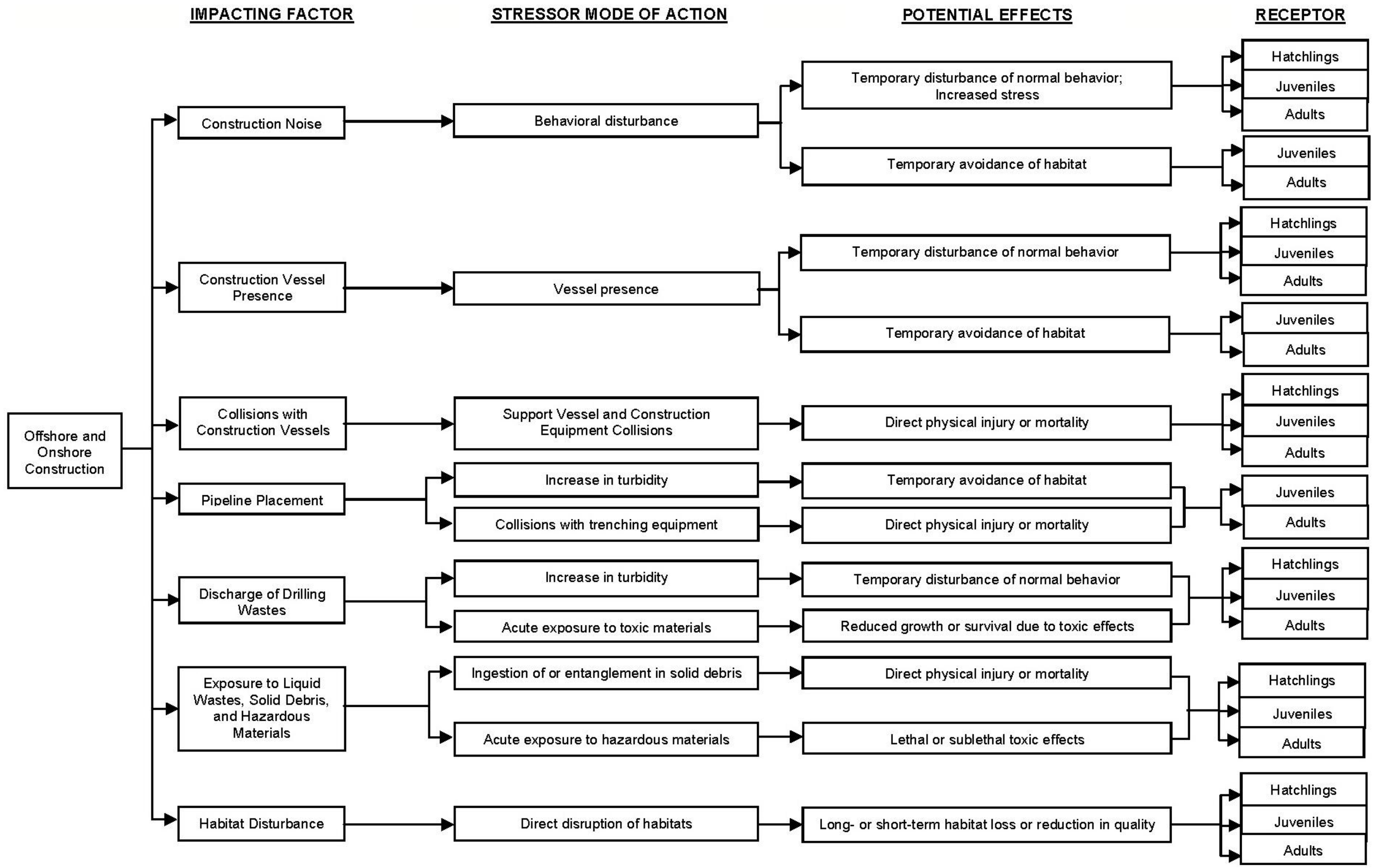

FIGURE 4.4.7-7 Conceptual Model for Potential Effects of OCS-Related Construction Activities on Turtles in the GOM

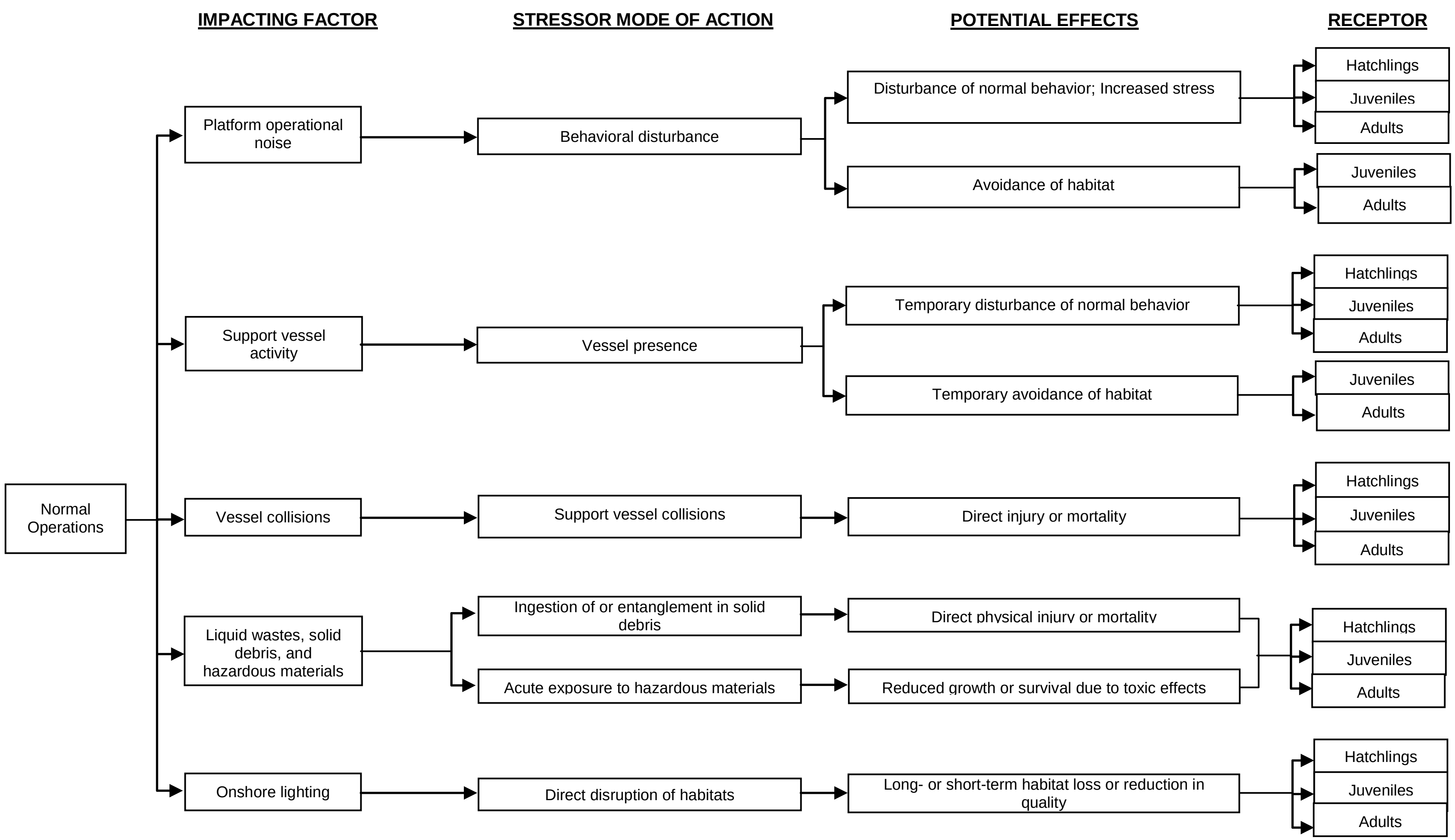

FIGURE 4.4.7-8 Conceptual Model for Potential Effects of OCS Operation on Turtles in the GOM

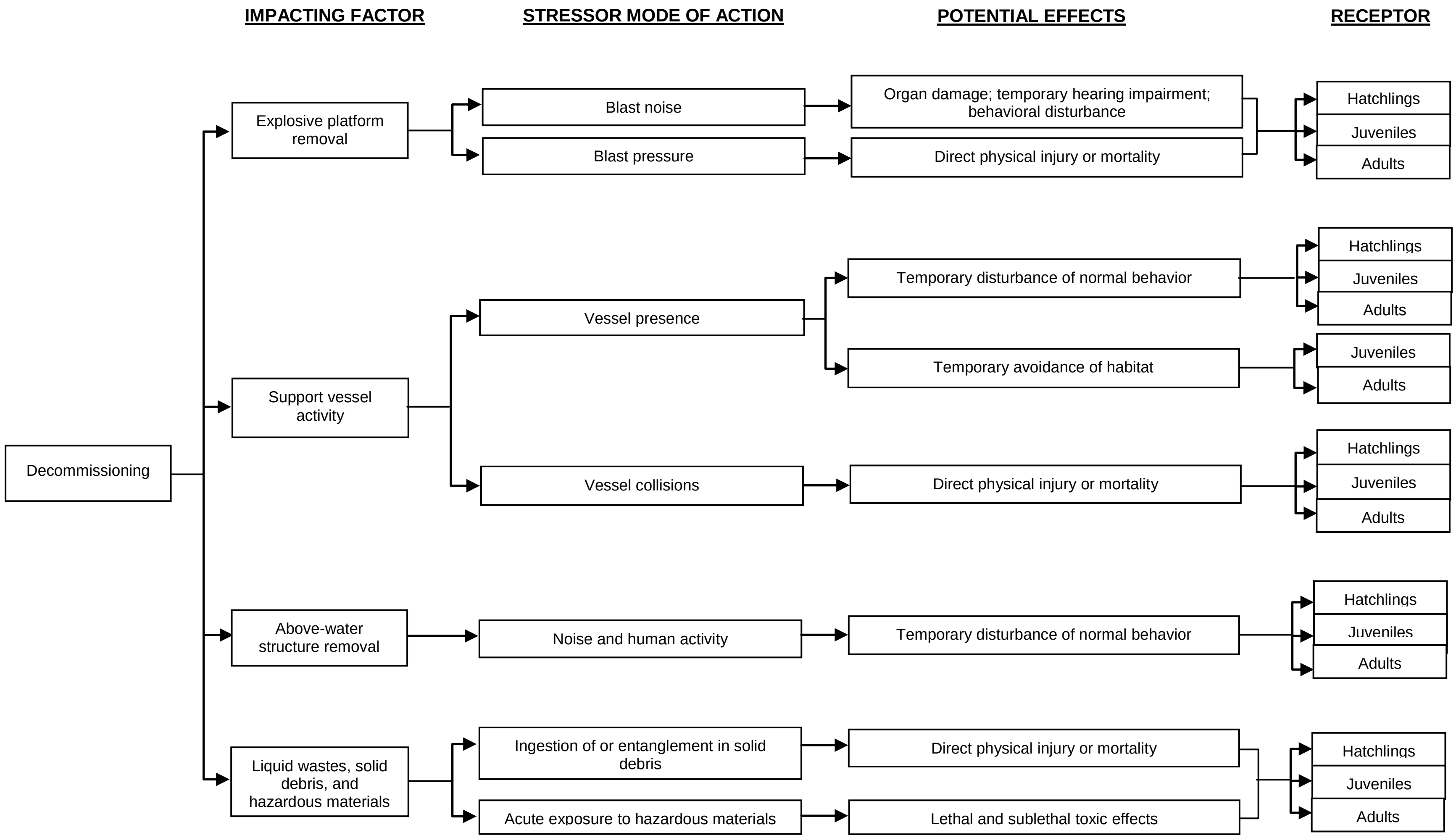

FIGURE 4.4.7-9 Conceptual Model for Potential Effects of Platform Decommissioning on Turtles in the GOM

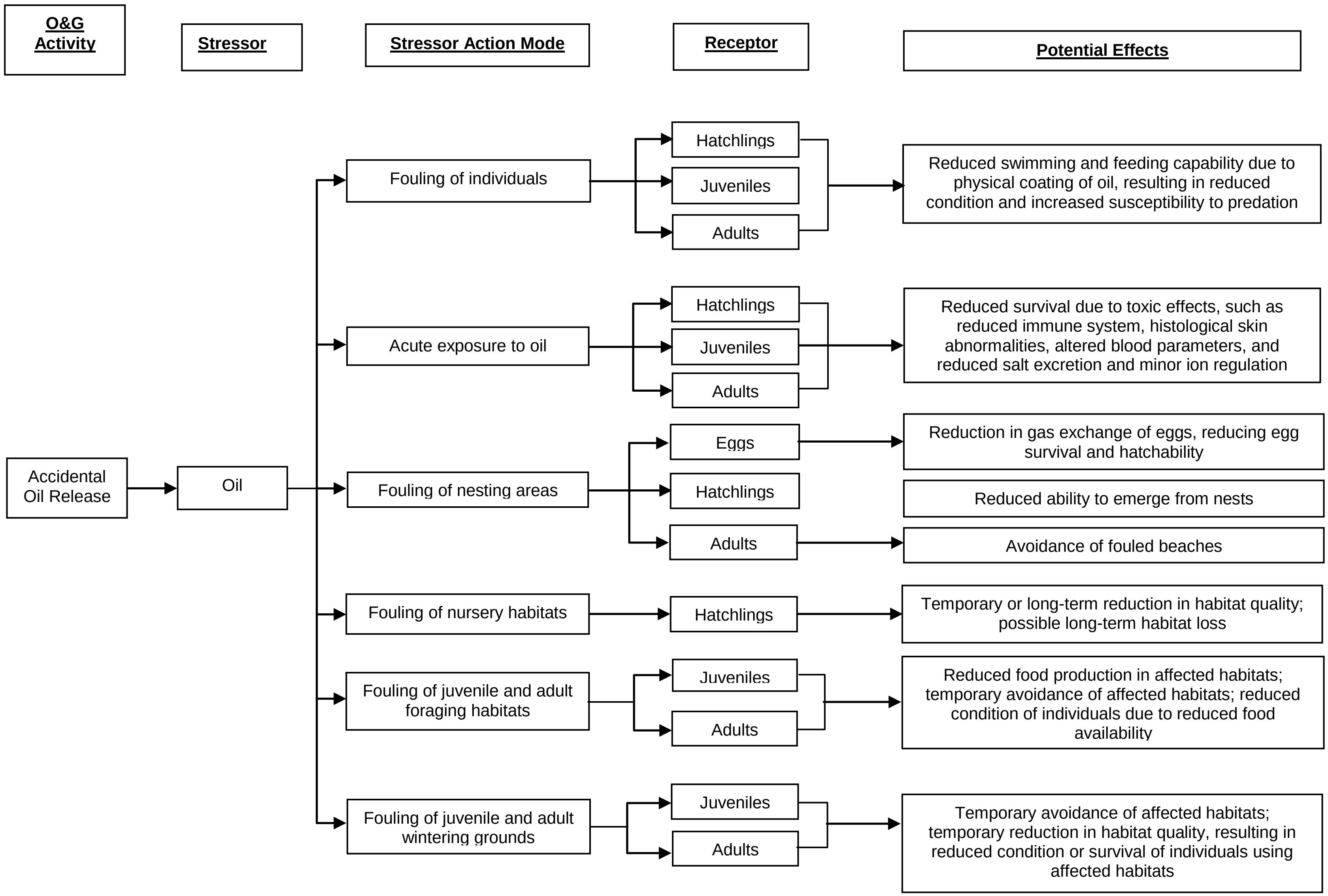

FIGURE 4.4.7-10 Conceptual Model for Potential Effects of Oil Spill on Reptiles in the GOM

Noise. Hearing sensitivity includes the hearing threshold (the minimum sound level that an animal can perceive in the absence of significant background noise) and the hearing bandwidth (the range of frequencies that an animal can hear). There is very little published data on sea turtle hearing sensitivities, but the little available data suggests that sea turtle species exhibit best hearing at low frequencies 200–700 Hz (BOEMRE 2010b), with an upper hearing limit of 1,600 Hz (Dow et al. 2008). Reported hearing thresholds are also of low frequency, estimated to be between 50 and 1,000 Hz (Tech Environmental, Inc. 2006). Threshold detection levels for these species over this frequency range are relatively high (>100 dB referenced to 1 micropascal within 1 meter of the source [dB re 1 µPa-m]) (Tech Environmental, Inc. 2006).

Potential responses to noises generated during normal operations may be expected to be behavioral and may include avoidance of the noise source, disorientation, and disturbance of normal behaviors such as feeding. Evidence suggests that sea turtles may be affected by seismic noises (McCauley et al. 2000; BOEMRE 2010b; NSF and USGS 2010), but it is largely unknown how sea turtles may respond to and be affected by noise generated during structure placement, drilling and production, pipeline trenching, vessel traffic, and explosive structure removal (Geraci and St. Aubin 1987). Because some sea turtles, such as the loggerhead, may be attracted to OCS structures, these may be more susceptible to sounds produced during routine operations.

Noise generated by seismic surveys may affect sea turtles (Figure 4.4.7-6). Seismic surveys generate both high-frequency and low-frequency noise at levels up to 250 dB re 1 µPa-m, with emitted energy levels in the low-frequency range of 10–120 Hz (IACMST 2006). These survey noises are expected to be detected by sea turtles. Table 4.4.7-7 provides a general summary of available information on the effects of exposure to seismic noises (e.g., sonar) on sea turtles. It has been suggested that sound levels above 175 dB re 1 µPa-m induce behavioral reactions in sea turtles. Airguns and pingers typically used in seismic surveys have nominal source outputs ranging from 192 to 265 dB re 1 µPa-m. Therefore, depending on the species of turtle, its age class, and proximity to the acoustic source, there is potential for airgun blasts to affect sea turtle behavior. Currently, the effects of seismic noise on sea turtle physiology are unknown (BOEMRE 2010b; NSF and USGS 2010; Table 4.4.7-7).

Offshore drilling and production structures produce a broad array of sounds at frequencies and levels that may be detected by sea turtles within the area of the installation (Geraci and St. Aubin 1987). These sounds are generally of relatively low frequencies, typically 4.5–30 Hz, and may be generated at sound levels up to 190 dB re 1 µPa-m. Helicopters and service and construction vessels may affect sea turtles due to machinery noise and/or visual disturbances (NRC 1990). The effects of noise generated from construction and operations are illustrated in Figures 4.4.7-7 and 4.4.7-8.

Underwater explosions associated with the explosive removal of offshore facilities may generate noises that disturb sea turtles (Figure 4.4.7-9; MMS 2005d). Underwater explosions associated with the explosive removal of offshore facilities may generate sound levels in excess of 267 dB re 1 µPa-m. Exposure criteria developed by the U.S. Navy (as cited in Frankel and Ellison 2005) to evaluate the potential for impacts of impulsive sounds (i.e., underwater detonations) on marine biota include a sound level of 182 dB re 1 µPa-m. Using this criterion, a

TABLE 4.4.7-7 Summary of Known and Anticipated Effects of Seismic Noise on Sea Turtles in the GOM

Species	Masking	Disturbance	Temporary Hearing Impairment	Injury	Other Physiological Effects	Comments
Green	Unknown	Possible – Short-term	Possible if close to high-energy acoustic source	Unknown	Unknown	Potential for limited adverse effects due to frequency overlap between seismic source and green sea turtle hearing, based on airborne sounds not measured behaviorally (Ridgway et al. 1969; Bartol and Ketten 2006; Dow et al. 2008)
Hawksbill	Unknown	Possible – Short-term	Possible if close to high-energy acoustic source	Unknown	Unknown	No studies available
Kemp’s ridley	Unknown	Possible – Short-term	Possible if close to high-energy acoustic source	Unknown	Unknown	Potential for limited adverse effects due to frequency overlap between seismic source and juvenile Kemp’s ridley sea turtle hearing (Bartol and Ketten 2006)
Leatherback	Unknown	Possible – Short-term	Possible if close to high-energy acoustic source	Unknown	Unknown	Potential for limited adverse effects due to frequency overlap between seismic source and leatherback vocalizations (Mrosovksy 1972)
Loggerhead	Unknown	Possible – Short-term	Possible if close to high-energy acoustic source	Unknown	Unknown	Potential for limited adverse effects due to frequency of seismic source and a study indicating that loggerheads avoided low-frequency sound (O’Hara and Wilcox 1990)

Source: NSF and USGS 2010.

sea turtle may be affected if exposed to a sound level that exceeds 182 dB re 1 µPa-m. Depending on the size of the charges used in an explosive detonation, the surrounding water depth, and the distance to the nearest sea turtles, individual turtles in the vicinity of the facility undergoing explosive removal may be exposed to sound at or above this level. Based on responses reported for marine mammals, sea turtles exposed to explosive noise may experience temporary hearing loss as well as behavioral changes (NRC 2003c, 2005a). Behavioral responses may include avoidance of the noise source, disorientation, and disturbance of normal behaviors such as resting or feeding. Turtles may also sustain organ or tissue damage when exposed to explosive noise (Klima et al. 1988).

In advance of explosive severance activities, BOEM and NOAA fisheries have implemented protocols to detect the presence of sea turtles within a 1,000-yard radius around decommissioning sites through observer programs operated by vessels, platforms, and helicopters. Since 1987, these observer programs have documented takes of four sea turtles (all loggerheads) in the GOM as a result of explosive severance. Of these four takes, one animal was killed, one stunned, and two injured (MMS 2005d). BOEM continues to require these mitigation measures (see Appendix F of MMS 2005d) and, with compliance, expects these requirements to reduce the potential for negative impacts to sea turtles from explosive removals.

Noise related to exploration, construction vessel passage, and facility removal may be expected to be transient, while noise generated during production may be more long-term. The dominant source of noise from vessels is propeller operation, and the intensity of this noise is largely related to ship size and speed. Vessel noise resulting from O&G activities in the GOM is expected to occur at low levels, generally 150 to 170 dB re 1 µPa-m at frequencies below 1,000 Hz. Vessel noise is transitory and generally does not propagate at great distances from the vessel. Also, available information suggests that sea turtles are not thought to rely on acoustics; the effects to sea turtles from vessel noise are discountable (NMFS 2007).

As few studies on sea turtle hearing sensitivities or noise-induced stress exist, a full understanding of physical and behavioral impacts from sounds generated during exploration, normal operations, and explosive facility removal is not available. Experiments using airguns to try to repel turtles to avoid hopper dredges have been inconclusive (O'Hara and Wilcox 1990; Moein et al. 1995), while sea turtles exposed to an operating seismic source of 166 dB re 1µPa-m were shown to increase their swimming speed in response to the sound (McCauley et al. 2000). In addition, BOEM has implemented mitigation measures for seismic surveys in the GOM requiring ramp-up, protected species observer training, visual monitoring, and reporting for all surveys potentially affecting marine mammals and sea turtles (MMS 2004b). These measures were developed in consultation with NOAA fisheries, and with operator compliance, they are expected to reduce the potential for impacts to sea turtles.

Due to their poor hearing sensitivity, noise impacts related to O&G activities would most likely result in behavioral changes as sea turtles move away from the noise source. These impacts are not expected to result in long-term effects or in population-level impacts. Recovery rates of affected sea turtles are expected to be short-term.

Offshore Structure Placement and Pipeline Trenching. The placement of offshore structures and pipeline trenching may affect hatchling, juvenile, and adult sea turtles in two ways (Figure 4.4.7-7). Individuals coming in contact with construction or trenching equipment may be injured or killed; construction and trenching activities may also temporarily affect habitat use as habitats may experience short-term and long-term changes in abundance and quality.

During placement, pipelines are placed on or in the seafloor to connect offshore platforms with onshore facilities (MMS 2001b). Burial of pipelines using equipment such as jetting sleds physically digs a trench in the bottom sediment and results in a temporary, localized increase in turbidity. This increased turbidity may temporarily affect habitat use by sea turtles, with sea turtles avoiding such areas. Increases in turbidity from trenching at any particular location may be expected to be short-lived, as jet sleds can lay pipe at an average of 1.6 km/day (1 mi/day) (MMS 2001b). While some turtles may alter their use of habitats in the vicinity of a pipeline, affected turtles would likely return to these areas following a return to more normal turbidity levels and experience little adverse affect from any temporary avoidance of the area.

Because hatchlings are not strong swimmers and undergo passive transport by ocean currents, it is unlikely that they would be able to avoid or leave areas where pipeline trenching or structure placement is occurring, and, if present during offshore construction or trenching, they could be injured or killed. In contrast, juvenile and adult sea turtles are active swimmers, and thus may be able to avoid areas where construction or trenching is occurring. Sea turtles have been known to be killed or injured during dredging operations (Dickerson 1990; Dickerson et al. 1992), and thus may also be affected during trenching activities. Juveniles or adults may also be affected if the placement of new structures occurs in foraging or developmental habitats or offshore of nesting beaches (see Section 3.6.4.1 for a discussion of these habitats and areas). Following several years out in open water as growing hatchlings, juvenile sea turtles move into nearshore habitats for further growth and maturation. Adults also utilize nearshore habitats for feeding and may mate in nearshore habitats directly off nesting beaches. In addition, females may become residents in the vicinity of nesting beaches. Offshore construction and trenching may reduce the quality or availability of foraging habitat for juveniles and adults, and may affect adult nesting behavior or access to nest sites. It is assumed that habitats such as seagrass beds and live-bottom areas commonly used by turtles for feeding or resting would be avoided during facility siting and pipeline routing, and that some soft-bottom areas affected by construction or trenching would recover (see Section 4.4.6.2.1).

Based on exploration and development (E&D) scenario estimates (Section 4.4.1.1), up to 2,100 exploration wells and 2,600 production wells may be constructed and up to 12,000 km (7,500 mi) of new pipeline may be installed among the GOM planning areas under the proposed action. At any single location, construction and trenching activities would be of relatively short duration (only until the offshore structure or pipeline is in place). Thus, any impacts incurred from structure placement or trenching would be short-term and localized to the construction area and immediate surroundings and, therefore, would likely affect relatively few juveniles or adults. Because they are passively aggregated by currents, a greater number of hatchlings may be affected if present in a construction or trenching area. However, these effects are not expected to result in population-level impacts.

Removal of Offshore Structures. Sea turtles are known to be attracted to offshore platforms (Lohoefener et al. 1990); therefore, they may be killed or injured during explosive platform removal (Klima et al. 1988; Gitschlag and Herczeg 1994). Even if turtles are not capable of hearing the acoustic properties of an explosion, physiological or behavioral responses (startle) to detonations may still result (MMS 2007c). The effects of blast pressure on sea turtles during explosive platform removal activities are illustrated in Figure 4.4.7-9. Exposure to explosion pressure could result in internal injuries, such as lung hemorrhaging, and individuals may be rendered unconscious by the force of the blasts (Duronslet et al. 1986; Klima et al. 1988). However, evidence of sea turtle mortality or injury from blast pressure is sparse, probably due to the difficulty in observing submerged turtles and because affected turtles may remain submerged rather than float to the surface (NRC 1990). Despite this, the relative importance of oil platform removal to overall sea turtle mortality (from human activities) is considered to be low (NRC 1990; NOAA 2003). Under the proposed action, approximately 150 to 275 existing platforms could be removed from the planning areas using explosives.

Mitigation measures in the form of guidelines for explosive platform removals have been established by BOEM with the cooperation of the National Marine Fisheries Service (NMFS). These guidelines require a mitigation plan that uses qualified observers to monitor the detonation area for protected species prior to and after each detonation. The detection of sea turtles within a predetermined radius from the structure prior to detonation would, without exception, delay structure removal. As long as operators comply with these mitigating measures, it is expected that impacts other than short-term behavioral disturbance would be avoided or greatly reduced, and no population-level effects would occur.

OCS Vessel Traffic. Sea turtles could be disturbed by the presence of OCS project vessels traveling from port locations to the construction area, as well as ships supporting pipeline trenching activities. It is unknown whether or how the presence of passing project vessels might affect nearby sea turtles. Sea turtles exposed to a passing vessel could exhibit short-term cessation of normal behaviors and possibly exhibit behavioral responses such as fleeing (Hazel et al. 2007). Construction vessel traffic would be expected in both offshore and coastal areas, and thus could affect sea turtles in coastal nest staging, foraging, and wintering habitats, as well as in offshore foraging areas and along migration routes. Several studies have reported sea turtles to exhibit strong fidelity to migration corridors, habitat foraging grounds, and nesting areas (e.g., see Morreale et al. 1996; Morreale and Standora 1998; Avens et al. 2003; and Casale et al. 2007). Many important coastal habitats for sea turtles are in areas with high levels of commercial and recreational boat traffic (e.g., see USDOT 2008). In such areas, construction vessel traffic would likely result in only a very small incremental increase in overall vessel traffic in many locations.

Boat collisions are reported to be a major cause of injury and mortality in sea turtles (Lutcavage et al. 1997; TEWG 2007). While juvenile and adult sea turtles may avoid areas with heavy vessel traffic, most species generally exhibit considerable tolerance to ships. Because of their limited swimming abilities, hatchlings would likely not be able to avoid oncoming vessels, and thus may be more susceptible to vessel collisions, especially if aggregated in areas of current convergence or in mats of floating *Sargassum*. To date, there is no direct evidence of OCS vessel collisions with sea turtles (of any life stage) in the GOM from oil and gas activities.

The likelihood of such a collision would vary depending upon species and life stage present, the location of the vessel, its speed, and its visibility. Hatchling turtles, including those aggregated in convergence zones or patches of *Sargassum*, would be difficult to spot from a moving vessel because of their small size and generally cryptic coloration patterns, which blend in with the color and patterns of the *Sargassum*. While adult and juvenile turtles are generally visible at the surface during periods of daylight and clear visibility, they may also be very difficult to spot from a moving vessel when resting below the water surface and during nighttime and periods of inclement weather.

While sea turtles are distributed within nearshore waters and waters of the continental shelf throughout the GOM, they appear to occur in greatest abundance east of Mobile, Alabama, in the Eastern Planning Area (Davis et al. 2000). Only a small portion of the Eastern GOM located greater than 160 km (100 mi) from the Florida coast (Figure 1-2) is being considered for the Program. Service vessels that would go to this area are assumed to originate from bases located in coastal areas adjacent to the Central Planning Area; thus the potential for sea turtle collisions with OCS project boats may be very low for the Eastern Planning Area. In contrast, there may be a greater potential for turtle-vessel collisions in the Western and Central Planning Areas, due to the large number of vessel trips in these areas. Under the proposed action, it is estimated that between 300 and 600 vessel trips would occur per week; most of this activity would occur in the Central and Western Planning Areas.

BOEM has implemented measures for all oil and gas operators in the GOM that require actions to minimize the risk of vessel strikes to protected species, including sea turtles and reporting observations of injured or dead animals (see NTL 2003-G10 [MMS 2003b]). In lieu of a formal observer program, this Notice to Lessees and Operators (NTL) also provides specific guidelines for operators to follow to avoid injury to marine mammals and sea turtles. With compliance, BOEM expects these measures to reduce the potential for negative impacts to sea turtles from vessel collisions.

Construction and Operation of Onshore Infrastructure. Unless existing onshore facilities are available, new platforms and pipelines will require the construction of new onshore infrastructure such as pipeline landfalls. Onshore construction activities along the northern GOM coastline have the potential to disturb nesting adults, hatchlings, and nest sites of all sea turtle species, as well as all life stages and terrestrial habitats of the Alabama red-belly turtle and gopher tortoise.

If present in a construction area, nests containing eggs or emerging hatchlings could be destroyed by site clearing and grading activities. Females ready to nest may avoid disturbed historic nesting beaches or may dig nests in poor quality locations where hatchling success may be greatly reduced. Lighting from construction areas may disorient hatchings emerging from nearby nests, which could increase exposure to predators, cause entanglement in vegetation, or lead hatchlings away from the surf (NRC 1990; Witherington and Martin 1996; Lorne and Salmon 2007). Onshore lighting may also draw hatchlings back out of the surf, as well as disorient adult females seeking to nest on nearby beaches. In addition, terrestrial habitat for the Alabama red-belly turtle and gopher tortoise may be fragmented, degraded, or lost due to the construction and operation of onshore infrastructure.

Although disturbed beaches may undergo restoration activities, such as placement of new sand in disturbed areas, the effectiveness of such actions to restore nesting activity is unknown. Constructed beaches often differ physically from natural beaches and depending on the type of sand used may exhibit sand temperatures quite different from the original pre-disturbed beaches (NMFS and USFWS 2008). Loggerhead nesting activity on restored beaches was found to be reduced the first season following restoration, but much less reduced by the second season, suggesting that nesting activity may return to pre-disturbance levels within a few years (Rumbold et al. 2001). Because nest temperatures affect the sex of hatchlings, restored beach sites with cooler temperatures may skew sex ratios toward males (Milton et al. 1997). Similar impacts could be incurred to the Alabama red-belly turtle, gopher tortoise, and other reptile species that are listed as species of concern by the USFWS (e.g., diamondback terrapin [*Malaclemys terrapin*], gulf salt marsh snake [*Nerodia clarkia*]).

Given the small amount of onshore construction that could occur with a pipeline landfall, it is unlikely that onshore construction would impact more than a few reptile nests, and it is likely that the amount of disturbance to terrestrial habitat for the Alabama red-belly turtle and gopher tortoise would be limited. The implementation of all mitigation measures required by statutes, regulations, and/or lease stipulations that have applied in past lease sales would also greatly limit the potential for impacts to nests and emerging hatchlings. Applicable mitigation measures may include preconstruction surveys for nest sites and delay of construction activities until hatchlings have emerged and moved into open water. In addition, onshore facilities could be located such that known nesting beaches would not be affected by construction and operation of such facilities.

Operational Discharges and Wastes. Normal operations generate a variety of wastes such as produced water, drilling muds and cuttings, sanitary and other waste fluids, and miscellaneous trash and debris. Hatchling, juvenile, and adult sea turtles may be exposed to these wastes by permitted and accidental discharges from onshore and offshore facilities and OCS service and construction vessels. Produced water and drilling muds may contain a variety of constituents, such as trace metals, hydrocarbons, and NORM (Neff 1997), which may be toxic to fish and wildlife, including sea turtles. Exposure to these wastes may occur through direct contact with the wastes in the ocean water and through the ingestion of food contaminated by one or more of the waste constituents. Because produced water and other liquid wastes would be rapidly diluted in the open ocean (i.e., to ambient levels within several thousand meters of the discharge), sea turtles would be expected to experience only very low levels of exposure from the water column. Species such as loggerheads and Kemp’s ridleys that feed at the top of the food chain have been found to have higher tissue levels of bioaccumulative compounds than species feeding at lower trophic levels (Pugh and Becker 2001).

While there is limited information regarding the levels of some contaminants (such as polychlorinated biphenyls [PCBs] and metals) in sea turtle tissues, little is known about what concentrations are within normal ranges of a particular species or what tissue levels may result in acute or chronic effects (Pugh and Becker 2001; NOAA 2003). In loggerhead turtles, chlordane concentrations have been negatively correlated with blood parameters indicative of anemia, and several classes of organic contaminants have been correlated with hepatocellular damage and possible alterations of protein and ion regulation (Keller et al. 2004).

Ingestion of, or entanglement with, discarded solid debris can adversely impact sea turtles. Ingestion of plastic and other nonbiodegradable debris has been reported for almost all sea turtle species and life stages (NOAA 2003). Ingestion of waste debris can result in gut strangulation, reduced nutrient uptake, and increased absorbance of various chemicals in plastics and other debris (NOAA 2003). Sublethal quantities of ingested plastic debris can result in various effects including positive buoyancy, making them more susceptible to collisions with vessels, increasing predation risk, or reducing feeding efficiency (Lutcavage et al. 1997). Some species of adult sea turtles, such as loggerheads, appear to readily ingest appropriately sized plastic debris. In oceanic waters, floating or subsurface translucent plastic material and sheeting may be mistaken for gelatinous prey items such as jellyfish. Entanglement in debris (such as rope and discarded fishing line) can result in reduced mobility, drowning, and constriction of and subsequent damage to limbs (Lutcavage et al. 1997). However, the discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by BOEM (30 CFR 250.40) and the USCG (MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]). Assuming compliance with these regulations and laws and only accidental releases occur, very little exposure of sea turtles to solid debris generated during normal operations is expected.

Produced waters, drilling muds, and drill cuttings are routinely discharged into offshore marine waters and regulated by USEPA NPDES permits and USCG regulations. Compliance with these permits and regulations will greatly limit the exposure of sea turtles to produced water and other wastes generated at offshore facilities and on OCS vessels. Most operational discharges, as regulated, are diluted and dispersed when released in offshore areas and are considered to have sublethal effects (API 1989; Kennicut 1995). Any potential for impact on sea turtles from drilling fluids would be indirect, either by impact on prey items or through ingestion via the food chain (API 1989). Contaminants in drilling muds or waste discharge may biomagnify and bioaccumulate in the food web, which may kill or debilitate prey species or species lower in the food web. Sea turtles may bioaccumulate chemicals (Sis et al. 1993), which may ultimately reduce fitness characteristics, such as reproductive output.

Impacts of Expected Accidental Events and Spills. The accidental oil spill scenario for the GOM under the proposed action identifies as many as 8 large (≥1,000 bbl) and as many as 470 small (<1,000 bbl) oil spills potentially occurring with development resulting from the lease sales of the proposed action (Table 4.4.2-1). The majority of the expected small accidental spills would be <50 bbl (see Table 4.4.2-1), would quickly dissipate, and would only have the potential to affect a very small amount of reptile habitat and relatively few individuals. Small spills larger than 50 bbl (≤1,000 bbl) would similarly be relatively easy to contain and would only affect small areas of reptile habitat and few individuals. A large spill (≥1,000 bbl), depending on the season and location, could be more difficult to contain and may result in impacts to important habitats (e.g., nesting beaches) and lethal and sublethal effects on a potentially large number of individuals. All sea turtle life stages, as well as nest sites and eggs, may be exposed to accidental oil releases in the GOM planning areas. Although unlikely and not expected to occur under the proposed Program, in extreme catastrophic oil spills, all life stages and habitats of the American crocodile and Alabama red-belly turtle may also be exposed to oil (Table 4.4.7-6). The American crocodile inhabits brackish and freshwater environments and is primarily known to occur in coastal mangrove swamps in southern Florida. The Alabama red-belly turtle is known to occur in coastal brackish environments in Alabama and Mississippi. Depending on location and magnitude, catastrophic oil spills in the GOM have the potential to affect these habitats for the American crocodile and Alabama red-belly turtle.

The effects of accidental oil spills on reptiles are illustrated in Figure 4.4.7-10. Nests may be exposed by oil washing ashore and soaking through overlying soils onto buried eggs, while hatchlings may be exposed as they emerge from nests. Hatchlings, juveniles, and adults may be exposed while swimming through oil on the water surface, through inhalation of petroleum vapors, and through ingestion of contaminated foods and floating tar. Nesting adults (females) may also be exposed while coming ashore on oiled beaches. In addition to direct adverse effects from such exposures, adults and juveniles may also be indirectly affected if an accidental spill reduces the quality or quantity of foraging or nesting habitats. Impacts to nesting habitats could result in population-level effects. Similar impacts could be incurred to more inland reptile species that may occur in brackish environments that are listed as species of concern by the USFWS (e.g., diamondback terrapin [*Malaclemys terrapin*], gulf salt marsh snake [*Nerodia clarkia*]).

Sea turtle behavior may put the turtles at greater risk of oil exposure in the event of an accidental spill. Sea turtles are air breathers and must surface frequently to breathe. Many turtles surface at convergence areas, highly productive areas where ocean currents converge and where spilled oil could be pushed by the ocean currents. These convergence areas also provide food, shelter, and habitat for sea turtles, especially young individuals. Therefore, the accumulation of oil in GOM convergence areas increases the risk of sea turtle exposure to oil (NOAA 2010a).

Sea turtles accidentally exposed to oil or tarballs have been reported to incur a variety of conditions, including inflammatory dermatitis, breathing disturbance, salt gland dysfunction or failure, hematological disturbances, impaired immune responses, and digestive disorders or blockages (Vargo et al. 1986; Lutz and Lutcavage 1989).

Sea turtle nest sites and emerging hatchlings may be exposed to and subsequently affected by oil spills that wash up on nesting beaches and contaminate active nests. Oil may interfere with gas exchange within an oiled nest, may alter hydric conditions of the sand so that it is too wet or too dry for optimal nesting, or may alter nest temperatures by changing the color or thermal conductivity of the overlying sand (NOAA 2003). Adult females may refuse to use oiled beaches (NOAA 2003).

Eggs exposed to freshly oiled sands may incur a significant decrease in hatching success and an increase in developmental abnormalities in hatchlings (Fritts and McGehee 1982). In contrast, eggs exposed to weathered oil did not produce measurable impacts on hatchling survival or development, suggesting that impacts to nest sites would be greatest if the accidental spill occurred during the nesting season. Because most sea turtles nest above the high-tide line and oil washing ashore would be deposited at and just above the high-tide line, oiling of actual nests is unlikely except possibly in the event of exceptionally high tides or storms.

Hatchlings may become oiled while traveling from the nest to water, and a heavy oil layer or tar deposits on the beach may prevent the hatchlings from reaching water. Oiled hatchlings may have difficulty crawling and swimming, increasing the potential for predation. Open-water convergence zones where hatchlings may aggregate are also areas where oil slicks may aggregate. For example, the Sargasso Sea has been estimated to annually entrap 70,000 metric tons of tar (NOAA 2003). Because hatchlings spend more time at the sea surface, they will be more likely to be exposed to surface oil slicks than adults or juveniles. Post-hatchling sea turtles have been collected from convergence zones off Florida with tar in their mouths, esophagi, and stomachs, and tar caking their jaws (Loehefener et al. 1989; Witherington 1994). Ingested tar may result in starvation from gut blockage and decreased food adsorption efficiency, absorption of toxins, local necrosis or ulceration associated with gut blockage, interference with fat metabolism, and buoyancy problems (NOAA 2003).

Sea turtles surfacing and diving in an oil spill may inhale petroleum vapors and aspirate small quantities of oil. While no information is available about the effects of petroleum vapors or aspirated oil on sea turtles, inhalations by mammals of small amounts of oil or petroleum vapors have been shown to result in acute fatal pneumonia, absorption of hydrocarbons in organs and other tissues, and damage to the brain and central nervous system.

Ingested oil, particularly the lighter fractions, could be toxic to sea turtles. Ingested oil may remain within the gastrointestinal tract, irritate and/or destroy epithelial cells in the stomach and intestine, and subsequently be absorbed into the bloodstream (NOAA 2003). Certain constituents of oil, such as aromatic hydrocarbons and PAHs, include some well-known carcinogens. These substances, however, do not show significant biomagnification in food chains and are readily metabolized by many organisms. Hatchling and juvenile turtles feed opportunistically at or near the surface in oceanic waters and may be especially vulnerable and sensitive to spilled oil and oil residues such as floating tar (Lutz and Lutcavage 1989; Lutcavage et al. 1995). Tar found in the mouths of turtles may have been selectively eaten or ingested accidentally while feeding on organisms or vegetation bound by tar (Geraci and St. Aubin 1987; Geraci 1990).

Certain species of sea turtles may be at greater risk of exposure to spilled oil based on their distributions and habitat preferences and also on the timing of a spill. For example, loggerhead and Kemp's ridley sea turtles frequent current-restricted areas such as bays and estuaries. Because oil entering these areas may remain for longer periods of time due to reduced weathering rates and natural dispersion, sea turtles using habitats in these areas may incur longer exposure periods. Spills occurring in coastal waters of the Western Planning Area may affect greater numbers of green, hawksbill, loggerhead, and leatherback sea turtles during summer months when nearshore densities are greater than offshore densities.

Oil spill response activities that may adversely affect sea turtles include artificial lighting at night, machine and human activity and related noise, sand removal and cleaning, and the use of dispersant or coagulant chemicals. Lights used to support nighttime cleanup activities may attract sea turtles to the spill location or disorient hatchlings emerging from nearby nests. Machine and human activity may cause a temporary avoidance of nearby habitats (including nest sites) by sea turtles, produce noise that may disturb sea turtles, and also increase the potential for sea turtle collisions with vessels and onshore vehicles. Onshore activities may also crush existing nests and result in beach compaction, reducing the suitability of existing nest sites for future use. Sand removal may also directly impact nest site habitat quality. While oil dispersants or coagulants contain constituents that are considered to be low in toxicity when compared to many of the constituents of spilled oil (Wells 1989), there are little available data regarding the effects of these chemicals on sea turtles (Tucker & Associates, Inc. 1990).

The magnitude and severity of impacts that could result from accidental spills would depend on the location of the spill, spill size, type of product spilled, weather conditions, the water quality and environmental conditions at the time of the spill, and the species and life stage of the individual exposed to the spill. The magnitude and extent of any adverse effects would also depend on how quickly a spill is contained and how quickly and effectively cleanup is accomplished.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes a CDE in the GOM planning areas with a volume of 0.9-7.2 million bbl and a duration of 30–90 days (Table 4.4.2-2). It is important to note that a CDE is unlikely to occur as part of the proposed action. However, should a CDE occur, the impacts discussed below would be reasonably foreseeable. The recent oil spill associated with the DWH event, which occurred in April 2010 approximately 66 km (41 mi) off the Louisiana coast, may have had detrimental consequences to sea turtles that had direct contact with spilled oil. A total of 1,146 sea turtles were recovered from the GOM that had come in contact with or were in the vicinity of spilled oil. The recovered turtles included adults or free-swimming juveniles of four species: green, hawksbill, Kemp's ridley, and loggerhead. However, some recovered sea turtle species could not be identified (Table 3.8.3-3). Of the total number of turtles recovered, approximately 53% were found dead and 47% were found alive. Most of the recovered sea turtles (dead or alive) were Kemp's ridley sea turtles (Table 3.8.3-3). Approximately 85% of the live turtles recovered were visibly oiled; approximately 3% of the dead turtles recovered were visibly oiled (NOAA 2012a). While in the case of the DWH event, the cause of death of the deceased turtles remains unclear, it is possible for turtles to ingest or inhale oil during a CDE that could be potentially fatal without any noticeable external indications.

A CDE also has the potential to affect sea turtle populations by fouling habitats such as seagrass beds and nesting beaches. As discussed in Section 4.4.6.3.1, a CDE could affect a large portion of the pelagic *Sargassum* habitat that supports developing sea turtles, depending on the timing (season), location, and scale (magnitude) of the spill. However, *Sargassum* reproduces every year, so it is expected that the *Sargassum* population will recover if affected by an oil spill.

Oil released from a CDE may also enter coastal and brackish habitats for the American crocodile and Alabama red-belly turtle, where individuals may come in contact with oil. In the case of the DWH event, preliminary reports from the NOAA Natural Resource Damage Assessment Team have indicated that about 1,600 km (1,000 mi) of shoreline along the GOM has tested positive for oil, including salt marshes, beaches, mudflats, and mangroves (NOAA 2010b). The presence of oil in these areas likely affected foraging and nesting habitats for sea turtles, and perhaps the Alabama red-belly turtle, although the true ecological consequences of these effects are not known.

Impact Conclusions.

***Routine Operations*.** Under the proposed action, some routine operations could affect individual reptiles, but population-level impacts are not expected. Noise generated during exploration and production activities and platform removal may result in the temporary disturbance of some sea turtles, while some turtles may be injured or killed during the use of underwater explosives for platform removal. The overall impact of noise related Program activities on reptiles would be minor. Reptiles could also be directly affected by construction of offshore and onshore facilities and pipeline trenching, and also indirectly by short-term and long-term impacts to habitats. The construction and operation of new onshore facilities may impact nest sites, possibly result in eggs being crushed, and disturb hatchling movement from the nest sites to the water. The overall impact of offshore and onshore construction and removal activities on reptiles is expected to be moderate. Sea turtles may also be injured or killed by collisions with OCS vessels. The overall impact of vessel traffic related to Program activities on reptiles is expected to be moderate. Sea turtles may also be exposed to a variety of waste materials which have the potential to cause a variety of lethal and sublethal effects. The overall impact of operational discharges and wastes on reptiles is expected to be moderate.

Many of these impacts would be of relatively short duration and localized and would likely affect relatively few individuals in the immediate project area. Existing permit requirements, regulatory stipulations, and BOEM guidelines and mitigation measures, if applied, target many of the routine operations and could limit the potential effects. Overall, impacts to reptiles from routine operations associated with the Program are expected to range from minor to moderate.

***Expected Accidental Events and Spills*.** The majority of the expected small accidental spills would be <50 bbl (see Table 4.4.2-1), would quickly dissipate, and would only have the potential to affect a very small amount of habitat and relatively few individuals. Small spills ≥50 bbl but <1,000 bbl would similarly be relatively easy to contain and would only affect small areas of habitat and few individuals. A large spill (≥1,000 bbl), depending on the season and location, would be more difficult to contain and may result in impacts to important habitats (e.g., nesting beaches) and lethal and sublethal effects on a potentially large number of individuals. Accidental spills have the potential to foul habitats and injure or kill exposed reptiles. An oil spill may result in the exposure of one or more life stages of reptiles to oil or its weathered products. Oil may reduce egg hatching and hatchling survival and may inhibit hatchling access to water. Hatchlings, juveniles, and adults may inhale or ingest oil and oil vapors and may incur any of a variety of physiological impacts. The presence of oil slicks or oiled beaches may alter habitat use and affect nest site access and use. Small spills that may occur under the proposed action are unlikely to affect a large number of reptiles or their habitats and are not expected to have long-term effects on reptile populations in the GOM. The overall impact of small spills (<1,000 bbl) on reptiles is expected to range from negligible to minor. The overall impact of large spills (≥1,000 bbl) on reptiles is expected to range from minor to moderate.

***An Unexpected Catastrophic Discharge Event*.** A CDE is unlikely to occur under the proposed Program. A CDE could affect many individuals and habitats, including nesting beaches, and potentially may incur population-level effects. The magnitude of effects from a CDE would depend on the location, timing, and volume of the spills; the environmental settings of the spills; and the species and life stages of reptiles exposed to the spills. Because 93% of the new oil production that is expected to occur during the Program is assumed to occur far from the coast in deep water (>200 m [656 ft] deep), the likelihood of a large spill occurring close enough to the coastline to affect turtle nesting beaches is expected to be small. However, a CDE occurring in deep water has a greater likelihood of reaching coastal areas, although this will depend on the specific location of the spill and the prevailing currents in that area. The rapid deployment of spill-response teams and implementation of cleanup activities could limit the magnitude of impacts incurred by sea turtles in the event of an accidental spill; however, cleanup operations themselves could also impact sea turtle habitats. In the unlikely event of a CDE, impacts to reptiles would be expected to be major and long-term if multiple individuals and their habitat (especially nesting habitat) are exposed to oil.

4.4.7.5 Invertebrates and Lower Trophic Levels

4.4.7.5.1 Gulf of Mexico.

Impacts of Routine Operations.

Impacting factors common to all phases include vessel discharges (bilge and ballast water), miscellaneous discharges (deck washing, sanitary waste), and offshore lighting. Many of these waste streams are disposed of on land, and all vessel and platform waste streams must meet USEPA and/or USCG regulatory requirements before discharge into surface waters. Impacts on invertebrate populations from waste discharges would be localized and temporary. Studies conducted in the northern GOM suggest that platform lighting could alter predator-prey dynamics by enhancing phytoplankton productivity around the platform, attracting phototaxic pelagic invertebrates, and potentially improving the visual foraging environment for fishes (Keenan et al. 2007). Consequently, increased predation of invertebrates may occur in the vicinity of the platform. Potential impacts from platform lighting would be localized but long-term and are expected to have minimal impacts on invertebrate populations.

Exploration and Site Development. During the OCS oil and gas exploration and development phase, invertebrates could be affected by noise from seismic surveys and noise and bottom disturbance from drilling, platform placement, and pipeline trenching and placement activities. Releases of drilling muds and cuttings could also affect invertebrates by contaminating sediments and surrounding surface waters (Table 4.4.7-8).

Noise from vessel traffic, construction, seismic surveys, and drilling could kill or injure invertebrates close enough to the noise source, as well as reducing habitat suitability, as some species would avoid the area. For example, decapods and cephalopods, two numerically abundant and commercially important groups of invertebrates, are known to detect vibrations from underwater noise and may be sensitive to noise from vessel traffic, seismic surveys, and

TABLE 4.4.7-8 Impacting Factors Potentially Affecting Invertebrates and Their Habitat in the GOM Planning Areas

	Life Stage Affected[a]		
Development Phase and Impacting Factor	Eggs	Larvae	Adults
Impacting Factors Common to All Phases			
Vessel noise	X	X	X
Vessel traffic	X	X	X
Hazardous materials	X	X	X
Solid wastes	X	X	X
Offshore lighting	X	X	X
Aircraft noise			
Offshore air emissions			
Onshore air emissions			
Aircraft traffic			
Miscellaneous platform discharges	X	X	X
Vessel discharges	X	X	X
Bottom disturbance from vessel anchors	X	X	X
Exploration and Development			
Seismic noise	X	X	X
Noise from drilling and construction	X	X	X
Bottom disturbance from platform placement, drilling, and pipeline placement and trenching	X	X	X
Discharge of drilling muds and cuttings	X	X	X
Production			
Production noise	X	X	X
Produced water discharge	X	X	X
Artificial reef	X	X	X
Decommissioning			
Platform removal (non-explosive)	X	X	X
Platform removal (explosive)	X	X	X

[a] colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

drilling (DFO 2004; NSF and USGS 2010). Recent reviews of the impacts of anthropogenic noise on invertebrates indicates that invertebrates exposed to noise could exhibit pathological effects (i.e., injury and mortality), physiological changes (i.e., changes in hormone, protein, and enzyme levels), and/or behavioral changes (such as a startle response) and change swimming and movement patterns (DFO 2004; NSF and USGS 2010). Although data is limited, zooplankton and larvae stages may be injured because of their small size and relative lack of mobility, while noise is often found to have minimal effects on adult invertebrates (reviewed in DFO 2004 and NSF and USGS 2010). The studies typically suggested that injury was limited to within 10 m (33 ft) of the noise source. The numbers of invertebrates that could be affected by noise during the exploration and site development phase make it unlikely that noise impacts would have appreciable effects on invertebrate populations in the Western and Central Planning Areas. A recent review of the effects of seismic survey activities on marine invertebrates concluded that although data were limited, mortality and injury of invertebrates would be limited to organisms located within a few meters of the airgun, and that there would be no significant impacts on marine invertebrate populations from airgun and sonar sounds (NSF and USGS 2010). The severity and duration of noise impacts would vary with site and development scenario, but impacts are expected to be temporary and localized.

Bottom-disturbing activities such as coring and drilling, platform placement and mooring, and pipeline trenching and placement would displace, injure, or kill invertebrates in the vicinity of the activities. The estimated bottom habitat that may be directly disturbed by new pipeline and platform installation ranges from 2,150 to 14,000 ha (5,313 to 34,594 ac) over the entire GOM. In the initial drilling phase before a riser is installed, drilling muds would accumulate around the well and bury benthic invertebrates as well as create a turbidity plume that could impact pelagic invertebrates located near the bottom. Drilling is also expected to increase the amount of sand in sediments surrounding the well for at least 300 m (984 ft) (Continental Shelf Associates, Inc. 2006). This change in grain size could alter community composition and prevent the settlement of some species. In addition, bottom disturbance during platform and pipeline placement would result in sedimentation and turbidity, which could bury benthic infauna and damage the gills of water-column and benthic invertebrates present within some distance of the disturbance. These disturbances would be localized and temporary. Species most likely to be affected are sessile benthic organisms and small zooplankton, which lack the mobility to avoid the direct disturbance and the associated turbidity plumes. An FPSO system may be employed for deepwater wells. Under the FPSO system, oil would be transported from the well to a surface vessel and ultimately to shore. By eliminating the need for pipelines, an FPSO system would greatly reduce bottom disturbance and the chance for disturbing benthic and near-bottom invertebrates and their habitat. Most disturbed areas would be recolonized quickly, but, if grain size is significantly altered, the benthic community may take several years to return to its pre-disturbance composition (Bolam and Rees 2003 and references therein).

The effects of drilling muds and cuttings (including drilling fluids adhering to the cuttings) on invertebrates can be chemical such as toxicity or physical such as gill abrasion, burial, or displacement from turbidity and sedimentation. Impacts from turbidity and sedimentation would be similar to those described above and could damage respiratory structures and disrupt food acquisition at all trophic levels. Drilling wastes released near the sediment surface or in shallow water would bury benthic organisms in the release area. Muds released in deeper water or near the water's surface would be spread over a greater area in a thinner layer and may not result in high mortality, although impacts to water-column invertebrates may be greater under this scenario. The disturbance would be short in duration, with repopulation of the affected area occurring by larval recruitment. In addition, drilling discharges must comply with NPDES permit requirements regarding the discharge amount, rate, and toxicity, which would greatly reduce the impact to invertebrate communities.

The USEPA and BOEM have sponsored research on the biological effects of drilling fluids on benthic invertebrates. In studies conducted on the GOM continental shelf and slope, synthetic drilling fluids in sediments were elevated within 500 m (1,640 ft) of the well (Continental Shelf Associates, Inc. 2004a, 2006). Meiofaunal and macroinvertebrate abundance were typically highest near the well, and were often found to increase with the concentration of drilling fluids in the sediment (Continental Shelf Associates, Inc. 2006). However, the effects of drilling muds appears to be species-dependent. Amphipod, ophiuroid, and ostrocod densities were depressed within 300 m (984 ft) of the well compared to control areas, while copepods, nematodes, and several classes of dominant infauna including worms, clams, and snails were more abundant within 300 m (984 ft) of the well (Continental Shelf Associates, Inc. 2006). Sediments collected near the well were found to be toxic to amphipods, which explains their depressed abundance (Continental Shelf Associates, Inc. 2004a, 2006). The elevated abundance of most infauna may have been due to the high organic matter content of the drilling fluids adhering to the muds and cuttings. Some sites showed particularly high abundance of species tolerant of organic enrichment (Continental Shelf Associates, Inc. 2006). However, the high organic matter content also created anoxic patches along the seafloor that contained very few infauna. The recovery time for benthic communities will depend on impact magnitude and species present, and existing data suggest recovery will begin rapidly but may take years for recovery to pre-disturbance communities (Continental Shelf Associates, Inc. 2004a, 2006).

Production. Production activities that could affect soft sediment habitat include operational noise, bottom disturbance from the movement of mooring anchors, chains, and cables, and the release of process water. In addition, the platform would replace existing featureless soft sediments and potentially serve as an artificial reef (Table 4.4.7-8).

Chronic bottom disturbance would result from the movement of anchors and chains associated with support vessels and floating platform moorings. Bottom disturbance would impact invertebrates in a manner similar that described above for the exploration and site development phase. The disturbance would be episodic and temporary, but would last for the lifetime of the platform.

Sessile epifaunal invertebrates requiring hard substrate (i.e., barnacles and corals) as well as small motile invertebrates (amphipods and worms) would be able to colonize the structure of the platform, resulting in an artificial reef. Unburied pipelines would also provide hard substrate for sessile and structure-oriented invertebrates. Although densities of some zooplankton species were elevated near the platforms in the northern GOM, the effect was not consistent (Keenan and Benfield 2003). The platform would likely increase shell material and organic matter in the surrounding sediments, potentially resulting in a shift in benthic invertebrate community composition. The replacement of soft sediment with artificial reef would only exist during the production phase, unless the platform was permitted to remain in place after decommissioning. Because platforms are spread across a large area of the GOM, they could provide habitat for non-native invertebrate species that prefer hard substrate. Such species could be introduced by a number of mechanisms both natural and anthropogenic (commercial shipping and human introduction). In the deep sea, floating production platforms are used that could create a floating reef habitat at the surface. In deep sea soft sediment, communities may form on mooring structures, but colonization would likely be slow and mooring structures would be completely removed during decommissioning, so impacts, if any, would be temporary.

Produced water contains metals, hydrocarbons, salts, and radionuclides, and its discharge could contaminate habitat resulting in lethal and sublethal effects on invertebrates. Organisms attached to oil platforms have not been found to accumulate metals, although they have been found to bioaccumulate organic contaminants (Neff 2005; Trefry et al. 1995). Produced water from deepwater wells is expected to contain more chemical contaminants to maintain adequate flow. Contaminants from produced water discharges are not expected to reach toxic levels in the sediment and water column due to dilution and NPDES permitting requirements regarding discharge rate, contaminant concentration, and toxicity. Invertebrates collected in sediments near platforms in the GOM do not appear to bioaccumulate the common contaminants in produced water, such as radionuclides, metals, and hydrocarbons, and in most cases, the concentration of these contaminants in their tissues did not exceed USEPA-specified concentrations considered harmful (Continental Shelf Associates, Inc. 1997). Produced water is also not expected to contribute significantly to the creation of hypoxic bottom water conditions (Rabalais 2005; Bierman et al. 2007).

The results of the GOM Offshore Monitoring Experiment, funded by BOEM, provide a good summary of the long-term sublethal impacts of oil and gas development on invertebrates at the individual, population, and community level (Kennicutt et al. 1995). Stations surrounding petroleum wells were sampled in a radial pattern with stations at 30–50, 100, 200, 500, and 3,000 m distances (98–164, 328, 656, 1,640, and 9,842 ft). Elevated sediment concentrations of sand, organic matter, hydrocarbons, and metals were generally restricted to sediments within 200 m (656 ft) of the platforms. Overall, there was no evidence of sublethal physiological stress or change in distribution of epifaunal invertebrates attributable to the presence of the platform. Oil and gas development activities resulted in altered infaunal communities within 100 m (328 ft) of the platform, with reduced density and diversity of crustaceans (primarily amphipods and copepods) near the platform and enhanced density of polychaetes and deposit-feeding nematodes. The patterns in invertebrate density were often attributable to changes in a few species. Differences in abundance between near- and far-field stations were the product of toxic response of sensitive crustacean species and sediment organic enrichment, which increased the density of worms (Kennicutt et al. 1995). Toxicity tests indicated copepod survival, reproduction, and genetic diversity were lower near the platforms due to metal concentrations (Montagna and Harper 1996) or the reef effect of the platform (Montagna et al. 2002).

Decommissioning. Platform removal (potentially using explosives) would temporarily affect benthic and pelagic invertebrates, as described above, by disturbing sediments and increasing noise and turbidity for some length of the water column. Deposition of suspended sediments could bury, smother, or kill some benthic organisms in the vicinity of work sites. Reviews of the effects of underwater blasts on invertebrates suggest they are relatively insensitive to the effects of the pressure wave associated with the blast (Keeving and Hempen 1997). Any mortality should be limited to epifauna within a few meters of the blast (Keevin and Hempen 1997). In addition, the explosive charges typically would be set at 5 m (16 ft) below the seafloor surface, which would significantly attenuate the shock wave as it moved through the seabed. Displaced invertebrate communities would repopulate the area over a short period of time, although a return to the pre-disturbance community may take longer. However, if fixed platforms are toppled and left in place, the changes to invertebrate communities resulting from the initial platform installation would be long-term. Pipelines installed and anchored on the seafloor would be capped and left in place, although there is the potential for chronic sediment disturbance from pipeline movement. Pipelines not buried would also continue to serve as hard substrate for sessile invertebrates and structure oriented invertebrates.

Impacts of Expected Accidental Events and Spills. Accidental hydrocarbon spills can occur at the surface or at the seafloor, potentially affecting pelagic and benthic invertebrates. It is assumed that up to 8 large spills (≥1,000 bbl), up to 70 spills between 50 and 999 bbl, and up to 400 smaller spills between 1 and 50 bbl could occur during the lease period under the proposed action (Table 4.4.2-1). Most oil and gas spills would be small and are expected to primarily affect invertebrates in the water column, as most hydrocarbons would float above the sediment surface. However, even a small spill (<999 bbl) could affect intertidal and subtidal invertebrates if oil were to contact the shoreline. After the spill of 600 bbl of crude oil in Barataria Bay, Louisiana, Roth and Baltz (2009) found a reduction in total number of decapod crustaceans as well as reduction in grass shrimp (*Palaeomonetes pugio*) 3 weeks after the spill occurred. The impact magnitude of these small oil spills on invertebrates is primarily a function of the invertebrate species and habitat affected. It is anticipated that only a small amount of the water column and shoreline would be affected by these smaller oil spills and would not, therefore, present a substantial risk to invertebrate populations. Consequently, the effects of small spills on invertebrates and their habitat are expected to be short-term and affect relatively few individuals.

Larger areas and numbers of individuals may be affected by large spills (>1,000 bbl). Exposure to hydrocarbons can result in lethal or sublethal (reproduction, recruitment, physiology, growth, development, and behavior) impacts at the level of the individual. The invertebrates most likely to be affected are sessile benthic organisms and small zooplankton, which lack the mobility to avoid the oil. Invertebrates differ in their sensitivity to hydrocarbon pollution both by organism class and life stage (Laws 1993). For example, crustaceans appear to be among the taxa most sensitive to oil pollution, while certain species of worms, such as Capitellid polychates, appear to be tolerant of oil pollution (Laws 1993; NRC 2003b). Among meiofauna, nematodes may be less sensitive to oil than copepods. Oil exposure can reduce the abundance of zooplankton in the oiled area, induce narcosis, and bind to feeding appendages (Teal and Howarth 1984). Zooplankton are known to ingest oil, some of which is retained in the gut and some of which is exported to the seafloor in fecal pellets (Teal and Howarth 1984). Impacts from large spills would be greatest if the spill occurred during a reproductive period or contacted a location important for spawning or growth such as intertidal and nearshore subtidal habitats. However, impacts from large spills are expected to be temporary as oil is diluted and broken down by natural chemical and microbial processes.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes a CDE in the GOM planning areas with a volume of 0.9-7.2 million bbl and a duration of 30–90 days (Table 4.4.2-2). Spilled oil has been found to affect pelagic and sediment-dwelling invertebrates, as well as dramatically increase the relative abundance of hydrocarbon-consuming bacteria in the sediment and water column (Laws 1993; reviewed in NRC 2003b; Kostka et al. 2011). Hydrocarbon releases at the seafloor would typically rise in the water column, which would limit direct contact with benthic invertebrates but increase the exposure of small zooplankton, which lack the mobility to avoid the oil. Benthic invertebrates could be affected directly by oil reaching intertidal or shallow subtidal habitats or natural deposition of oil-contaminated pelagic organic matter and biota. Benthic and pelagic invertebrates are important trophic links connecting primary producers to higher-trophic-level organisms. Consequently, oil spill contamination on a large scale could result in significant contaminant transfer to higher trophic levels and/or reduce food availability to higher trophic levels if invertebrate populations were severely depressed.

The location of the CDE and the season in which the CDE occurred would be important determinants of the impact magnitude of the spill. For example, catastrophic spills occurring during recruitment periods or spills that affect areas with high larval invertebrate concentrations (i.e., estuaries) would have the greatest impact. In addition, the magnitude of a spill's impacts on invertebrates and their habitat would likely increase with the degree of shoreline oiling, as estuaries have high biological productivity and serve as critical habitat for invertebrates. Oil would persist longer in the environment than gas and oil could be transported to the shoreline where it could reduce local populations of shallow subtidal and intertidal coastal habitat for an extended period of time. However, a spill of this kind is unlikely to occur, and invertebrates typically have short generation times and should recover from even a catastrophic spill.

Some oil spill response activities could adversely affect lower-trophic-level organisms. For example, dispersants could increase oil toxicity, and cleanup techniques, the presence of large numbers of people, or the use of heavy equipment on shorelines could kill some coastal organisms during cleanup responses. Dispersant toxicity varies by species and dispersant used. Newer dispersant formulations, such as COREXIT® 2500, do not appear to be more toxic to invertebrates than oil alone (Hemmer et al. 2011). However, few species and life stages have been tested; additive toxicity from oil dispersant mixtures may be significant for some species (Hemmer et al. 2011). Studies of microbial communities on oiled beaches in Louisiana indicated that the dispersant COREXIT altered microbial communities by reducing the abundance of *Marinobacter* spp. and *Acinetobacter* spp., both hydrocarbon-degrading bacteria, and increasing the relative abundance of *Vibro* spp., a nonhydrocarbon-degrading bacteria (Hamdan and Fulmer 2011). These results indicate that dispersants may inhibit the biodegradation of oil.

Prior studies provide insight into the potential long-term effects of an oil spill on invertebrate populations in the GOM. A large oil spill in Panama affected intertidal and subtidal infauna and epifauna, with the impact magnitude and recovery time varying with the habitat, organism, and degree of oiling (Jackson et al. 1989; Keller and Jackson 1993). Oysters and mussels within mangroves, as well as amphipods, tanaids, and ophiurods in seagrass habitats, displayed long-term (>9 months) reduction in abundance compared to unoiled areas. Corals and associated biota were also affected by the spill, especially at the reef edge that received the heaviest oiling. Although many species recovered within a few months to 2 years, certain crustaceans and oysters had not recovered within 5 years (Keller and Jackson 1993). Guzman et al. (1991) estimated a total recovery time of 10 to 20 years for the same spill. Similarly, surveys of deepwater coral sites following the DWH event revealed that corals and brittle stars showed signs of stress such as mucus secretion, bleaching, abnormal color, and/or attachment posture (White et al. 2012). The 1979 Ixtoc I spill in the Bay of Campeche was not well studied; therefore it is difficult to assess the extent of impacts on invertebrates (ERCO 1982). Most studies of the Ixtoc spill occurred in south Texas far from the spill site. In these studies, sediment contamination was not detected and no strong links between Ixtoc oil and changes in invertebrate communities could be found (ERCO 1982; Laws 1993). In a study of upper Galveston Bay, a site of heavy oil and gas activity with a history of spills, Rozas et al. (2000) found no consistent significant relationships between sediment oil concentration and invertebrate densities, despite testing multiple species. Although sediment contamination did not appear to affect habitat use, sublethal exposure impacts could have been possible.

Species Protected under the Endangered Species Act.

***Elkhorn Coral*.**

Impacts of Routine Operations. The only colonies of elkhorn coral known to exist in the Western and Central Planning Areas are the two colonies in the FGBNMS. As described in Section 4.4.6.2, the Flower Gardens are part of a national sanctuary; no oil and gas exploration or site development will be permitted within the sanctuary. In addition, BOEM instituted a Topographic Features Stipulation establishing No Activity Zones that prohibit structures, drilling rigs, pipelines, and anchoring around the Flower Gardens. Drilling muds can reduce the growth of elkhorn coral (Kendall et al. 1984); however, the Topographic Features Stipulation requires that any discharged drilling muds and cuttings within 4 mi (6.4 km) of the Flower Gardens be shunted to within 10 m (33 ft) of the seafloor (http://www.gomr.mms.gov/homepg/lsesale/topo_features_package.pdf). These protections will limit direct impacts to the elkhorn coral patches from exploration and site development activities.

Impacts on elkhorn coral during the production phase could result from miscellaneous discharges, the movement of vessel anchors and mooring structures, and produced water discharge. However, as described in Section 4.4.6.2, impacts to elkhorn coral would be minimized by an existing stipulation that prohibits exploration and development activities in the vicinity of the FGBNMS. During the production phase, produced water discharges are not likely to impact the FGBNMS because of the Topographic Features Stipulation requiring large buffers between the FGBNMS and oil and gas development activities (Section 4.4.6.2.1).

Impacts of Expected Accidental Events and Spills. Spills at the seafloor would rise in the water column but are not likely to contact the FGBNMS at concentrations toxic to marine life (see Section 4.4.6.2.1). Platform spills and tanker spills at the ocean surface could penetrate the water column to documented depths of 20 m (66 ft) or more, which is within the depth range at which the elkhorn colonies are found in the FGBNMS. However, at these depths, the contaminant concentrations are typically several orders of magnitude lower than those demonstrated to have an effect on marine organisms (MMS 2008a). In addition, no oil and gas infrastructure would be permitted in the vicinity of the FGBNMS, which would allow more time for dilution of the oil before reaching the banks. Therefore, it is likely that only small concentrations of oil from surface spills would reach the FGBNMS (MMS 2008a).

Impacts of an Unexpected Catastrophic Discharge Event. It is possible that a CDE originating from outside the No Activity Zones established by the Topographic Features Stipulation could reach the vicinity of the FGBNMS and potentially affect the two elkhorn coral colonies located therein. The concentration of oil reaching the colonies would depend on the location and characteristics of the CDE. Hydrocarbons have been shown to have lethal and sublethal (reproduction, larval settlement, photosynthesis, and feeding) effects on corals, and as a highly branching species, elkhorn coral may be particularly vulnerable to oil exposure (Guzman et al. 1991). Any impacts associated with a large or catastrophic spill reaching sensitive corals would most likely be sublethal, because of the dilution that would occur as the oil dispersed from the spill site to the Flower Gardens Banks. Corals have the capacity to recover quickly from hydrocarbon exposure (Knap et al. 1985), but larval stages of coral are far more sensitive than adults. Therefore, the impact magnitude of a CDE is partly dependent on whether the spill occurs during a period of coral spawning. For lethal exposures that eliminate the elkhorn colony, recolonization could occur, although recovery may be slow because recruits would have to come from elkhorn coral populations located farther south. Consequently, it is anticipated that the impacts of lethal concentrations of oil reaching coral reef or hard-bottom habitat from a CDE would be long-term. However, impacts to or extirpation of the elkhorn corals in the FGBNMS would not result in overall species-level impacts because this species is primarily located in the southern GOM, Caribbean, and south Florida.

Impact Conclusions.

Routine Operations. The primary impacts of oil and gas activities on invertebrates in the GOM planning areas would be from drilling waste discharges and from bottom-disturbing activities during the exploration and site development phase, which could displace, bury, injure, or kill invertebrates in the vicinity of the activities. Displaced invertebrate communities would generally repopulate the area over a short period of time, although a return to the pre-disturbance community may take longer. Where floating platforms are used, scour from the movement of mooring structures represents a chronic disturbance to benthic invertebrates lasting the life of the production phase. If discharged into open water, the effects of drilling wastes and produced water on invertebrates community structure and function should be restricted to the vicinity of the platform. Impacts to elkhorn coral are expected to be negligible because routine operations are not permitted near the Flower Gardens Banks. Overall impacts to benthic and pelagic invertebrates from routine program activities (exploration and site development, production, and decommissioning phases) would range from negligible to moderate and would primarily affect benthic invertebrates, with the severity of the impacts generally decreasing dramatically with distance from the disturbance. Impacts to Elkhorn coral would be negligible.

Expected Accidental Events and Spills. Small surface or subsurface hydrocarbon spills would be rapidly diluted and would likely result in only small localized, sublethal impacts to invertebrates. Large spills could affect a large number of benthic and pelagic invertebrates and their habitats. The location of the spill and the season in which the spill occurred would be important determinants of the impact magnitude. A large spill could contact shoreline areas, and benthic invertebrates in sensitive intertidal and shallow subtidal habitats could experience large-scale lethal and long-term sublethal effects. Impacts to elkhorn coral are expected to be negligible because of restrictions on oil and gas activities near the Flower Gardens Banks.

Overall, impacts from small spills would range from negligible for spill less than 50 bbl, minor for spills up to 1,000 bbl, and from minor to moderate for large spills (≥1,000 bbl). Impacts to elkhorn coral are expected to be negligible.

An Unexpected Catastrophic Discharge Event. A CDE could affect a wide area, with the magnitude of the impacts depending on factors such as the location, timing, and volume of spills, distribution and ecology of affected invertebrate species. A CDE would likely contact shoreline areas, and benthic invertebrates in sensitive intertidal and shallow subtidal habitats could experience large-scale lethal and long-term sublethal effects. However, a CDE is unlikely to occur, and invertebrates typically have short generation times and should recover. A CDE has the potential to oil the few elkhorn coral colonies present in the Flower Gardens Banks, but no species-level impacts are expected because this species primary range is the southern GOM. Overall, impacts to benthic and pelagic invertebrates (including elkhorn coral) from a CDE could range up to moderate.

4.4.7.5.2 Alaska – Cook Inlet.

Impacts of Routine Operations. Potential OCS oil and gas development impacting factors relevant to invertebrates are shown by phase in Table 4.4.7-9. Impacting factors common to all phases include vessel noise and discharges (bilge and ballast water), miscellaneous discharges (deck washing, sanitary waste), and offshore lighting. Impacts from these activities would be localized and temporary and would range from short-term to long-term. Overall, vessel and miscellaneous discharges are not expected to impact invertebrate communities in the sediment or water column, because many of these waste streams are disposed of on land or must meet USEPA and/or USCG regulatory requirements before being discharged into surface waters. Studies of platform lighting suggest the lights would alter predator-prey dynamics by enhancing phytoplankton productivity around the platform, attracting phototaxic invertebrates and potentially improving the visual foraging environment for fishes (Keenan et al. 2007).

Exploration and Site Development. During the OCS oil and gas exploration and development phase, invertebrates could be affected by noise from seismic surveys and noise and bottom disturbance from drilling, platform placement, and pipeline trenching and placement activities.

Noise from vessel traffic, construction, seismic surveys, and drilling could kill or injure invertebrates close enough to the noise source, as well as reducing habitat suitability, as some species would avoid the area. For example, decapods and cephalopods, two numerically abundant and commercially important groups of invertebrates, are known to detect vibrations from underwater noise and may be sensitive to noise from vessel traffic, seismic surveys, and drilling (DFO 2004; NSF and USGS 2010). Recent reviews of the impacts of anthropogenic noise on invertebrates indicates that invertebrates exposed to noise could exhibit pathological effects (i.e., injury and mortality), physiological changes (i.e., changes in hormone, protein, and enzyme levels), and/or behavioral changes (such as a startle response) and change swimming and movement patterns (DFO 2004; NSF and USGS 2010). Although data is limited, zooplankton and larvae stages may be injured because of their small size and relative lack of mobility, while

TABLE 4.4.7-9 Impacting Factors Potentially Affecting Invertebrates and Their Habitat in the Cook Inlet Planning Area

Development Phase and Impacting Factor	Life Stage Affected[a]		
	Eggs	Larvae	Adults
Impacting Factors Common to All Phases			
Vessel noise	X	X	X
Vessel traffic	X	X	X
Hazardous materials	X	X	X
Solid wastes	X	X	X
Offshore lighting	X	X	X
Aircraft noise			
Offshore air emissions			
Onshore air emissions			
Aircraft traffic			
Miscellaneous platform discharges	X	X	X
Vessel discharges	X	X	X
Bottom disturbance from vessel anchors	X	X	X
Exploration and Development			
Seismic noise	X	X	X
Noise from drilling and construction	X	X	X
Bottom disturbance from platform placement, drilling, and pipeline placement and trenching	X	X	X
Discharge of drilling muds and cuttings	X	X	X
Production			
Production Noise	X	X	X
Produced water discharge	X	X	X
Artificial reef	X	X	X
Decommissioning			
Platform removal (non-explosive)	X	X	X

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

noise is often found to have minimal effects on adult invertebrates (reviewed in DFO 2004 and NSF and USGS 2010). The studies typically suggested that injury was limited to within 10 m (33 ft) of the noise source. The numbers of invertebrates that could be affected by noise during the exploration and site development phase make it unlikely that noise impacts would have appreciable effects on invertebrate populations in the overall Cook Inlet Planning Area. A recent review of the effects of seismic survey activities on marine invertebrates concluded that although data were limited, mortality and injury to invertebrates would be limited to organisms located within a few meters of the airgun, and that there would be no significant impacts on marine invertebrate populations from airgun and sonar sounds (NSF and USGS 2010). The severity and duration of noise impacts would vary with site and development scenario, but impacts are expected to be temporary and localized.

Bottom-disturbing activities such as coring and drilling, platform placement and mooring, and pipeline trenching and placement would displace, injure, or kill invertebrates in the vicinity of the activities. Exploration would involve semisubmersible or floating drilling rigs, jack-up rigs, and bottom-founded rigs depending on water depth. Production rigs would most likely be fixed platforms. In the initial drilling phase before a riser is installed, drilling muds and cuttings would accumulate around the well and bury benthic invertebrates as well as create a turbidity plume that could adversely impact pelagic invertebrates located near the bottom. This change in grain size could alter community composition and prevent the settlement of some species. In addition, bottom disturbance during platform and pipeline placement would result in sediment resuspension and turbidity, which could bury benthic infauna and damage the gills of water-column and benthic invertebrates present within some distance of the disturbance. Platforms and pipeline placement would disturb 1.5 to 4.5 ha (4 to 11 ac) and 35 to 210 ha (86 to 519 ac) of bottom habitat, respectively. In addition, up to one pipeline landfill may result from the proposed action. Species most likely to be affected by bottom-disturbing activities are sessile and infaunal benthic organisms and small zooplankton that lack the mobility to avoid the direct disturbance and the associated turbidity plumes. Pipelines would be installed and anchored on the surface or buried. Pipelines could crush, injure, or displace invertebrates, as well as shift invertebrate community composition to those species preferring hard substrate. Soft-sediment invertebrates, particularly in shallow water, are subject to frequent bottom disturbance and sediment resuspension due to human activities such as trawling and natural occurrences such as storms. Thus, disturbed areas would likely be recolonized quickly, but, if grain size is greatly altered and slow to recover, the benthic community may take from a few months to several years to return to its pre-disturbance composition (Bolam and Rees 2003 and references therein).

The discharge of drilling muds and cuttings (including synthetic drilling fluids adhering to the cuttings) can adversely affect invertebrates in several ways. The effects of drilling muds and cuttings (including drilling fluids adhering to the cuttings) on invertebrates can be chemical such as toxicity or physical such as gill abrasion, burial, or displacement from turbidity and sedimentation. Impacts from turbidity and sedimentation would be similar to those described above and could damage respiratory structures and disrupt food acquisition at all trophic levels. Drilling wastes released near the sediment surface or in shallow water would bury benthic organisms in the release area. Muds released in deeper water or near the water's surface would be spread over a greater area in a thinner layer and may not result in high mortality, although impacts to water column invertebrates may be greater under this scenario. The disturbance would be short in duration, with repopulation of the affected area occurring by larval recruitment. In addition, drilling discharges must comply with NPDES permit requirements regarding the discharge amount, rate, and toxicity, which would greatly reduce the impact to invertebrate communities.

Production. Production activities that could affect invertebrates in Cook Inlet include operational noise, bottom disturbance from anchors and the release of process water. In addition, the platform would replace existing featureless soft sediments and serve as an artificial reef (Table 4.4.7-9).

Chronic disturbance to benthic invertebrates would result from the movement of pipelines and anchors and chains associated with support vessels. Pipelines not buried would be anchored in place which would minimize their movement and potential to disturb benthic invertebrate communities. Bottom disturbance would impact invertebrates in a manner similar that described above for the exploration and site development phase. The disturbance would be episodic and temporary, but would last for the lifetime of the platform.

Produced water contains metals, hydrocarbons, salts, and radionuclides, and their discharge could contaminate habitat resulting in lethal and sublethal effects on invertebrates, particularly non-mobile benthic infauna. However, NPDES permitting requirements regarding discharge rate, contaminant concentration, and toxicity would greatly reduce the potential for impacts to invertebrates. In addition, it is assumed that all produced water would be disposed of by injection into permitted disposal wells. Therefore, the effects of produced water discharges on invertebrates are expected to be minimal.

Platforms would add a hard substrate to the marine environment, providing additional habitat for marine plants and animals (e.g., kelp and mussels) that require a hard substrate. The platform would likely increase shell material and organic matter in the sediments surrounding the platform, potentially resulting in a shift in benthic invertebrate community composition.

A two-year (1997–1998) study of contaminant levels in the sediments of the Shelikof Strait and Cook Inlet provide information on the overall, long-term potential effects of oil and gas development in the Cook Inlet Planning Area (MMS 2001a). Samples of sediment from depositional areas (where sediment contamination is expected to be greatest) suggested that metals and PAHs in sediments derived primarily from natural sources rather than past oil and gas developments (MMS 2001a). In addition, sediment concentrations of metals and organic contaminants in outermost Cook Inlet and Shelikof Strait (1) have not increased significantly since offshore oil exploration and production began in Cook Inlet (circa 1963) and (2) posed low risk to benthic biota or fish (MMS 2001a).

***Decommissioning*.** No explosive platform removals are anticipated under the proposed action. Nonexplosive removals (e.g., abrasive, mechanical, or diver cutters) would have no long-term impacts to invertebrates, although individuals associated with the platform would experience, injury, mortality, or loss of habitat. Most sediments will recover their normal physical characteristics, ecological functions, and biological communities. Pipelines installed and anchored on the seafloor would be capped and left in place, although there is the potential for chronic sediment disturbance from pipeline movement. If fixed platforms are left in place, the changes to invertebrate communities resulting from the initial platform installation would be long-term.

Impacts of Expected Accidental Events and Spills. It is assumed that 1 to 3 small spills between 50 and 999 bbl, 7 to 15 smaller spills between 1 and <50 bbl, and 1 large spill (≥1,000 bbl) could occur under the proposed action (Table 4.4.2-1). Most oil and gas spills would be small and are expected to primarily affect invertebrates in the water column, as most hydrocarbons would float above the sediment surface. It is anticipated that only a small amount of the water column and shoreline would be affected by these smaller oil spills and would not, therefore, present a substantial risk to invertebrate populations. Consequently, the effects of small spills on invertebrates and their habitat are expected to be short-term and affect relatively few individuals.

Larger areas and numbers of individuals may be affected by large spills (>1,000 bbl). Exposure to hydrocarbons can result in lethal or sublethal (reproduction, recruitment, physiology, growth, development, and behavior) impacts at the level of the individual. The invertebrates most likely to be affected are sessile benthic organisms and small zooplankton, which lack the mobility to avoid the oil. Invertebrates differ in their sensitivity to hydrocarbon pollution both by organism class and life stage (Laws 1993). For example, crustaceans appear to be among the taxa most sensitive to oil pollution, while certain species of worms, such as Capitellid polychates, appear to be tolerant of oil pollution (Laws 1993; NRC 2003b). Among meiofauna, nematodes may be less sensitive to oil than copepods. Oil exposure can reduce the abundance of zooplankton in the oiled area, induce narcosis, and bind to feeding appendages (Teal and Howarth 1984). Zooplankton are also known to ingest oil, some of which is retained in the gut and some of which is exported to the seafloor in fecal pellets (Teal and Howarth 1984). Impacts from large spills would be greatest if the spill occurred during a reproductive period or contacted a location important for spawning or growth such as intertidal and nearshore subtidal habitats. However, impacts from large spills are expected to be temporary as oil is diluted and broken down by natural chemical and microbial processes.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes a CDE in the Cook Inlet Planning Area with a volume of 75-125 thousand bbl and a duration of 50–80 days (Table 4.4.2-2). Because the Cook Inlet Planning Area is located within a relatively confined estuary, the likelihood of oil from a catastrophic spill contacting part of the shoreline is relatively high. Site-specific evaluations would have to be conducted to fully evaluate potential spill trajectories from future lease sales. Benthic invertebrates in intertidal and shallow subtidal areas are likely to be contacted by an oil spill. In addition, some oil spill-response activities could adversely affect invertebrates. For example, dispersants could increase oil toxicity, and cleanup techniques, the presence of large numbers of people, or the use of heavy equipment on shorelines could kill some coastal organisms during cleanup responses. Dispersant toxicity varies by species and dispersant used. Newer dispersant formulations, such as COREXIT® 2500, do not appear to be more toxic to invertebrates than oil alone (Hemmer et al. 2011). However, few species and life stages have been tested; additive toxicity from oil dispersant mixtures may be significant for some species (Hemmer et al. 2011). In addition, studies of microbial communities from oiled beaches in Louisiana indicated that the dispersant COREXIT can alter bacterial composition by reducing the abundance of *Marinobacter* spp. and *Acinetobacter* spp., both hydrocarbon-degrading bacteria, and increasing the relative abundance of *Vibro* spp., a nonhydrocarbon-degrading bacteria (Hamdan and Fulmer 2011). These results indicate that dispersants may inhibit biodegradation of oil.

Benthic and pelagic invertebrates are important trophic links connecting primary producers to higher-trophic-level organisms. Consequently, oil spill contamination on a large scale could result in significant contaminant transfer to higher trophic levels and/or reduce food availability to higher trophic levels if invertebrate populations were severely depressed by a CDE. The toxicity of released hydrocarbons would probably decrease rapidly because of evaporation, dispersion, and dilution. Thus, it is concluded that planktonic invertebrates within the area of lethal hydrocarbon concentration could be killed during the first few days of a hydrocarbon spill; after that, the primary effects would be sublethal responses such as reduction in their growth or reproductive rates. Reproduction of copepods is tied to temperature and food availability and is therefore highly seasonal. Oil spills occurring during these reproductive periods could contaminate or reduce the abundance of a critical food source for higher trophic levels. Large-scale changes in overall plankton populations in Cook Inlet are considered unlikely. However, intertidal invertebrates could experience long-term exposures, as oil could persist in intertidal sediments for decades. Thus invertebrate populations could be depressed for a decade or more (Highsmith et al. 2001; Exxon Valdez Oil Spill Trustee Council 2009a).

Studies following the *Exxon Valdez* spill give insight into the impacts of a catastrophic oil spill on invertebrate communities and their subsequent recovery. Amphipods, sea stars, and certain crabs were less abundant in oiled sites compared to areas not affected by the spill (*Exxon Valdez* Oil Spill Trustee Council 2010a). Studies of mussels indicated hydrocarbons accumulated in their tissue in the decade after the spill at sites where oil did not break down. However, by 1999, contaminant levels in mussels from the most heavily oiled beds in Prince William Sound were similar to background levels even though sediment contamination was still present (*Exxon Valdez* Oil Spill Trustee Council 2010a). Stress-tolerant invertebrates like polychaetes and snails did not appear to suffer long-term population declines in oiled areas. As late as 2002, studies of clams indicated differences in population structure between areas affected by the spill and clean areas (*Exxon Valdez* Oil Spill Trustee Council 2010a). However, much of the long-term reduction in clam densities may have been due to the high-pressure beach washing that occurred after the spill (*Exxon Valdez* Oil Spill Trustee Council 2009a). In intertidal areas, the *Exxon Valdez* spill created large density fluctuations in kelp communities that serve as habitat for benthic invertebrates. Intertidal experimental studies have demonstrated that rocky intertidal communities are particularly slow to recover (+10 years) following disturbance (Highsmith et al. 2001). As of 2009, clams, mussels, and intertidal communities are still listed as recovering (*Exxon Valdez* Oil Spill Trustee Council 2009a).

Impact Conclusions.

Routine Operations. The primary impacts of oil and gas activities on invertebrates in the Cook Inlet Planning Area would be from drilling waste discharges and from bottom-disturbing activities during the exploration and site development phase, which could displace, bury, injure, or kill invertebrates in the vicinity of the activities. Displaced invertebrate communities would generally repopulate the area over a short period of time, although a return to the pre-disturbance community may take longer. If discharged into open water, the effects of drilling wastes and invertebrates community structure and function should be restricted to the vicinity of the platform. Overall impacts to benthic and pelagic invertebrates from routine program activities (exploration and site development, production, and decommissioning phases) would range from negligible to moderate, with the severity of the impacts generally decreasing dramatically with distance from the disturbance.

Expected Accidental Events and Spills. Small surface or subsurface hydrocarbon spills would be rapidly diluted and would likely result in only small localized, sublethal impacts to invertebrates. Large spills could affect a large number of benthic and pelagic invertebrates and their habitats. The location of the spill and the season in which the spill occurred would be important determinants of the impact magnitude. A large spill could contact shoreline areas, and benthic invertebrates in sensitive intertidal and shallow subtidal habitats could experience large-scale lethal and long-term sublethal effects. Overall, impacts from small spills would range from negligible for spill less than 50 bbl, minor for spills up to 1,000 bbl, and from minor to moderate for large spills (≥1,000 bbl).

An Unexpected Catastrophic Discharge Event. A CDE could affect a large area, with the magnitude of the impacts depending on factors such as the location, timing, and volume of spills, and distribution and ecology of affected invertebrate species. A CDE would likely contact shoreline areas, and benthic invertebrates in sensitive intertidal and shallow subtidal habitats could experience large-scale lethal and long-term sublethal effects. Local populations of intertidal organisms affected by such large spills could be measurably depressed for several years and oil could persist in shoreline sediments for decades. However, a CDE is not expected to occur and invertebrates typically have short generation times and should recover. Overall, impacts to invertebrates from a CDE could range up to moderate.

4.4.7.5.3 Alaska – Arctic. Impacting factors common to all phases include vessel discharges (bilge and ballast water), miscellaneous discharges (deck washing, sanitary waste), and offshore lighting. Impacts from these activities would be localized and temporary and would range from short-term to long-term. These discharges are expected to have minimal impacts on invertebrate communities in the sediment and water column because many of these waste streams are disposed of on land or must meet USEPA and/or USCG regulatory requirements before being discharged into surface waters. Studies of platform lighting suggest the lights would alter predator-prey dynamics by enhancing phytoplankton productivity around the platform, attracting phototaxic invertebrates, and potentially improving the visual foraging environment for fishes (Keenan et al. 2007).

Impacts of Routine Operations.

Exploration and Site Development. During the OCS oil and gas exploration and development phase, invertebrates could be affected by noise from seismic surveys and noise and bottom disturbance from drilling, subsea well, gravel island, and platform placement, and pipeline trenching and placement activities. See Section 4.4.7.5.2 for a complete discussion of the effects of exploration and site development activities on invertebrates.

Noise from seismic surveys and drilling could kill or injure invertebrates close enough to the noise source and reduce habitat suitability as some species would avoid the area. Noise is expected to have minimal effects on invertebrate populations in the overall Beaufort and Chukchi Planning Areas (see Section 4.4.7.5.2).

Bottom-disturbing activities such as drilling, subsea well and platform placement, and pipeline trenching and placement would displace, injure, or kill invertebrates in the vicinity of the activities, as described in Section 4.4.7.5.2. In addition to burying and displacing benthic communities, the construction of artificial islands would alter sediment composition and shift benthic invertebrate communities to species adapted to coarse gravel substrate. Platform and pipeline placements in the Beaufort and Chukchi Planning Areas would disturb 3 to 13.5 ha (7 to 33 ac) and 77 to 567 ha (190 to 1,401 ac) of bottom habitat, respectively. Pipelines would be installed and anchored on the surface or buried in waters less than 50 m (156 ft) to prevent damage from ice gouges. Pipelines could crush, injure, or displace invertebrates, as well as shift invertebrate community composition to those species preferring hard substrate. Benthic habitats such as the Steffanson Boulder Patch and kelp beds would be protected by stipulations that require surveys for and avoidance of sensitive biological habitat. Although pipeline and platform placement would disturb a large area of the seafloor, it is not expected to have a measurable effect on regional populations. The benthic community in these areas experiences similar naturally occurring disturbances from ice gouging, strudel scour, and severe storms. In the Arctic, recolonization by benthic invertebrates can be slow to begin, and the benthic community may take several years to return to its pre-disturbance composition following bottom-disturbance activities (Conlan and Kvitek 2005).

The discharge of drilling muds and cuttings from exploration wells could adversely affect pelagic and benthic invertebrates (Section 4.4.7.5.2). However, drilling discharges must comply with NPDES permit requirements regarding the discharge amount, rate, and toxicity, which would greatly reduce the impact to invertebrate communities.

Production. Production activities that could affect invertebrates include operational noise, bottom disturbance from the movement of mooring anchors, chains, and cables, and the release of process water. In addition, the platform and gravel islands would replace existing featureless soft sediments and serve as artificial reefs (Table 4.4.7-10).

Chronic disturbance to benthic invertebrates would result from the movement of anchors and chains associated with support vessels. Bottom disturbance would impact invertebrates in a manner similar to that described above for the exploration and site development phase. The disturbance would be episodic and temporary, but would last for the lifetime of the platform.

Produced water contains metals, hydrocarbons, salts, and radionuclides, and its discharge could contaminate habitat resulting in lethal and sublethal effects on invertebrates, particularly nonmobile benthic infauna. However, it is assumed that produced water would be reinjected into the well rather than discharged into the ocean. In addition, produced water discharges must comply with NPDES permit requirements regarding the discharge amount, rate, and toxicity, which would greatly reduce the impact to invertebrate communities (Section 4.4.7.5.2).

The presence of platforms or artificial islands would favor invertebrates requiring or preferring hard substrates, thus shifting community composition in some areas. The platform would likely increase shell material and organic matter in the sediments surrounding the platform, potentially resulting in a shift in benthic invertebrate community composition.

The results of the study Arctic Nearshore Impacts Monitoring in the Development Area funded by BOEM provide a good summary of the long-term changes to benthic communities resulting from oil and gas development in the Arctic. Boehm (2001) determined that

TABLE 4.4.7-10 Impacting Factors Potentially Affecting Invertebrates and Their Habitat in the Beaufort and Chukchi Planning Areas

	Life Stage Affected[a]		
Development Phase and Impacting Factor	Eggs	Larvae	Adults
Impacting Factors Common to All Phases			
Vessel noise	X	X	X
Vessel traffic	X	X	X
Hazardous materials	X	X	X
Solid wastes	X	X	X
Offshore lighting	X	X	X
Aircraft noise			
Offshore air emissions			
Onshore air emissions			
Aircraft traffic			
Miscellaneous platform discharges	X	X	X
Vessel discharges	X	X	X
Bottom disturbance from vessel anchors	X	X	X
Exploration and Development			
Seismic noise	X	X	X
Noise from drilling and construction	X	X	X
Bottom disturbance from drilling and placement of platforms, subsea wells, artificial islands, and pipelines	X	X	X
Discharge of drilling muds and cuttings	X	X	X
Production			
Production noise	X	X	X
Produced water discharge	X	X	X
Artificial reef	X	X	X
Decommissioning			
Platform removal (nonexplosive)	X	X	X

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

hydrocarbons in sediments (largely attributable to natural sources) were not readily bioavailable to marine filter feeders and deposit-feeders, and concluded that small incremental contaminant additions from future development activities are unlikely to cause immediate ecological harm to organisms in the Beaufort Sea study area. After reviewing tissue samples between 2000 and 2006, hydrocarbon and metals concentrations in invertebrates sampled near the Northstar development and Liberty Prospect area were found to be similar to or lower than invertebrate tissue levels found elsewhere in the world (Neff & Associates, LLC 2010). No increase in hydrocarbons and metals in marine invertebrate tissues was attributable to oil and gas production, even for benthic infauna such as amphipods and clams. Concentrations of metals and hydrocarbons in benthic invertebrates collected in the Boulder Patch were similar to concentrations in invertebrates collected elsewhere in the development area.

Decommissioning. No explosive platform removals are anticipated under the proposed action. Nonexplosive removals (e.g., abrasive, mechanical, or diver cutters) would have no long-term impacts on invertebrates, although individuals associated with the platform would experience injury, mortality, and loss of habitat. Pipelines installed and anchored on the seafloor would be capped and left in place, although there is the potential for chronic sediment disturbance from pipeline movement. The changes to invertebrate communities resulting from the construction of artificial gravel islands would be long-term.

Impacts of Expected Accidental Events and Spills. It is assumed that large spills (≥1,000 bbl), up to 35 small spills (50 to 999 bbl), and up to 190 smaller spills (>1 and <50 bbl) could occur during the lease period under the proposed action (Table 4.4.2-2). Hydrocarbons can cause both lethal and sublethal effects to marine invertebrates. Sublethal effects occur at lower concentrations and include reduced growth and/or fecundity, increased physiological stress, and behavioral changes that may reduce fitness and population size. Most accidental releases would be small, and any impacts would be sublethal except in the immediate vicinity of the spill where lethal concentrations of oil may be present. However, it is anticipated that only a small amount of shoreline would be affected by these smaller oil spills and would not, therefore, present a substantial risk to invertebrate populations. Hydrocarbons released during small spills would be diluted and broken down by natural processes. Consequently, the effects of small spills on invertebrates and their habitat are expected to be short-term and affect relatively few individuals.

Larger areas and numbers of individuals may be affected by large spills (>1,000 bbl). Accidental hydrocarbon releases can occur at the water's surface or at the seafloor, potentially affecting both pelagic and benthic invertebrates. Following an accidental hydrocarbon release, most oil and gas would float above the seafloor, so direct contact with benthic communities in deeper water should be relatively low, while higher exposures would be expected for zooplankton, which lack the mobility to avoid the oil. Oil exposure can reduce the abundance of zooplankton in the oiled area, induce narcosis, and bind to feeding appendages (Teal and Howarth 1984). Zooplankton are known to ingest oil, some of which is retained in the gut and some of which is exported to the seafloor in fecal pellets (Teal and Howarth 1984). The impact magnitude of large oil spills on invertebrates is primarily a function of the invertebrate species and habitat affected. Impacts from spills would be greatest if a large spill occurred during a reproductive period or contacted a location important for spawning or growth such as intertidal and nearshore subtidal habitats. Impacts from large spills are expected to be temporary as oil is diluted and broken down by natural chemical and microbial processes.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes a CDE in the Chukchi Sea Planning Area with a volume of 1.4-2.2 million bbl and a duration of 40–75 days, and a CDE in the Beaufort Sea Planning Area with a volume of 1.7-3.9 million bbl and a duration of 60–300 days (Table 4.4.2-2). A CDE could contaminate sediments and the water column for some distance around the leak or rupture. Benthic and pelagic invertebrates are important trophic links connecting primary producers to higher-trophic-level organisms.

Consequently, oil spill contamination on a large scale could result in contaminant transfer to higher trophic levels and/or reduce food availability to higher trophic levels if invertebrate populations were severely depressed by a CDE. Reproduction of copepods is tied to temperature and food availability and is therefore highly seasonal. Thus, a CDE occurring during these reproductive periods could contaminate or reduce the abundance of a critical food source for higher trophic levels. Similarly, catastrophic oil spills could affect euphausiids, which are seasonally abundant in the Beaufort Sea and Chukchi Sea (Berline et al. 2008). Euphausiids are a primary food source for migrating baleen whales. These examples suggest that catastrophic oil spills could result in population-level impacts or contamination of invertebrates, which may, in turn, impact higher trophic levels.

If large quantities of oil from a catastrophic oil spill were to reach intertidal sediments or shallow subtidal sediment, benthic invertebrates in the affected areas could experience high levels of contamination and mortality, and, given the slow rate of oil breakdown in the Arctic, benthic invertebrate populations could be depressed for many years. In addition, some oil spill-response activities could adversely affect invertebrates. For example, dispersants could increase oil toxicity, and cleanup techniques, the presence of large numbers of people, or the use of heavy equipment on shorelines could kill some coastal organisms during cleanup responses. Dispersant toxicity varies by species and dispersant used, although newer dispersant formulations, such as COREXIT 2500, do not appear to be more toxic to invertebrates than oil alone (Hemmer et al. 2011). However, few species and life stages have been tested; additive toxicity from oil dispersant mixtures may be significant for some species (Hemmer et al. 2011). See Section 4.4.7.5.2 for a detailed discussion of oil spills on invertebrates following the catastrophic *Exxon Valdez* spill.

Hydrocarbon releases contacting the hard-bottom kelp communities could have direct impacts on invertebrates inhabiting the area. The magnitude of impacts to the Boulder Patch would depend on the location and severity of the spill. Studies show that the Boulder Patch communities are slow to recolonize (Konar 2007 and references therein). Kelp associated benthic animal communities have also been shown to have major shifts in species composition following exposure to oil (Dean and Jewett 2001). Impacts to kelp habitat from an oil spill could be long-term. *Laminaria* beds oiled by the *Exxon Valdez* spill recovered within 10 years (Dean and Jewett 2001). Planning and permitting procedures requiring no impacts to sensitive biological communities will also minimize spill impacts to the Boulder Patch area.

Oil from a CDE occurring under ice is more difficult to locate and clean than surface spills. Since weathering would be greatly reduced by ice cover, pelagic invertebrates could continue to be harmed or killed as they drift into the trapped oil. In addition, invertebrates living beneath the ice are a crucial food source in the Arctic food web that could be degraded or lost by contact with oil spills. Arctic cod are particularly dependent on sea ice invertebrates.

Impact Conclusions.

Routine Operations. The primary impacts of oil and gas activities on invertebrates in the Arctic planning areas would be from drilling waste discharges and from bottom-disturbing activities during the exploration and site development phase, which could displace, bury, injure, or kill invertebrates in the vicinity of the activities. Bottom-disturbing activities would be temporary and recovery could be short-term to long-term. Displaced invertebrate communities would generally repopulate the area over a short period of time, although a return to the pre-disturbance community may take longer, particularly in the Arctic. If discharged into open water, the effects of drilling wastes on invertebrates community structure and function should be restricted to the vicinity of the platform. Overall impacts to invertebrates from routine program activities (exploration and site development, production, and decommissioning phases) would range from negligible to moderate, with the severity of the impacts generally decreasing dramatically with distance from bottom-disturbing activities.

Expected Accidental Events and Spills. Small surface or subsurface hydrocarbon spills would be rapidly diluted and would likely result in only small localized, sublethal impacts to invertebrates. Large spills could affect a large number of benthic and pelagic invertebrates and their habitats. The location of the spill and the season in which the spill occurred would be important determinants of the impact magnitude of the spills. A large spill could contact shoreline areas, and benthic invertebrates in sensitive intertidal and shallow subtidal habitats could experience large-scale lethal and long-term sublethal effects. Overall, impacts from small spills would range from negligible for spills less than 50 bbl, minor for spills up to 1,000 bbl, and from minor to moderate for large spills (≥1,000 bbl).

An Unexpected Catastrophic Discharge Event. A CDE would likely contact shoreline areas, and benthic invertebrates in sensitive intertidal and shallow subtidal habitats could experience large-scale lethal and long-term sublethal effects. In Alaska, local populations of intertidal organisms affected by such large spills could be measurably depressed for several years and oil could persist in shoreline sediments for decades. However, a CDE is unlikely to occur, and benthic and pelagic invertebrates typically have short generation times and should recover. Invertebrates associated with hard-bottom kelp communities could also be affected and, if so, recovery of the community could be long-term. Oil from a CDE occurring under ice is more difficult to locate and clean than surface spills and may have more persistent effects on water column and sea ice-associated invertebrates. Overall, impacts to invertebrates from a CDE could range up to moderate.

4.4.8 Potential Impacts to Areas of Special Concern

4.4.8.1 Gulf of Mexico

Impacts of Routine Operations.

Marine Protected Areas (MPAs). National System MPAs in the Western and Central Planning Areas consist of the FGBNMS, Jean Lafitte National Historical Park and Preserve, Barataria Preserve, and a number of National Wildlife Refuges (NWRs) (Table 3.9.1-1). MPAs would primarily be affected by pipeline landfalls and potentially by accidental oil spills occurring nearshore as well as large offshore oil spills. Impacts on the FGBNMS and NWRs are described below. *De facto* MPAs are primarily military use areas and are also discussed below.

National Marine Sanctuaries of Texas and Louisiana in the Western Gulf of Mexico Planning Area (Figure 3.9.1-1). Potential impacts on the FGBNMS resulting from site exploration and development activities are discussed in detail in (Section 4.4.6.2.1). Direct impacts on the FGBNMS from bottom disturbance would be prevented by the Topographic Features Stipulation, which prohibits exploration and development activities and the deposition of drilling muds and cuttings in the vicinity of the FGBNMS. During the production phase, produced water discharges are not likely to impact the FGBNMS because of the Topographic Features Stipulation requiring large buffers between the FGBNMS and oil and gas development activities (Section 4.4.6.2.1).

New oil and gas production platforms could act as artificial reef habitat and potentially act as stepping stones allowing the establishment of invasive species in the FGBNMS (Section 4.4.6.2.1). However, there is no conclusive evidence this has occurred historically, and it is more likely that invasive species would establish at the FGBNMS even without the platforms, although the platforms may speed the process.

***National Parks, National Seashores, Reserves, and Refuges*.** See Section 4.4.6.1.1 for a discussion of the potential impacts of the Program on coastal habitats. It is assumed that pipeline landfalls, shore bases, and waste facilities would not be located in National Parks, NWR, or National Estuarine Research Reserves because of their special status and protections. Consequently, impacts to these areas from oil and gas exploration and production activities are not expected to occur.

It is possible that shore bases and waste facilities may be located in one or more estuaries in the Western or Central GOM Planning Area. It is assumed that new shore bases and waste facilities would be constructed in existing developed or upland areas and would not be sited in coastal habitats such as barrier beaches or wetlands. Therefore, impacts on parks, seashores, refuges, and reserves are not likely to occur.

Trash and debris from various sources, including OCS operations, frequently wash up on beaches, which could affect Gulf Shores or Padre Island National Seashore. The discharge or disposal of solid debris from OCS structures and vessels is prohibited, and assuming that operators comply with regulations, most potential impacts would be avoided, although some accidental loss of materials is inevitable.

NPS lands, wildlife refuges, and research reserves could potentially be affected by increased boat and aircraft traffic associated with OCS oil and gas activities. Existing mitigation measures limit vessel speeds in inland waterways and aircraft altitudes over Areas of Special Concern. With these measures in place, most impacts on these Areas of Special Concern due to vessel and aircraft traffic would be avoided.

***Military Uses*.** The Military Areas Stipulation applies to all blocks leased in military areas and requires lessees to coordinate their activities with the relevant military authorities and also states that the U.S. Government is not responsible for any accidents involving military operations. The Military Areas Stipulation reduces use conflicts and improves safety but does not reduce or eliminate the actual physical presence of oil and gas operations. Accidents and use conflicts involving oil and gas and military operations would be minimized or eliminated by adherence to the Military Areas Stipulation. Currently, both activities coexist in the GOM, and there has never been an accident involving the military and oil and gas lessees.

Impacts of Expected Accidental Events and Spills. It is assumed that up to 8 large spills (between 1,700 and 5,300 bbl), up to 70 spills between 50 and 999 bbl, and up to 400 smaller spills between 1 and 50 bbl could occur during the lease period under the proposed action. Small spills at the seafloor would rise in the water column but are not likely to contact the FGBNMS at concentrations toxic to marine life (see Section 4.4.6.2.1). Small platform spills and tanker spills at the ocean surface could penetrate the water column to documented depths of 20 m (66 ft) or more, which is within the depth range of the crests of some coral reefs and topographic features including the FGBNMS. However, at these depths, the contaminant concentrations are typically several orders of magnitude lower than those demonstrated to have an effect on marine organisms (MMS 2008a). Therefore, it is likely that only small concentrations of oil from surface spills would reach the FGBNMS (MMS 2008a).

An oil spill reaching sensitive coastal habitats could impact National Parks, NWRs, National Estuarine Research Reserves, or National Estuary Program sites. Impacts could result from both oiling of the shoreline and mechanical damage during the cleanup process. Small or large spills (>1,000 bbl) would be diluted and degraded by natural processes and, given the small size of most spills, impacts to a significant area of the shoreline are unlikely.

Impacts of an Unexpected Catastrophic Discharge Event. This PEIS analyzes a CDE in the GOM planning areas with a volume of 0.9-7.2 million bbl and a duration of 30–90 days. It is possible that such a spill originating from outside the No Activity Zones established by the Topographic Features Stipulations could reach the vicinity of the FGBNMS. However, because of the tendency for oil components to rise toward the surface and to be diluted as they are transported by water currents, any impacts associated with a CDE reaching sensitive corals would most likely be sublethal. Hydrocarbons have been shown to have lethal and sublethal (reproduction, larval settlement, photosynthesis, and feeding) effects on corals, although no effects on corals following oil spills are also frequently reported (Loya and Rinkevich 1980; Bak 1987; Guzman et al. 1991; Dodge et al. 1995; Haapkyla et al. 2007). Corals have the capacity to recover quickly from hydrocarbon exposure. For example, Knap et al. (1985) found that when *Diploria strigosa*, a common massive brain coral at the Flower Garden Banks, was dosed with oil, it rapidly exhibited sublethal effects but also recovered quickly. However, larval stages of coral are far more sensitive than adults. Therefore, the impact magnitude of a spill is partly dependent on whether the spill occurs during a period of coral spawning. For lethal exposures, the community would likely recover once the area had been cleared of oil, although full recovery could take many years (Haapkvla et al. 2007). Consequently, it is anticipated that impacts of lethal concentrations of oil reaching coral reef or hard-bottom habitat would be long-term but temporary.

A CDE taking place near shore or in deeper water could affect coastal parks, reserves, and refuges if the oil was transported to these areas by currents. Impacts on parks, preserves, and refuges would depend on the size and specific location of the oil spill and the effectiveness of cleanup procedures. If a large volume of heavy oil were to reach these areas, that situation could result in park closure and reduced visitation. In general, oil spills affecting parks, refuges, and reserves would diminish their function by reducing habitat value for wildlife and aquatic biota and interrupting monitoring and research activities.

The impacts of oil spills on parks, preserves, and refuges could include death of wetland vegetation and associated wildlife, oil saturation and trapping by vegetation and sediments (thus causing it to become a chronic source of pollution), and mechanical destruction of the wetland area during cleanup. Spills that damage wetland vegetation protecting canal and waterway banks could accelerate erosion of those banks (see Section 4.4.6.1.1). Some areas may recover completely if proper remedial action was taken. Others may not recover completely. Oil could remain in some coastal substrates for decades, depending on the type of oil spilled, the amount present, sand grain size, the degree of penetration into the subsurface, the exposure to the weathering action of waves, and sand movement onto and off the shore. See Section 4.4.6.1.1 for a discussion of the potential impacts of oil spills on coastal habitats.

Impact Conclusions.

Routine Operations**.** Overall, impacts on Areas of Special Concern resulting from routine Program activities would be minimized by existing protections and use restrictions applicable to these areas. Routine operations are not expected to conflict with military uses. However, increased vessel and aircraft traffic and the construction of pipelines and platforms could have temporary and localized effects on wildlife and reduce the scenic value of National Parks and NWRs for some visitors. Overall, impacts on Areas of Special Concern resulting from routine Program activities are expected to be negligible to moderate.

Expected Accidental Events and Spills**.** While most accidental spills would be small and would have relatively small impacts on Areas of Special Concern, large spills that reach coastal National Parks and NWRs could have more persistent impacts and could require remediation. Impacts from large spills could result from both oiling of the shoreline and mechanical damage during the cleanup process. Overall, impacts to Areas of Special Concern from small spills would range from negligible for spill less than 50 bbl, minor for spills up to 1,000 bbl, and from minor to moderate for large spills (≥1,000 bbl).

An Unexpected Catastrophic Discharge Event**.** The impacts from a CDE would depend on the location and size of the spill, the type of product spilled, weather conditions, the type of area affected, the effectiveness of cleanup operations, and other environmental conditions at the time of the spill. Although unlikely, if oil from a CDE were to reach an Area of Special Concern, coastal habitats and fauna as well as subsistence use, commercial or recreational fisheries, and tourism could be negatively affected. Overall, a CDE could result in up to moderate effects on Areas of Special Concern.

4.4.8.2 Alaska – Cook Inlet

Impacts of Routine Operations.

***Marine Protected Areas (MPAs)*.** The Alaska Peninsula unit and Gulf of Alaska unit of the Alaska Maritime NWR are the only Federal MPAs in the vicinity of the Cook Inlet Planning Area. NWRs could primarily be affected by pipeline landfalls and potentially by accidental oil spills, as described below.

***National Parks, National Forests, National Seashores, Reserves, and Refuges*.** Impacts on National Parks, Forests, Reserves, and Refuges could result from facilities developed to support offshore oil drilling and production, and could include effects from pipeline landfall; dredging and construction; and the construction of roads, processing and waste facilities, and onshore pipelines. In addition, subsistence hunting and fishing, which are permitted on all refuges in Alaska, could be affected by oil and gas operations. It is assumed that pipeline landfalls, shore bases, and waste facilities would not be located in National Parks, National Forests, NWRs, or National Estuarine Research Reserves because of the special status and protections afforded these areas. See Section 4.4.6.1.2 for a discussion of the potential impacts of OCS oil and gas activities on coastal habitats.

National Park Service (NPS) lands are potentially susceptible to impacts from activities related to OCS oil and gas development as a consequence of the Program in Cook Inlet. The potentially affected lands include the Lake Clark National Park and Preserve, the Katmai National Park and Preserve, and Aniachak National Monument. Kenai Fjords National Park is east of Cook Inlet on the GOA, but it could be affected by an oil spill associated with OCS activities in Cook Inlet.

Impacts from routine OCS operations could come from facilities developed to support oil drilling and production, and could include effects from pipeline landfalls, dredging, air pollution, and the construction of roads and new facilities. Onshore oil facilities are permissible only on private acreage within each national park land. All of these national parks, monuments, and preserves contain privately held acreage, and development of onshore oil support facilities is possible in these areas. Because of the more confined nature of Cook Inlet, OCS construction of facilities within the Cook Inlet Planning Area could have some negative effects on scenic values for some users of the Lake Clark and Katmai National Parks and Preserves, if the facilities were visible from shore or the air during flightseeing.

Noise and vessel traffic associated with construction activities in offshore areas adjacent to park and refuge boundaries could temporarily disturb some wildlife and could negatively affect recreational values for park users. It is anticipated that noise generated by offshore construction activities would be at low levels, intermittent, and would not occur for more than a few months. Scenic values for some park users could be negatively affected in the long term by the presence of platforms visible from park areas.

National Wildlife Refuges (NWRs) in the vicinity of Cook Inlet are identified in Section 3.9.2.2. NWRs potentially affected by OCS activities in the Cook Inlet Planning Area include the Alaska Peninsula NWR, Becharof NWR, Kodiak NWR, Kenai NWR, and Izembek NWR. Section 22(g) of the Alaska Native Claims Settlement Act of 1971 (ANCSA) requires that new development on National Wildlife Refuge lands must be in accordance with the purpose for which the refuge was formed. Therefore, although development of onshore oil and gas support facilities is technically possible, such projects would be subject to intensive review. The potential effects of routine operations and accidental events on these NWRs are essentially the same as those discussed above for the NPS lands. Noise and vessel traffic associated with construction activities in offshore areas adjacent to park and refuge boundaries could temporarily disturb some wildlife and could negatively affect recreational values for park users. It is anticipated that noise generated by offshore construction activities would be at low levels, intermittent, and would not occur for more than a few months. Scenic values for some park users could be negatively affected in the long term by the presence of platforms visible from park areas. In addition, subsistence hunting and fishing are permitted on all refuges in Alaska and could, therefore, be affected by accidents and routine operations in the immediate vicinity of refuge properties.

The only national forest within the vicinity of the Cook Inlet Planning Area is the Chugach National Forest, which is located mainly on the eastern side of the Kenai Peninsula and portions of Turnagain Arm (Figure 3.9.2-1). Because there would be no OCS-related development, such as pipelines or other onshore facilities, within the Chugach National Forest, it would not be affected by routine OCS activities associated with lease sales in the Cook Inlet Planning Area. The Chugach National Forest also borders Prince William Sound and is close to Valdez. The Chugach National Forest is, therefore, potentially susceptible to effects of routine oil-related operations from transport and tanker loading of oil produced (OCS and non-OCS) in other regions (e.g., the Beaufort Sea Planning Area) and transported by pipeline to the Port of Valdez. Potential effects include increased noise and air pollution from tanker traffic.

Other Areas of Special Concern. There are multiple State parks, refuges, sanctuaries, critical habitat areas, and recreation areas near the Cook Inlet Planning Area, many of which border Cook Inlet or are located in areas that could be contacted by accidental oil spills. Such areas include Captain Cook State Recreation Area, Clam Gulch State Recreation Area, Chugach State Park, Kachemak Bay State Park and State Wilderness Park, and Ninilchik State Recreation Area. In addition, the Kachemak Bay National Estuarine Research Reserve is located in Cook Inlet on the southern end of the Kenai Peninsula. Impacts from OCS activities would be similar to those described above for National Parks and Refuges. Existing protections and restrictions on uses should limit the direct terrestrial impacts from OCS activities on these areas. It is assumed that pipeline landfalls, shore bases, and waste facilities would not be located in the State parks and recreation areas. It is anticipated that noise generated by OCS offshore construction activities would be at low levels, intermittent, and would not persist for more than a few months at any one time. It is considered unlikely that these additional activities would noticeably affect wildlife or park user values compared to current (non-OCS) activities within the considered planning areas. There are no Military Use Areas in the Cook Inlet Planning Area; therefore, no conflicts between OCS activities and the military are expected to occur.

Impacts of Expected Accidental Events and Spills. Accidental oil spills could occur from land-based pipelines and facilities, vessels, and offshore platforms and pipelines. It is assumed that 2 small spills between 50 and 999 bbl and 10 smaller spills between 1 and 50 bbl could occur under the proposed action. It is assumed that one large spill between 1,500 and 7,800 bbl could occur in Cook Inlet. Spills on land are not likely to affect National Parks, Refuges, or National Forests because pipelines and other oil and gas infrastructure would not likely be permitted in these areas. However, there are several NWRs and National Parks along the shorelines of the Cook Inlet Planning Area, as well as one National Estuarine Research Reserve, and all could be affected by a large spill. A section of the Chugach National Forest borders Turnagain Arm and could be affected by spills originating in Cook Inlet as well as tanker spills associated with the Port of Valdez. The Lake Clark National Park and Preserve has approximately 50 km (31 mi) of shoreline along Cook Inlet, including shoreline areas in Tuxedni and Chinitna Bays that are considered to contain sensitive habitats. Katmai National Park and Preserve also contains extensive shoreline in proximity to the Cook Inlet Planning Area and the Shelikof Strait, and it is also adjacent to Katmai Bay, which is considered a sensitive resource area. If a large amount of oil were to contact a National Park, visitation would be likely to decrease or be temporarily prohibited. The several NWRs located in and around Cook Inlet, such as the Kodiak NWR and the Alaska Maritime NWR, could also experience a loss of habitat value if they experienced heavy oiling from offshore spills. Site-specific evaluations would be conducted to fully evaluate potential spill trajectories and spill probabilities in a lease sale EIS.

Several State parks, refuges, sanctuaries, critical habitat areas, wildlife ranges, and recreational areas border Cook Inlet and could be affected by accidental releases of oil spilled from onshore facilities and offshore drilling rigs. An oil spill contacting shoreline habitats could affect subsistence harvests in those parks in which recreation and subsistence hunting and fishing are allowed and could affect the number of park visitors. Impacts would depend primarily on the spill location, size, and time of year.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes the impacts of a CDE in the Cook Inlet Planning Area that has a volume of 75-125 thousand bbl and a duration of 50–80 days (Table 4.4.2-2). If a large volume of oil were to reach the shoreline following a catastrophic spill, NWRs could suffer a reduction in their primary function, which is to support wildlife and aquatic biota. Given the cold temperatures in Alaska, oil could contaminate nearshore refuge habitats for several years to decades and result in lethal and long-term sublethal impacts to refuge biota. Impacts would depend primarily on spill location, spill size, and timing of the spill. In general, directly affected coastal fauna would include marine mammals; fishes that reproduce in, inhabit, or migrate through coastal areas; terrestrial mammals that forage on fish; and marsh and seabirds that use these habitats for nesting and/or foraging. Spilled oil could also affect subsistence harvests in those parks in which subsistence hunting and fishing are allowed. See Sections 4.4.6.1.2 and 4.4.6.1.3 for a description of potential impacts of catastrophic oil spills on coastal areas and biota. Oil could contaminate nearshore habitats for several years to decades and result in lethal and long-term sublethal impacts on refuge biota (Short et al. 2007; Taylor and Reimer 2008; *Exxon Valdez* Oil Spill Trustee Council 2010a). The degree of effects and length of recovery depend on a number of factors such as the type of oil, extent of biota exposure, substrate type, degree of sediment contamination, time of year, and species sensitivity (NOAA 1998; Hayse et al. 1992; Hoff 1995). Sheltered intertidal areas are particularly slow to recover. More than 20 years after the *Exxon Valdez* oil spill, intertidal communities were considered to be recovering, but had not yet fully recovered from the effects of the spill (*Exxon Valdez* Oil Spill Trustee Council 2010a).

Impact Conclusions.

***Routine Operations*.** Overall, impacts on Areas of Special Concern resulting from routine Program activities would be minimized by existing protections and use restrictions applicable to these areas. However, increased vessel and aircraft traffic and the construction of pipelines and platforms could have temporary and localized effects on wildlife and reduce the scenic value of National Parks and NWRs for some visitors. Overall, impacts on Areas of Special Concern resulting from routine Program activities are expected to be negligible to moderate.

***Expected Accidental Events and Spills*.** Impacts on Areas of Special Concern from hydrocarbon spills are unlikely because most spills would be small. Large spills that reach coastal National Parks and NWRs could have more persistent impacts and could require remediation. Impacts from large spills could result from both oiling of the shoreline and mechanical damage during the cleanup process. If a large amount of oil were to contact a National Park, visitation would be likely to decrease or be temporarily prohibited and NWRs could also experience a loss of habitat value to fish and wildlife. Overall, impacts to Areas of Special Concern from small spills would range from negligible for spill less than 50 bbl, minor for spills up to 1,000 bbl, and from minor to moderate for large spills (≥ 1,000 bbl).

***An Unexpected Catastrophic Discharge Event*.** The impacts from a CDE would depend on the location and size of the spill, the type of product spilled, weather conditions, the type of area affected, the effectiveness of cleanup operations, and other environmental conditions at the time of the spill. Although a CDE is unlikely, if oil from a CDE were to reach an Area of Special Concern, coastal habitats and fauna as well as subsistence use, commercial or recreational fisheries, and tourism would be negatively affected. Based on monitoring data following the *Exxon Valdez* spill, oil in some coastal habitats would likely persist for multiple years. Overall, a CDE could result in up to moderate effects on Areas of Special Concern.

4.4.8.3 Alaska – Arctic

Impacts of Routine Operations.

***Marine Protected Areas (MPAs)*.** The Arctic National Wildlife Refuge (ANWR) and the Chukchi Sea unit of the Alaska Maritime National Wildlife Refuge are the two Federal system MPAs in or adjacent to the Beaufort and Chukchi Planning Areas, and are described in Section 3.6.5.1. NWRs could primarily be affected by pipeline landfalls and potentially by accidental oil spills, as described below.

***National Forests, Parks and Refuges*.** There are no National Forests in the vicinity of the Beaufort and Chukchi Sea Planning Area; therefore, no impacts on U.S. Forest Service lands are expected. Impacts on NWRs could result from facilities developed to support offshore oil drilling and production, and could include effects from onshore pipelines and pipeline landfalls, dredging and construction, air pollution and the construction of roads, and processing and waste facilities. In addition, subsistence hunting and fishing, which are permitted on all NWRs in Alaska, could be affected by OCS activities. See Section 4.4.6.1.3 for a discussion of the potential impacts of the Program on coastal habitats. Oil facility development currently is prohibited on the ANWR and is discretionary on all other NWRs within Alaska. Although numerous refuge lands have been conveyed to private ownership and Native corporations, Section 22(g) of ANCSA requires that new development on these lands must be in accordance with the purpose for which the refuge was formed. Therefore, development of onshore oil and gas support facilities, though technically possible, would be subject to an exhaustive environmental review process. Therefore, it is currently considered unlikely that onshore oil and gas activities would be developed on refuge lands. Indirect impacts resulting from OCS activities, such as noise pollution or emissions associated with transportation of oil from adjacent planning areas, could occur but would be unlikely to have substantial effects on resources within refuge boundaries.

The Iñupiat Heritage Center, located in Barrow, Alaska, is the only NPS-managed area along the coast of the Beaufort and Chukchi Planning Areas. The area is already urbanized and would not be adversely affected by OCS activities. Although not an NPS land, the National Petroleum Reserve is managed by BLM and has a large shoreline component that borders the Chukchi Sea. Cape Krusenstern National Monument and the Bering Land Bridge National Preserve are south of the Chukchi Planning Area. Although oil transport through the Cape Krusenstern National Monument is permitted under the ANCSA and an existing road is present that could be used to access or create support facilities, such development is considered unlikely under the proposed action. Onshore oil and gas development within the boundaries of the Bering Land Bridge National Preserve is also considered to be unrealistic. Consequently, there are likely to be no effects in either of these National Parks from the proposed action.

Impacts of Expected Accidental Events and Spills. It is assumed that up to 3 large oil spills between 1,700 and 5,100 bbl, up to 35 small spills (50 to 999 bbl) and up to 190 smaller spills (>1 and <50 bbl) could occur during the lease period under the proposed action. Oil spills can occur from offshore drilling platforms, from vessels, or from pipelines located onshore and offshore. OCS infrastructure and activities are not likely to be permitted in NPS lands or in NWRs. Therefore, impacts to these areas from onshore pipeline spills are not likely. While small oil spills would likely only have limited influence on potentially affected resources within these refuges, a large spill could result in more drastic effects on coastal habitats and fauna.

Impacts of an Unexpected Catastrophic Discharge Event. This PEIS analyzes the impacts of a CDE in the Chukchi Sea Planning Area that has a volume of 1.4-2.2 million bbl and a duration of 40–75 days, and a CDE in the Beaufort Sea Planning Area with a volume of 1.7-3.9 million bbl and a duration of 60–300 days (Table 4.4.2-2). A CDE from an offshore pipeline or platform could potentially contact shoreline habitats and communities in NWRs and NPS lands. However, Cape Krusenstern National Monument and the Bering Land Bridge National Preserve are located more than 322 km (200 mi) south of the Chukchi Sea Planning Area and are therefore unlikely to be adversely affected by accidental spills occurring offshore in the Beaufort and Chukchi Seas. The Arctic NWR and the Chukchi Sea unit of the Alaska Maritime NWR would be susceptible to oil spilled from subsea pipelines or drilling platforms.

If a large volume of heavy oil were to reach the shoreline following a CDE, NWRs could suffer a reduction in their primary function which is to support wildlife and aquatic biota. Given the cold temperatures in Alaska, oil could contaminate nearshore refuge habitats for several years to decades and result in lethal and long-term sublethal impacts to refuge biota. Impacts would depend primarily on spill location, spill size, and timing of the spill. In general, directly affected coastal fauna would include marine mammals; fishes that reproduce, inhabit, or migrate through coastal areas; terrestrial mammals that forage on fish also including invertebrate communities that are utilized in subsistence (clams, etc.) and important sources of foraging for marine mammals, fish, and bird populations; and marsh and seabirds that use these habitats for nesting and/or foraging. Spilled oil could also affect subsistence harvests in those parks in which subsistence hunting and fishing are allowed. See Section 4.4.6.1.3 for a description of potential impacts of a CDE on coastal areas and biota.

Impact Conclusions.

***Routine Operations*.** Overall, impacts on Areas of Special Concern resulting from routine Program activities would be minimized by existing protections and use restrictions applicable to these areas. However, increased vessel and aircraft traffic and the construction of pipelines and platforms could have temporary and localized effects on wildlife. Overall, impacts on Areas of Special Concern resulting from routine Program activities are expected to be negligible to moderate.

***Expected Accidental Events and Spills*.** While most accidents would be small and would have relatively small impacts on Areas of Special Concern, large spills that reach coastal NWRs could have more persistent impacts and could require remediation. Impacts from large spills could result from both oiling of the shoreline and mechanical damage during the cleanup process. If a large amount of oil were to contact a NWR, it could experience a loss of habitat value to fish and wildlife. Overall, impacts to Areas of Special Concern from small spills would range from negligible for spill less than 50 bbl, minor for spills up to 1,000 bbl, and from minor to moderate for large spills (≥1,000 bbl).

An Unexpected Catastrophic Discharge Event. Should oil from a CDE reach an Area of Special Concern, the impacts would depend on the location and size of the spill, the type of product spilled, weather conditions, the type of area affected, the effectiveness of cleanup operations, and other environmental conditions at the time of the spill. Although a CDE is unexpected, if oil from a CDE were to reach an Area of Special Concern, coastal habitats and fauna, as well as subsistence use could be negatively affected. Based on monitoring data following the *Exxon Valdez* spill, oil in some coastal habitats would likely persist for multiple years. Overall, a CDE could result in up to moderate effects on Areas of Special Concern.

4.4.9 Potential Impacts on Population, Employment, and Income

4.4.9.1 Gulf of Mexico

Impacts of Routine Operations. Under the proposed action alternative, between 200 and 400 new platforms would be located in the GOM over the 40-year planning period. Using impact estimates provided by the MAG-PLAN Model (see MMS 2005f; BOEM 2011b), Table 4.4.9-1 shows total (direct, indirect, and induced) employment and regional income for Economic Impact Areas (EIAs) in each State in the GOM coast region whose social and economic well-being is directly or indirectly affected by the OCS oil and gas industry (see Section 3.10). Average annual impacts of the proposed action in the GOM coast region would be the addition of between 20,025 and 41,825 jobs, which would amount to less than 1% of total projected GOM coast regional employment in 2015. Between $1,050 million and $2,180 million in income would be produced. The largest employment impacts would be in Texas, ranging from 10,900 to 21,925 additional jobs, with smaller impacts in Louisiana, where the employment created would range from 7,575 to 16,425 jobs. Income impacts in these States would range between $630 million and $1,270 million in Texas and between $350 million and $765 million in Louisiana. Employment impacts are lower in the other GOM coast States; the total number of jobs created would be between 975 and 2,150 in Florida, between 350 and 800 in Alabama, and between 225 and 525 in Mississippi. Although only a small amount of OCS oil and gas activity is proposed for the Eastern Planning Area, economic impacts would occur in Florida associated with expenditures on material and equipment supplied by sectors located in Florida, and the and use of ports and infrastructure for the associated transportation.

The additional jobs would create small but noticeable increases in the population of these regions. Using a historically observed ratio of 2.59 persons per new job (MMS 2006b), population increases of between 28,231 and 56,786 would be expected in Texas on average in each year of the proposed action, with increases of between 19,619 and 42,541 occurring in Louisiana. Smaller increases in population of between 2,525 and 5,569 per new job would occur in Florida, with increases of between 907 and 2,072 in Alabama, and between 583 and 1,360 in Mississippi.

Installation and operation of new offshore oil and gas platforms have the potential to impact property values in coastal areas within viewing distances of offshore activities. The extent of the impact of any given platform would vary according to distance to shore, location within a maximum viewing range, and regional visibility conditions. There are currently 3,679 offshore platforms in the Western and Central Planning Areas in Federal waters in the GOM. Under the proposed action alternative, between 200 and 450 platforms would be added over the 40-year planning period, an average of between five and ten platforms per year. It is also anticipated that between 150 and 275 platforms would be removed over the same period. Although the location of additional offshore platforms is not known, with some new platforms conceivably located in areas of the GOM with relatively little existing oil and gas development, the majority of new platforms are likely to be located in areas already hosting existing platforms.

TABLE 4.4.9-1 Average Annual Impacts of the Proposed Action (Alternative 1) on Coastal Regional Employment and Income[a]

Economic Impact Area	Employment	Income
Alabama		
Low	350	15
High	800	35
Florida		
Low	975	45
High	2,150	95
Louisiana		
Low	7,575	350
High	16,425	765
Mississippi		
Low	225	10
High	525	25
Texas		
Low	10,900	630
High	21,925	1,270
Total GOM		
Low	20,025	1,050
High	41,825	2,180

[a] Totals may not add due to rounding. All estimates are totals of direct, indirect, and induced impacts. Employment estimates are in employee years; personal income estimates are in millions of 2012 dollars.

Source: BOEMRE 2011n.

Impacts of Expected Accidental Events and Spills. Up to 8 large spills greater than 1,000 bbl, between 35 and 70 spills between 50 and 1,000 bbl, and up to 400 small spills less than 50 bbl could occur in the GOM from the proposed action. It is expected that many of these spills will occur in deepwater areas located away from the coast, based on the established trend for greater oil production activity to move into deepwater located for the most part at a substantial distance from the coast.

In previous oil spill analyses, there is a less than 0.5% probability that an oil spill greater than or equal to 1,000 bbl would reach the shores of the majority of coastal counties and parishes in Texas and Louisiana within 10 days of a spill occurring over the 40-yr leasing period in the Western and Central Planning Areas (MMS 2006a). Six counties in Texas and one parish in

Louisiana have a 1–5% chance of an OCS offshore oil spill greater than or equal to 1,000 bbl reaching their shoreline within 10 days. BOEM also estimates that between 5 and 15 chemical spills associated with the OCS program are anticipated each year, with a small percentage of these associated with the proposed action. The majority of spills are expected to be less than 50 bbl in size; a chemical spill of greater than or equal to 1,000 bbl as a result of the proposed action is very unlikely.

The immediate socioeconomic impact of a larger oil spill would include the loss of employment, income, and property value; increased traffic congestion; increased cost of public service provision, and possible shortages of commodities or services. In the short term, the impacts of a spill would be measured in terms of projected cleanup expenditures and the number of people employed in cleanup and remediation activities. Longer-term impacts could affect fishing, shrimping, oystering, and/or tourism if these activities were to suffer due to the real or perceived impacts of the spill, and could include substantial changes to the energy industries in the region as a result of the spill.

The employment and regional income impact from an oil spill would likely be greatest in Texas and Florida, with the highest concentration of tourism-related employment occurring in Florida, particularly in the Miami and Tampa-St. Petersburg areas and the Houston-Galveston areas. In the Central GOM Planning Area, the New Orleans area would also be affected due to their high concentration of tourism-related employment. Net employment impacts from a spill are not expected to exceed 1% of baseline employment for any LMA in any given year, even if they are included with employment associated with routine oil and gas development activities associated with the proposed action.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes an unexpected CDE with an assumed volume of 0.9-7.2 million bbl and a duration of 30–90 days (Table 4.4.2-2). A CDE could result in impacts, which could include the loss of employment, income, and possible shortages of commodities or services in both coastal and inland areas. In coastal areas, losses of property value and increased traffic congestion could also occur, with increases in the cost of public service provision also possible. In the short term, impacts of a CDE would be measured in terms of projected cleanup expenditures and the number of people employed in cleanup and remediation activities. Longer-term impacts may include impacts to fishing activities and tourism if these activities were to suffer as a result of the real or perceived impacts of the event, and could include substantial changes to energy industries in the region as a result of the event.

Impact Conclusions.

***Routine Operations*.** Routine Program activities would result in negligible impacts from small increases in population, employment, and income, resulting in increases of less than 1% of baseline levels.

Expected Accidental Events and Spills. Impacts of accidental oil spills could include the short-term loss of employment, income, and property value; increased traffic congestion; increased cost of public service provision; and possible shortages of commodities or services. In the short term, the impacts of a spill would also include projected cleanup expenditures and employment created in cleanup and remediation activities. Longer-term impacts could affect fishing, shrimping, oystering, and/or tourism if these activities were to suffer due to the real or perceived impacts of the spill, and could include substantial changes to the energy industries in the region as a result of the spill. Small spills up to 1,000 bbl would have negligible to minor socioeconomic impacts, while large spills of more than 1,000 bbl would have minor to moderate impacts.

An Unexpected Catastrophic Discharge Event. A CDE could result in the loss of employment, income, and possible shortages of commodities or services in both coastal and inland areas affected by the spill. Losses of property value could also occur in coastal communities, with increased cost of local public service provision also possible. In the short term, impacts of a CDE, measured in terms of projected cleanup expenditures and the number of people employed in cleanup and remediation activities, would be expected to be large. Longer-term impacts would likely be small, unless recreational activities and tourism suffered as a result of the real or perceived impacts of the event, or if there were substantial changes to energy production in the region as a result of the accidental spill; this would be more likely in the event of a CDE. Overall, the impacts of a CDE would be between minor to moderate.

4.4.9.2 Alaska – Cook Inlet

Impacts of Routine Operations. Under the proposed action alternative, between one and three new platforms would be located in Cook Inlet over the 40-year planning period. Table 4.4.9-2 shows total (direct, indirect, and induced) employment and income in Alaska as a whole. Average annual impacts of the proposed action in the Alaska region would be between 1,372 and 3,792 jobs, which would amount to less than 2% of total projected Alaska employment in 2015. Personal income would increase by between $86.5 million and $255.6 million annually in Alaska as a whole.

Based on current trends, it is assumed that most of the workers directly associated with OCS oil and gas activity will work offshore or onshore in worker enclaves separated from local communities, and that most OCS workers will likely commute to work sites from Alaska's larger population centers or from outside the immediate area. It is also assumed that OCS jobs would be available to the local populations in all areas, but that rural Alaskan employment in the petroleum industry, especially among Alaska Natives, will remain relatively low.

Many workers on oil rigs in the Cook Inlet Planning Area (and onshore oil and gas facilities on the Kenai Peninsula and the North Slope) currently live in Anchorage or on the Kenai Peninsula. The larger populations and more diverse economies of south central Alaska compared to other Alaskan communities will tend to lessen the potential effect of proposed leasing on their economies. As a result, employment generated by OCS activity in the Cook Inlet Planning Area at its peak is only expected to account for less than 5% of total Alaska employment.

TABLE 4.4.9-2 Average Annual Impacts of the Proposed Action (Alternative 1) on Alaska Employment and Income[a]

Area	Employment	Income
Cook Inlet		
Low	1,372	86.5
High	3,792	255.6

[a] All estimates are totals of direct, indirect, and induced impacts. Employment estimates are in employee years; labor income estimates are in millions of 2012 dollars.

Source: BOEMRE 2011o.

Installation and operation of new offshore oil and gas platforms have the potential to impact property values in coastal areas within viewing distances of offshore activities. The extent of the impact of any given platform would vary according to distance from shore, location within a maximum viewing range, and regional visibility conditions. Under the proposed action alternative, between one and three platforms would be added over the 40-yr planning period. It is also anticipated that between one and three platforms would be removed over the same period. Although the location of additional offshore platforms is not known, with some new platforms conceivably being located in areas of the Cook Inlet area, the majority of new platforms are likely to be located in the vicinity of areas already hosting existing platforms.

Impacts of Expected Accidental Events and Spills. One large spill greater than 1,000 bbl, up to 3 spills between 50 bbl and 1,000 bbl, and up to 15 small spills less than 50 bbl could occur in the Cook Inlet Planning Area under the proposed action. Although an oil spill could occur anywhere in the lease sale area, cleanup-related employment would likely occur in the area directly affected, generally in locations remote from communities. The hiring of cleanup workers will likely draw from labor markets in both the region and the rest of Alaska. Oil spills will generate only temporary employment (and population) increases during cleanup operations, because such operations are expected to be of short duration. Employment generated by spills will be a function of the size and frequency of spills.

Impacts of an Unexpected Catastrophic Discharge Event. For the Cook Inlet Planning Area, the PEIS analyzes a CDE with an assumed volume of 75-125 thousand bbl and a duration of 50–80 days (Table 4.4.2-2). The socioeconomic impact of a CDE could result in up to moderate impacts, which could include the loss of employment, income, and possible shortages of commodities or services in both coastal and inland areas. In coastal areas, losses of property value and increased traffic congestion could also occur, with increases in the cost of public service provision also possible. In the short term, impacts of a CDE would be measured in terms of projected cleanup expenditures and the number of people employed in cleanup and remediation activities. Longer-term impacts could include fishing and tourism if these activities were to suffer as a result of the real or perceived impacts of the event, and could include substantial changes to energy industries in the region as a result of the event.

Impact Conclusions.

Routine Operations. Routine Program activities would result in minor impacts in the Cook Inlet area, with population, employment, and income increasing by less than 5% of baseline levels in Alaska.

Expected Accidental Events and Spills. Impacts of accidental oil spills could include the short-term loss of employment, income, and property value; increased traffic congestion; increased cost of public service provision; and possible shortages of commodities or services. In the short term, the impacts of a spill would also include projected cleanup expenditures and employment created in cleanup and remediation activities. Longer-term impacts could affect fishing and/or tourism if these activities were to suffer due to the real or perceived impacts of the spill, and could include substantial changes to the energy industries in the region as a result of the spill. Small spills up to 1,000 bbl would have negligible to minor socioeconomic impacts, while large spills of more than 1,000 bbl would have minor to moderate impacts.

An Unexpected Catastrophic Discharge Event. A CDE could result in the loss of loss of employment, income, and possible shortages of commodities or services in both coastal and inland areas affected by the spill. Losses of property value could also occur in coastal communities, with increased cost of local public service provision also possible. In the short term, impacts of a CDE, measured in terms of projected cleanup expenditures and the number of people employed in cleanup and remediation activities, would be expected to be large. Longer-term impacts would likely be small, unless recreational activities and tourism suffered as a result of the real or perceived impacts of the event, or if there were substantial changes to energy production in the region as a result of the accidental spill; this would be more likely in the event of a CDE. Overall, the impacts of a CDE would be between minor to moderate.

4.4.9.3 Alaska – Arctic

Impacts of Routine Operations. Under the proposed action alternative, between one and five new platforms would be located in the Chukchi Sea and one and four platforms in the Beaufort Sea over the 50-yr planning period. Table 4.4.9-3 shows the potential effects of the proposed action alternative in the Arctic region. Average annual impacts of the proposed action in the Arctic region would be an increase of between 3,457 and 12,665 jobs, which would amount to 5.6% of total projected Alaska employment in 2015. Personal income would increase by between $232.9 million and $904.0 million annually in the Arctic region.

Most of the workers directly associated with OCS oil and gas activity will work offshore or onshore in worker enclaves separated from local communities, and most workers will likely commute to work sites from Alaska's larger population centers, including Anchorage and Fairbanks, or from outside Alaska (MMS 2006b). While OCS jobs would be available to the

TABLE 4.4.9-3 Average Annual Impacts of the Proposed Action (Alternative 1) on Alaska Employment and Income[a]

Area	Employment	Income
Beaufort Sea		
Low	1,581	106.0
High	5,193	364.2
Chukchi Sea		
Low	1,876	126.9
High	7,472	539.9
Total Arctic Region		
Low	3,457	232.9
High	12,665	904.0

[a] All estimates are totals of direct, indirect, and induced impacts. Employment estimates are in employee years; labor income estimates are in millions of 2012 dollars.

Source: BOEMRE 2011o.

local populations in all areas, rural Alaskan employment in the petroleum industry, especially among Alaska Natives, would likely remain relatively low.

Employment in the North Slope oil and gas industry has little direct impact on the communities of the North Slope Borough. While actively working, most North Slope oil and gas workers stay in enclave housing separate from local communities, permanently residing in south central Alaska (Anchorage, the Kenai Peninsula Borough, and the Matanuska-Susitna Borough), or the Fairbanks area, and commute to their homes (or other locations) when not working. As population, employment, and income impacts affect the regional economies in which employees permanently reside, BOEM has not included these impacts in the discussion of impacts of the proposed action in the Arctic region.

The most important benefit of oil and gas development in the Arctic region is revenue from taxation of oil industry facilities. Although jurisdictions in the North Slope Borough and Northwest Arctic Borough are unable to tax offshore OCS facilities, the borough collects property tax revenue from new onshore pipelines and other facilities. Shareholders of the Arctic Slope Regional Corporation, most of whom reside on the North Slope, receive dividends from investments in petroleum service companies many of which are service oil companies on the North Slope and are potential service companies for Chukchi activities. The effects of the proposed action on employment and income in Arctic region communities are likely to be significant, especially when combined with the continued decline in Prudhoe Bay and other North Slope production areas, and continued OCS production would allow jurisdictions in the

Arctic region to maintain revenue collection from onshore facilities associated with continued offshore production.

Impacts of Expected Accidental Events and Spills. Up to 3 large spills greater than 1,000 bbl, 10 and 35 spills between 50 and 1,000 bbl, and up to 190 small spills of less than 50 bbl could occur in the Beaufort and Chukchi Sea area from the proposed action. Although an oil spill could occur anywhere in the lease sale area, cleanup-related employment would likely occur in the area directly affected, generally in locations remote from communities. The hiring of cleanup workers would have a regional and State of Alaska emphasis. Oil spills will generate only temporary employment (and population) increases during cleanup operations, because such operations are expected to be of short duration. Employment generated by spills will be a function of the size and frequency of spills. Large spills of over 1,000 bbl would generate 60 to 90 jobs for up to 6 months and would generate moderate local effects (MMS 2008b).

Impacts of an Unexpected Catastrophic Discharge Event. For the Chukchi Sea Planning Area, the PEIS analyzes a CDE with an assumed volume of 1.4-2.2 million bbl and a duration of 40–75 days; for the Beaufort Sea Planning Area a CDE is assumed to have a volume of 1.7–3.9 million bbl and a duration of 60–300 days (Table 4.4.2-2). The socioeconomic impact of a CDE would result in up to moderate impacts, which could include the loss of employment, income, and possible shortages of commodities or services in both coastal and inland areas. Losses of property value could also occur in coastal communities, with increased cost of local public service provision also possible. In the short term, impacts of a CDE would be measured in terms of projected cleanup expenditures and the number of people employed in cleanup and remediation activities. Longer-term impacts could include recreational activities and tourism if these activities suffered as a result of the real or perceived impacts of the event, and may include substantial changes to energy production in the region as a result of the event.

Impact Conclusions.

Routine Operations. Routine operations would result in minor impacts in Alaska with increases in population, employment, and income of less than 5% of baseline levels in Alaska.

Expected Accidental Events and Spills. Impacts of accidental oil spills could include the short-term loss of employment, income, and property value; increased traffic congestion; increased cost of public service provision; and possible shortages of commodities or services. In the short term, the impacts of a spill would also include projected cleanup expenditures and employment created in cleanup and remediation activities. Longer-term impacts could affect fishing and/or tourism if these activities were to suffer due to the real or perceived impacts of the spill, and could include substantial changes to the energy industries in the region as a result of the spill. Small spills up to 1,000 bbl would have negligible to minor socioeconomic impacts, while large spills of more than 1,000 bbl would have minor to moderate impacts.

An Unexpected Catastrophic Discharge Event. CDE could result in the loss of employment, income, and possible shortages of commodities or services in both coastal and inland areas affected by the spill. Losses of property value could also occur in coastal communities, with increased cost of local public service provision also possible. In the short term, impacts of a CDE, measured in terms of projected cleanup expenditures and the number of people employed in cleanup and remediation activities, would be expected to be large. Longer-term impacts would likely be small, unless recreational activities and tourism suffered as a result of the real or perceived impacts of the event, or if there were substantial changes to energy production in the region as a result of the accidental spill; this would be more likely in the event of a CDE spill. Overall, the impacts of a CDE would be between minor to moderate.

4.4.10 Potential Impacts to Land Use and Infrastructure

The development of oil and gas facilities within the GOM, the Cook Inlet, and the Arctic would have both direct and indirect impacts on existing and future land use, development patterns, and infrastructure. Potential impacts of routine activities of the Proposed Action Alternative are presented below. Routine activities include seismic explorations and exploratory drilling, onshore and offshore construction, normal operations, and decommissioning. Potential impacts of expected accidental spills and an unexpected CDE are also presented. In general, the nature and magnitude of these impacts would depend upon the level and location of new construction, the degree to which the area is already developed, and, in the case of accidental spills or a CDE, the size and location of the spill.

Table 4.4.10-1 provides a summary of the resource receptors that pertain to routine activities. As shown in this table, potential receptors include the following:

- Land use categorization,
- Land use plans and initiatives,
- Development patterns, and
- Onshore infrastructure.

Conceptual models illustrated in Figures 4.4.10-1 through 4.4.10-3 show how various activities associated with seismic surveys, onshore and offshore construction, and normal oil and gas operations may impact land use, development patterns, and infrastructure. These figures are applicable to the GOM, the Cook Inlet, and the Arctic.

As shown in these figures, the potential effects of oil and gas activities typically include the following:

- Incompatibility with local land use/comprehensive planning patterns,
- Incompatibility with existing/planned development,
- Loss of use (intended or perceived) to existing landowners or users, and

TABLE 4.4.10-1 Impacting Factors Associated with Each Phase of Oil and Gas Activities[a]

	O&G Activities Phase				
	Exploration				
Resource Receptor Category Potentially Affected	Seismic Survey	Exploratory Wells	Development/ Construction	Production/ Normal Operations	Decommissioning
Land use categorization	I	I	X	I	X
Land use plans/initiatives	I	I	X	I	X
Development patterns	I	I	X	I	X
Onshore infrastructure	I	I	X	I	X

[a] I = Indirect impacts are anticipated; X = Both direct and indirect impacts are anticipated.

- Potential changes to the physical and/or infrastructural composition of the coast.

Each of these impacts is discussed in the context of seismic explorations, construction of onshore and offshore facilities, normal operations, and decommissioning. A more general discussion of impacts is provided for accidental releases or spills.

For the purpose of this discussion, land use refers to the activity that occurs on a specific area of land and within the structures that occupy it, whereas zoning regulations include such things as requirements for building size, bulk, and density. General land use is assumed to be the primary factor in determining existing and future development decisions. Specific zoning regulations were not evaluated for areas located within the GOM, the Cook Inlet, or the Arctic due to the large scale of the planning areas. Individual environmental assessments generally would account for localized regulations.

In addition, for the purposes of this discussion, intended land use is that prescribed by regulations or formalized land use plans. For instance, if a parcel of land is dedicated as agricultural land, the intended activities likely would include farming, animal husbandry, or a combination of rural activities. The actual use, however, may differ. For the purpose of this evaluation, "actual use" is the manner in which people physically use the land that may or may not be regulated or prescribed by laws or formal plans. Instead, the use may involve traditional practices or activities occurring for long periods of time.

4.4.10.1 Gulf of Mexico

As indicated in Table 4.4.1-1, potentially available oil includes a range of 2.7 to 5.4 billion barrels (Bbbl) within the GOM, along with 12–24 trillion cubic feet (tcf) of natural gas. In order to provide for production of these resources, a number of routine activities are

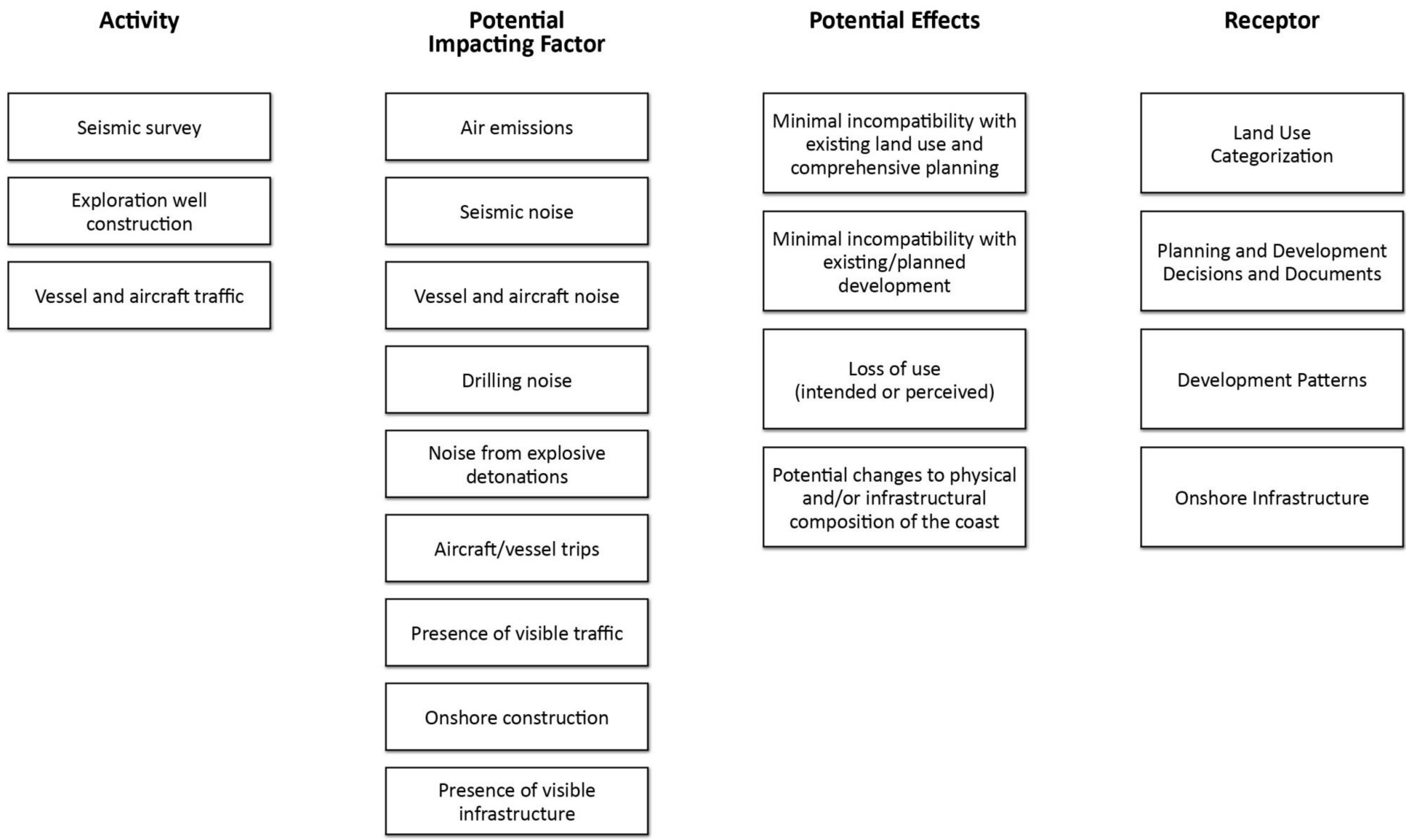

FIGURE 4.4.10-1 Conceptual Model for Potential Direct and Indirect Effects of Seismic Survey Activities on Land Use, Development Patterns, and Infrastructure

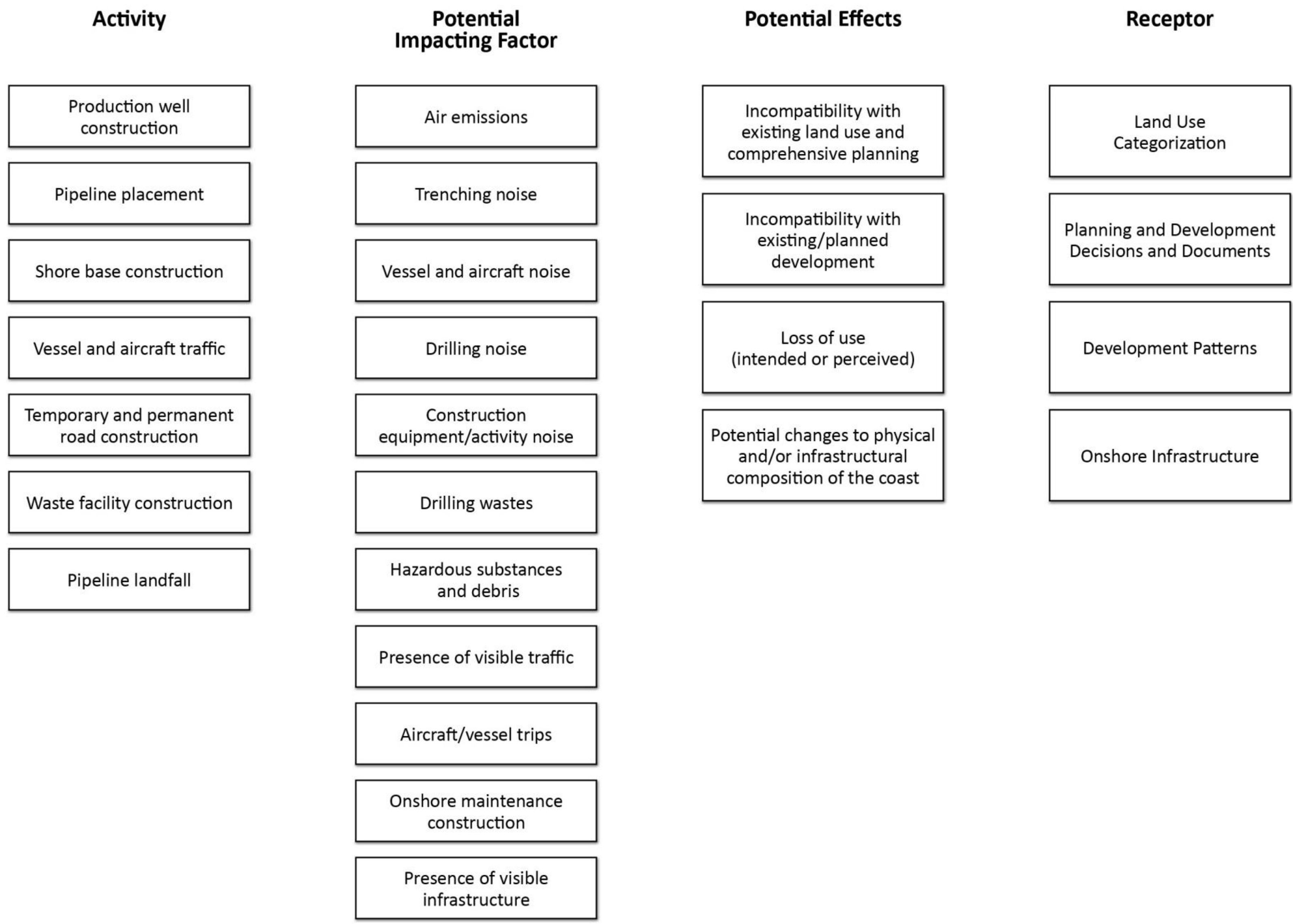

FIGURE 4.4.10-2 Conceptual Model for Potential Direct and Indirect Effects of Onshore/Offshore Construction Activities on Land Use, Development Patterns, and Infrastructure

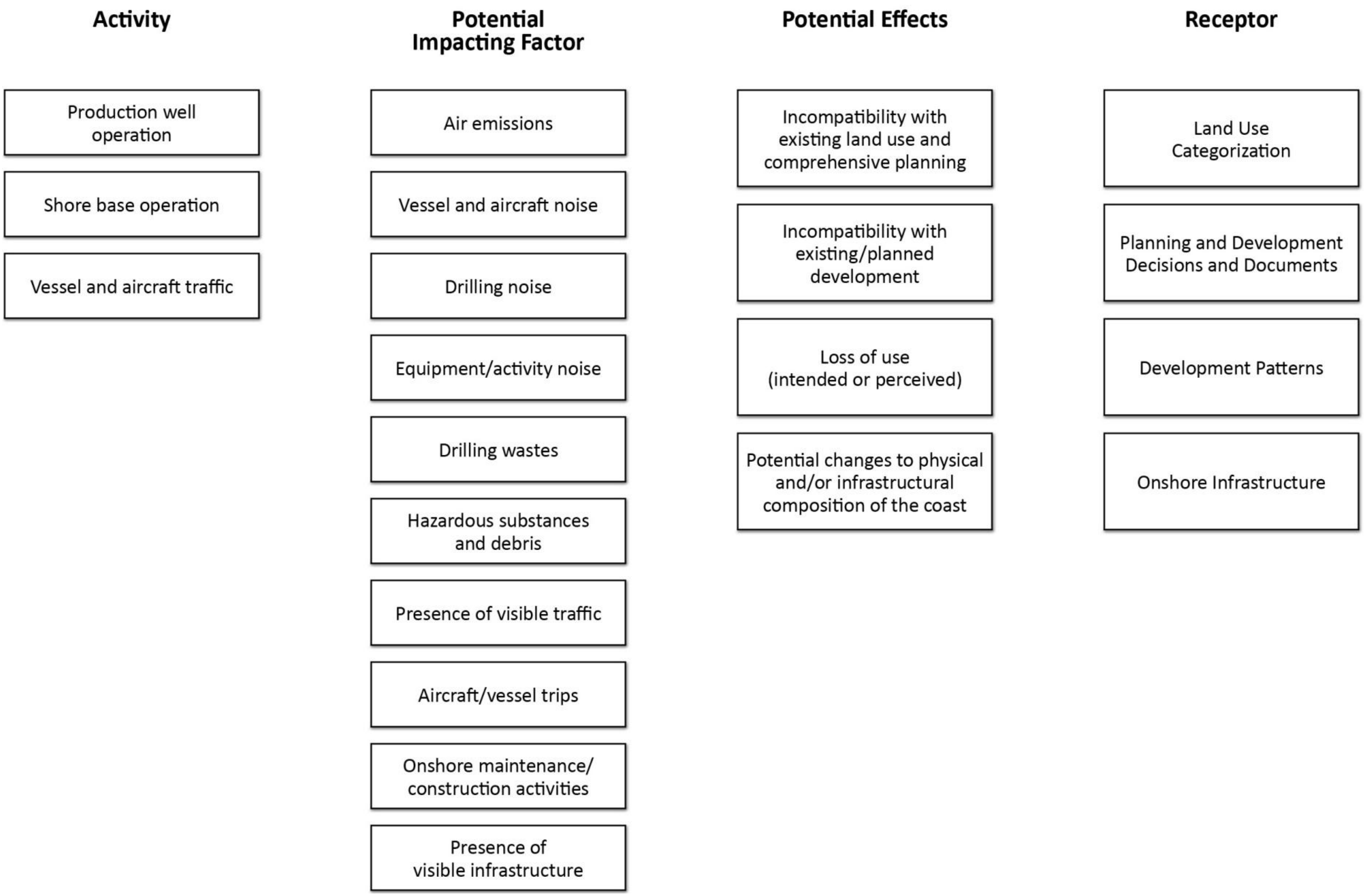

FIGURE 4.4.10-3 Conceptual Model for Potential Direct and Indirect Effects of Normal Operations on Land Use, Development Patterns, and Infrastructure

necessary. As previously indicated, these activities have the potential to impact existing and future land use, development patterns, and infrastructure.

Impacts of Routine Operations.

Seismic Explorations and Exploratory Drilling. Activities associated with exploration typically include a seismic survey, exploratory well construction, and aircraft and vessel traffic (see Figure 4.4.10-1).

<u>Local Land Use/Comprehensive Planning and Development Patterns.</u> Seismic explorations and exploratory drilling would not impact land use, development patterns, and infrastructure directly, as a majority of the activities would be located offshore. In general, existing and future land use categorizations would remain unchanged, along with current development patterns. Existing and planned activities associated with local planning initiatives and plans likely would not be hindered, as the jurisdiction of these plans typically would not extend to the offshore activities. State and Federal planning initiatives, such as the National Coastal Zone Management (CZM) Program, would generally be consistent with seismic surveys and exploratory drilling due to the need for prioritizing coastal-dependent uses (see Section 3.11.1 for more information on this program).

<u>Loss of Use to Existing Landowners or Users.</u> Seismic explorations and exploratory drilling activities would not impact access or use of a particular land area. Some safety-related temporary restrictions on access may be necessary both onshore and offshore; however, these restrictions likely would be temporary, lasting only as long as the exploration activities, with access restrictions lifted afterwards.

In addition, the use of individual properties may be affected indirectly if excessive noise and air emissions generated by survey equipment/vessels and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles) were to occur, or if a small increase in the amount of trash and debris washing ashore were to result from exploration. These occurrences may cause a temporary disturbance or annoyance among particular landholders or users and thereby interfere with their intended or actual use of the land. These impacts would be temporary in nature due to the short time frame of these activities. The level of impact would depend on the specific location of the exploration activities within the GOM.

<u>Physical and/or Infrastructural Composition.</u> While additional infrastructure, such as machinery and staging area improvements, may be needed to accommodate equipment and workers associated with the exploration activities, the increase likely would be negligible at this stage of oil and gas development. In general, existing infrastructure within the GOM would likely be able to accommodate activities associated with exploration (see Section 3.11.1 for further information regarding existing GOM infrastructure).

Onshore and Offshore Construction. Impacts on land use, development patterns, and infrastructure associated with onshore and offshore construction are presented below. As indicated in Figure 4.4.10-2, activities associated with this phase include production well placement, pipeline placement, onshore construction, and aircraft and vessel traffic. Similar to the exploration phase, these activities have the potential to impact local land use and comprehensive planning and existing and planned development; access and use of particular properties; and the physical and infrastructural makeup of the GOM as pertaining to emissions, waste, noise, and traffic; each is discussed below.

Local Land Use/Comprehensive Planning and Development Patterns. As indicated in Section 3.11.1, a number of onshore and offshore facilities are associated with the development of offshore oil and gas. Among these are ports, ship and shipbuilding yards, support and transport, pipelines, pipe coating yards, natural gas processing and storage, refineries, petrochemical plants, and waste management facilities. Current BOEM data suggests that more than 3,900 offshore production facilities are located within the GOM within Federal waters. Most of these facilities are located within the Western and Central Planning Areas.

According to previous government documents, a steady pace of offshore leasing has persisted in the GOM for nearly six decades with the first Federal lease sale in 1954 (MMS undated). Consequently, land use categorizations in the Western and Central Planning Areas often would be able to accommodate this type of industry. Therefore, very little change in land use categorizations (i.e., receptor) are likely to result from the continuation of leasing and subsequent exploration and development activities in the Western and Central GOM Planning Areas. In addition, the development of oil and gas facilities likely would be compatible with existing local land use, zoning, and comprehensive planning in these areas. Land use likely would evolve over time, with most changes occurring as a result of general regional growth rather than specific activities associated with the production of oil and gas (BOEMRE 2011a).

As a result of the DWH event, the overall climate for development of oil and gas has been altered in response to a recent suspension and changes in Federal requirements for drilling safety in the whole of the GOM (BOEMRE 2011a). In some areas of the GOM, for instance, local planning initiatives have been drafted in response to the recent event that could impact the construction of new and/or infill facilities. Some of these initiatives focus on the economic diversification of the GOM coast, rather than upon oil and gas activities, while other strategies focus on the investment of monies for necessary human services (Restore the Gulf 2010b). Perceptions about the spill may influence future decisions regarding the need for oil and gas investments, improvements to existing infrastructure, and the construction of new oil and gas facilities.

Likewise, individual businesses and organizations have adapted to the altered, post-DWH environment. For instance, some companies have removed a portion of their equipment, and a substantial decrease in helicopter flights and servicing of rigs has occurred. Companies have trimmed budgets by cutting hours and salaries of workers; associated support services, such as chemical suppliers and welders, also have been affected by the DWH event.

The effects of this decreased demand have rippled through the various infrastructure categories (e.g., fabrication yards, shipyards, port facilities, pipecoating facilities, gas processing facilities, and waste management facilities) and have affected the oil and gas support sector businesses (e.g., drilling contractors, offshore support vessels, helicopter hubs, and mud/drilling fluid/lubricant suppliers) (BOEMRE 2011a). Land use has been impacted indirectly through various economic incentives, compliance with permitting requirements, and the lack of use of existing facilities. As indicated in a 2011 lease sale, some locations offered a 30% reduction in rental rates in order to keep businesses (BOEMRE 2011a). Actions of this nature influence the overall development pattern. As a consequence, BOEM anticipates monitoring the overall oil and gas development climate as it pertains to the DWH event (BOEMRE 2011a).

If new infrastructure is needed onshore, some developments may be subject to local, State, and/or other Federal permitting and regulations. Within the Western and Central Planning Areas, infill development likely would occur in areas already established for oil and gas development. Specific timelines and requirements would vary by location, as BOEM typically is not the permitting or regulating agency for development activities that occur onshore.

<u>Loss of Use to Existing Landowners or Users.</u> With proper permitting and approvals, onshore and offshore construction generally would not interfere with or prevent use by existing owners or users within areas of immediate development. During construction activities, a temporary loss of access to some areas may be required for safety reasons, with access restored upon completion of the activities. Some users of surrounding land may be inconvenienced by closure or restrictions on access routes, as well. Permanent loss of use is not anticipated. If new land were necessary in order to construct onshore facilities, the acquisition would follow all pertinent local, State, and Federal requirements.

The use of individual properties in the vicinity of the construction activities may be affected indirectly if excessive noise and air emissions generated by the construction equipment and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles) were to occur, or if a small increase in the amount of trash and debris washing ashore were to result from the activities. These occurrences may cause a temporary disturbance or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level of impact would depend on the specific location within the GOM.

<u>Physical and/or Infrastructural Composition.</u> Physical land disturbance also would occur in locations where new facilities are needed. As indicated in Table 4.4.1-1, the Western and Central Planning Areas may require up to 12 new pipeline landfalls, four to six new pipe yards, and the potential for up to 12 new natural gas processing facilities. Approximately 3,862–12,070 km (2,400–7,500 mi) of new pipeline could be needed, as well.

The creation of pipeline landfalls could involve such activities as clearing land, preparing a ROW, and digging and backfilling trenches. These activities could alter the physical composition of the landscape, thus potentially limiting the intended use of a parcel unless located in existing utility ROWs. Likewise, the construction of new shore bases and waste facilities could involve, but would not be limited to, the preparation of a site through grading and clearing, excavations, and foundation building. As with a pipeline, these types of activities would alter the existing landscape and, depending on the scale and location, could alter the intended use of a parcel. While these changes would be necessary in some locations within the GOM, the activities associated with the oil and gas construction would not likely cause an extensive change to existing development patterns.

The construction of more permanent facilities could be a positive impact or a negative impact depending on the specific location within the GOM. For instance, where new roads would provide additional routes and capacity for coastline travel, they may be perceived as a positive impact by some stakeholders. However, if the same roadways added large traffic volumes to existing roadways that already were over capacity, the construction could be seen as a negative impact.

Additional indirect impacts include those associated with climate change. Siting of new facilities may account for potential changes resulting from rises in sea level, increased storm frequency and intensity, and temperature changes. Figure 4.4.10-4 provides an illustration of the potential sea rise levels in the GOM.

As noted in the publication, *Oceans and Marine Resources in a Changing Climate: Technical Input to the 2013 National Climate Assessment*, one of the main climate-related effects on the oil and gas industry is the failure of infrastructure that was not designed to withstand new climatic conditions. Some of the existing equipment, such as shallow-water oil platforms in the GOM, were designed to function under climatic conditions typical of 20 to 40 years ago, rather than the conditions of today (Orbach et al. undated). In the past, typical responses to landscape changes associated with a rising sea level included building seawalls and hard structures to hold back the water, raising the land level, replenishing beaches and shorelines, or allowing the water to advance (Twilley et al. 2001).

Today, potential solutions will need to account for these changes in the sea level and may include facility relocation, the construction of seawalls and storm surge barriers, dune reinforcement, and land acquisitions to create buffer areas (IPCC 2007). Advance planning for the potential rise in the sea level due to climate change will help to avoid costly impacts on onshore infrastructure.

Consequently, indirect impacts on land use, development patterns, and infrastructure could include locating facilities further inland and/or strengthening the foundations or building materials of existing facilities. These actions potentially could increase costs associated with development or lead to the construction of new facilities rather than the reuse or expansion of existing properties associated with oil and gas production. These decisions may be influenced by the potential for increased flooding and/or erosion.

***Production Operations*.** Routine operation activities would consist of production well operation, onshore facility operation, and vessel and aircraft traffic, and would also include the transport of oil from offshore to onshore locations using ships or pipelines (see Figure 4.4.10-3).

Local Land Use/Comprehensive Planning and Development Patterns. Once offshore wells are in operation, land use, development patterns, and infrastructure would not be greatly affected by routine operations, because a majority of the activities would be located offshore. As previously indicated, land use likely would evolve over time, with most changes occurring as a result of general regional growth rather than through activities associated with oil and gas production (BOEMRE 2011a). Some regions within the GOM may be impacted to a greater extent than others depending on the site-specific conditions.

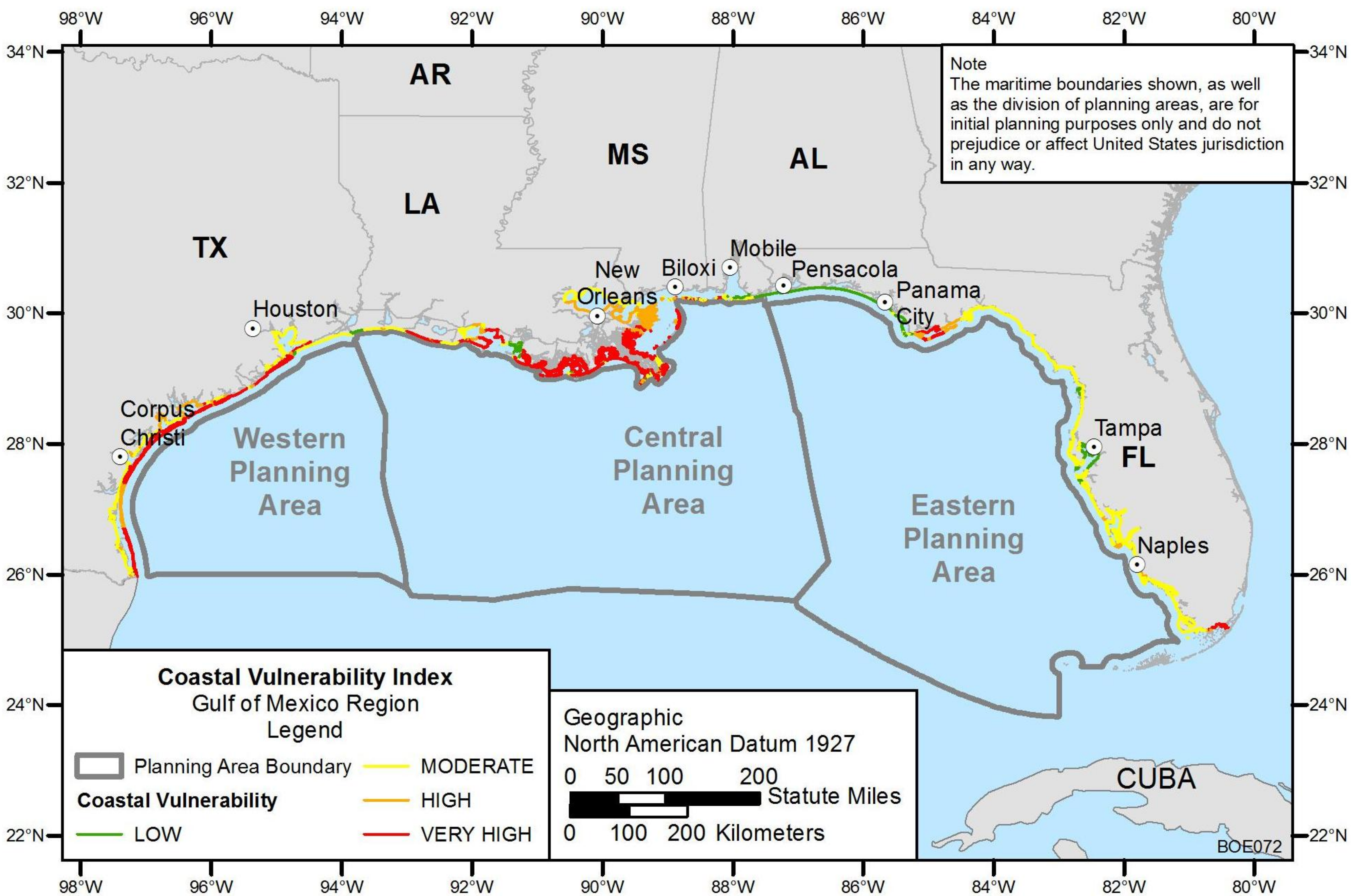

FIGURE 4.4.10-4 Coastal Vulnerability Index

Loss of Use to Existing Landowners or Users. Once the new offshore oil and gas facilities were in operation, temporary or permanent loss of use is not anticipated. As indicated in Section 3.11.1, many facilities already are located within the GOM to support oil and gas development. At times, some access to particular areas may be restricted within surrounding lands to accommodate a brief alteration in normal operations, such as an emergency response. These impacts would be limited and temporary.

Similar to construction, the use of individual properties in the vicinity of the operating platforms may be affected indirectly if excessive noise and air emissions were generated from equipment and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles), or if a small increase in the amount of trash and debris washing ashore were to result from the activities. These occurrences may cause disturbances or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level and extent of impact would depend on the specific location within the GOM.

Physical and/or Infrastructural Composition. To the extent possible, existing facilities would be used to support activities under new leases, and new facilities would be built only where necessary, which would tend to limit the potential to create lasting changes to the physical and/or infrastructural makeup of the GOM during operations.

***Decommissioning*.** Typical activities during the decommissioning/reclamation phase could include, but are not limited to, the closure of all wells, removal of access roads (not maintained or intended for other uses) and associated facility sites, and revegetation. These activities have the potential to directly impact land use, development patterns, and infrastructure.

Impacts associated with decommissioning, however, generally would be site-specific. In some cases, a return to pre-exploration and preconstruction conditions may not be feasible.

Local Land Use/Comprehensive Planning and Development Patterns. Depending on the location of the production wells and associated infrastructure, decommissioning activities onshore may be regulated by local land use, zoning, and comprehensive planning initiatives or requirements. The continued use of the facilities after production could impact planned development in a positive manner, either by providing an opportunity for reuse of facilities or allowing for the potential for additional or future oil and gas development.

Loss of Use to Existing Landowners or Users. No permanent loss of use is anticipated to occur during the decommissioning/reclamation phase. Some temporary loss may occur if road or area closures are necessary to accommodate equipment, workers, or specific activities associated with this type of process. Access typically would be restored to its preconstruction or operations state.

In addition, the use of individual properties in the vicinity of the activities may be affected indirectly if excessive noise and air emissions generated by the decommissioning equipment, activities, and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles) were to occur, or if a small increase in the amount of trash and debris washing ashore were to result from the activities. These occurrences may cause a temporary disturbance or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level of impact would depend on the specific location within the GOM.

Physical and/or Infrastructural Composition. During decommissioning, potential changes to the physical and infrastructural makeup of the GOM coast could occur. Any equipment added may be removed; defunct equipment also could be removed; however, these activities would not be expected to cause substantial changes to land use, development patterns, and infrastructure. These alterations would be site-specific and their extent would depend on the existing composition of land use and infrastructure.

Impacts of Expected Accidental Events and Spills. Oil spills are a principal accidental impact-causing event. Approximately 8 large spills up to 5,100 bbl, 35–70 small spills of 50 bbl or more but less than 1,000 bbl, and 200–400 small spills of less than 50 bbl are anticipated to occur in the GOM as a result of new development (see Table 4.4.2-1). If oil spills of these sizes and frequencies were to occur and were to contact the coast, overall changes to land uses, development patterns, and existing infrastructure typically would be small. Oil spilled in offshore areas usually is localized and has a low probability of contacting coastal areas, because much of the oil volatilizes or is dispersed by currents (MMS 2008a). In most cases, coastal or nearshore spills would have short-term adverse effects on coastal infrastructure requiring cleanup of any oil or chemicals spilled (MMS 2006a).

Potential impacts on land use and existing infrastructure would likely include “stresses of the spill response on existing infrastructure, direct land-use impact (such as impacts of oil contamination to a recreational area or to agricultural land), and restrictions of access to a particular area, while the cleanup is being conducted” (MMS 2007d). These impacts generally would be temporary and localized, particularly for small spills (and especially ones less than 50 bbl in volume). For large spills ($\geq$ 1,000 bbl), the degree of impact is influenced by many factors including, but not limited to, spill location, spill size, type of material spilled, prevailing wind and current conditions, the vulnerability and sensitivity of the land use and infrastructure, and response capability.

Impacts of An Unexpected Catastrophic Discharge Event. The PEIS analyzes the impacts of an unexpected CDE with a volume of 0.9-7.2 million bbl and a duration of 30–90 days (Table 4.4.2-2). A CDE is considered to be an unexpected, low-probability event unlikely to occur during routine operations (see Sections 4.3.3 and 4.4.2.2 for further discussions on the risks of CDE occurrence). While no direct major land use impacts would be expected following a CDE, response and restoration efforts may result in some immediate and temporary changes to the existing land use and infrastructure in the GOM.

For example, post-spill habitat restoration efforts could result in enhanced barrier islands (e.g., the construction of berms) and wetlands. After the DWH event, for instance, the State of Louisiana requested permission to build six large linear sand berms along the State’s barrier islands. The request also included some of the inlets between the barrier islands (USCG 2011a; Martinez et al. 2011). Alabama also had obtained funding for small berm projects, including a barrier for the Katrina Cut (USCG 2011a).

The existing network of pipes and platforms in coastal lands and wetlands of the GOM also could be exposed to potential wreckage and debris from a CDE and its associated response efforts. For instance, more than 40,200 km (24,979 mi) of pipeline rights-of-way are anchored in Louisiana's barrier islands and marshes. Some of the pipelines that were previously buried are now exposed to the surface as a result of erosion and other natural occurrences (Davis 2004). This infrastructure, therefore, is susceptible to changes that occur in the water and on the water surface, such as the presence of oil and vessel traffic that would be associated with a CDE.

In addition, changes in the operation of onshore infrastructure, such as oil pipelines, port facilities, and industrial facilities along the coast, may occur in response to concerns for damage from debris associated with a CDE. For instance, the Nakika crude oil pipeline was shut down as a precautionary measure following the DWH event (Aldy 2011). After this event, temporary waste staging areas and decontamination areas were set up to handle the spill-related waste (BOEM 2011a). In some cases, these facilities created short-term impacts due to changes in use of the land.

A number of indirect effects may also result from a potential CDE, including adaptations in commercial industries, such as fishing and tourism, fluctuating economic patterns, and changes in demographic distributions; all of these impacts could affect land use or development patterns by altering spending patterns of consumers and developers.

Following the DWH event, perceptions regarding emergency planning in the GOM have created a need for future planning and accounting for potential events of greater magnitude than typically anticipated. Trickle-down effects of the DWH event may include more stringent safety protocols in the operation and construction of infrastructure, which may include onshore facilities as well as offshore facilities. Similar types of effects would be anticipated if a catastrophic discharge event were to occur during the life of the Program.

"In the future, the long-term impacts of the DWH event will be clearer as time allows the production of peer-reviewed research and targeted studies that determine those impacts" (BOEM 2012). The oil well erupted on April 20, 2010, and continued until June 15th, thereby lasting a period of 86 days. The DWH event was declared "effectively dead" by the Federal Government on September 19, 2010 (IEM 2010). Due to the cleanup effort, the length of time, and the location, long-term impacts from an event such as this will need to be monitored in future years in order to truly understand its impacts on the GOM, including its impacts on land use and infrastructure (Restore the Gulf 2010b).

As shown by recent events in the GOM, the degree of impact is influenced by many factors including, but not limited to, spill location, spill size, type of material spilled, prevailing wind and current conditions, the vulnerability and sensitivity of the land use and infrastructure, and the response capability. As shown by the response to the DWH event, infrastructure exists in some locations to address this type of event. This would limit the potential for much larger effects to occur. As previously indicated, long-term impacts still are being monitored.

Impact Conclusions.

Routine Operations. Routine operations associated with the addition of new oil and gas leases within the GOM planning areas would result in negligible to minor impacts on land use, development patterns, and infrastructure. In general, the existing infrastructure would be expected to be sufficient to handle exploration and development associated with potential new leases.

Expected Accidental Events and Spills. Expected accidental events and spills could have both direct and indirect effects on land use, depending on the type, size, location, and duration of the incident. If oil spills were to occur and contact the coast, overall impacts on land use and existing infrastructure typically would be minor at most (especially for large spills), and negligible for most small spills (especially those <50 bbl).

An Unexpected Catastrophic Discharge Event. In the unlikely event of a low-probability CDE within the GOM, minor to moderate impacts to land use, development patterns, and infrastructure would be expected. Major impacts would not be expected, in part because existing infrastructure is in place in some locations to be able to address this type of event. This would limit the potential for much larger effects to occur.

4.4.10.2 Alaska – Cook Inlet

New oil and gas production is anticipated in the Cook Inlet, an area previously used for offshore production. As indicated in Table 4.4.1-3, oil production is anticipated to include a range of 0.1 to 0.2 Bbbl within south central Alaska; currently no active Federal leases are located within the Inlet. However, 16 active offshore producing platforms are located within the Cook Inlet in State submerged land. These platforms are served by more than 320 km (200 mi) of undersea gas and oil pipelines, as well as onshore facilities (see Section 3.11.2).

A number of routine activities would be necessary to provide for additional production; these activities have the potential to impact existing and future land use, development patterns, and infrastructure. This analysis of impacts, therefore, focuses solely on new production within the Cook Inlet.

Impacts of Routine Operations.

Seismic Explorations and Exploratory Drilling. As previously noted, activities associated with exploration typically include a seismic survey, exploratory well construction, and aircraft and vessel traffic (Figure 4.4.10-1). The impacts resulting from these activities are discussed below.

<u>Local Land Use/Comprehensive Planning and Development Patterns.</u> Seismic explorations and exploratory drilling would not directly impact land use, development patterns, and infrastructure within the Cook Inlet, because a majority of the activities would be located

offshore. During this phase, existing and future land use categorizations would remain largely unchanged, along with current development patterns.

In general, activities to support exploration would be located onshore within existing developments in order to act as staging areas for the seismic surveys and exploratory wells. Temporary onshore service bases could be needed to support offshore exploratory drilling operations. These bases would transfer materials between land and the offshore drilling rigs. In addition, supply vessels and helicopters would be used to shuttle personnel, equipment, and supplies. Existing facilities generally would be used within the Cook Inlet, if they were available in the selected location for exploration; if necessary, new facilities would be built, or prefabricated modules could be moved to the base of the exploration activities (Kenai Peninsula Borough 2008).

Loss of Use to Existing Landowners or Users. Activities associated with seismic explorations and exploratory drilling could affect access or use of a particular land area, to a limited extent. Some temporary onshore and offshore access restrictions could be necessary for safety reasons; however, these restrictions likely would be temporary, lasting only as long as the exploration activities.

The perception of loss of land or use, however, might increase among tribal communities,[19] local inhabitants, and visitors within the Cook Inlet. As offshore exploration includes the temporary siting of large drilling rigs and discharges of drilling muds and cuttings, some people using the coastal area for subsistence hunting and gathering or for recreation and tourism might perceive the effects of the drilling as a disruption to their regular activities (see Sections 4.4.13 and 4.4.14 for a further discussion of subsistence activities, Section 4.4.12 for a discussion of recreation and tourism, and Section 4.4.3.2 for a discussion of water quality). If the perceived disruption or "nuisance" becomes too intense, users may relocate to other parts of the Inlet in order to conduct their regular activities, in anticipation of the new oil and gas activities. Thus, the actual use of the land may be impacted, even if the intended land use designation or categorization is not altered. Within the Cook Inlet, these effects would likely be limited in extent, due to the presence of the existing oil and gas industry.

In addition, the use of individual properties in the vicinity of the exploration activities may be affected indirectly if excessive noise and air emissions generated by the exploratory equipment, activities, and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles) were to occur, or if a small increase in the amount of trash and debris washing ashore were to result from the activities. These occurrences may cause a temporary disturbance or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level of impact would depend on the specific location within the Cook Inlet.

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[19] Approximately 8.9% of all land within the Kenai Peninsula Borough is owned by Native Village and Regional Corporations. Large tracts of this type of land surround Nanwalek, Port Graham, Tyonek, Ninilchik, Seldovia, and Kenai. Some of the parcels have been used for logging, oil and gas extraction, and mining (Kenai Peninsula Borough 2005).

Physical and/or Infrastructural Composition. As noted in Table 4.4.1.2-1, approximately 4–12 exploration wells would be drilled within south central Alaska. Due to the existing oil and gas infrastructure already present, a minimal amount of additional machinery and staging area improvements would be needed in order to accommodate equipment and workers associated with exploration activities.

Onshore and Offshore Construction. Onshore and offshore construction could impact local land use and comprehensive planning and existing and planned development; access and use of particular properties; the physical and infrastructural composition of the Cook Inlet; and existing conditions as they pertain to emissions, waste, noise, and traffic (see Figure 4.4.10-2).

As indicated in Section 4.1.1-2, construction activities often include production well placement, pipeline placement, onshore construction, and aircraft and vessel traffic. Per the proposed development scenario within south central Alaska, construction of approximately one to three new platforms is anticipated, along with 40–241 km (25–150 mi) of new offshore pipeline and 80–169 km (50–105 mi) of onshore pipeline. Up to one new pipeline landfall also may be needed, as indicated in Table 4.4.1.1-3. Potential impacts of these activities are presented below.

Local Land Use/Comprehensive Planning and Development Patterns. Due to a long history of oil and gas development, existing land use categorizations in Cook Inlet often would be able to accommodate new leases for the proposed development scenario. As indicated in Section 4.4.1.2, existing infrastructure would be used to the extent possible, limiting the need for the acquisition of new sites for development.

Loss of Use to Existing Landowners or Users. Onshore and offshore construction generally would not interfere with or prevent use by existing owners or users within areas already used for oil and gas. As previously indicated, the use of existing facilities generally would be preferred over new construction. However, during construction activities, a temporary loss of access for some users may occur, even within an existing oil and gas development area. Restrictions on access may be put in place for safety reasons or to allow certain activities to occur. Depending on the location of the activities, the restrictions would be lifted after the completion of construction.

Likewise, some users of surrounding land may be inconvenienced by closure or restrictions on access routes or within areas used for subsistence activities. For example, within the Cook Inlet, as in other parts of Alaska, air carriers generally provide a large share of the cargo and passenger service to and within the State. Water transport, especially for large and heavy materials, also is an important component of the transportation network. Activities related to the construction may impact Alaska's air routes, air-terminal facilities, and barge-cargo services, causing delays or changes in scheduling or service (MMS 2002a). Consequently, the perceived impact associated with these restrictions or closures to access routes or land areas may weigh more heavily on permanent communities using surrounding lands or routes for subsistence activities or for daily employment than on temporary visitors or tourists.

While plans for oil and gas development generally would limit the amount of permanent loss of use, especially during construction, some users may be subject to this type of impact dependent on the specific location chosen. A permanent loss of use generally would be associated with land parcels in which land use categorizations were amended to allow for oil and gas construction activities. If new land were necessary in order to construct onshore facilities, such as a new pipeline or landfall, the acquisition process would need to follow all pertinent local, State, and Federal requirements.

In addition, the use of individual properties in the vicinity of the construction activities may be affected indirectly if excessive noise and air emissions generated by the construction equipment and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles) were to occur, or if a small increase in the amount of trash and debris washing ashore were to result from the activities. These occurrences may cause a temporary disturbance or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level of impact would depend on the specific location within the Cook Inlet

Physical and/or Infrastructural Composition. The physical and infrastructural composition of south central Alaska would be altered by the expansion and/or improvement of existing facilities, as well as by new construction. The extent of the impacts associated with these activities ultimately would depend on their specific location within the Cook Inlet. For example, this region has an inland network of oil and gas gathering distribution pipelines; one such community is Nikiski, which has existing oil and gas support facilities to account for current leasing (MMS 2007b). The basic onshore support and processing infrastructure that would be necessary to support the anticipated levels of activity are already in place within the Cook Inlet; these transport, loading, and storage capabilities would require expansion to handle an increased volume of produced crude oil rather than extensive construction of new facilities (MMS 2002a, 2007b).

While the oil and gas industry within Cook Inlet was one of the largest sources of high paying jobs within the last decade, natural gas production recently has provided a more stable source of employment. As a result, some of the aging infrastructure associated with offshore drilling is in poor repair, and thus would require updates, expansion, and/or other improvements (Fried and Windisch-Cole 2004). In these locations, new construction could be a more appropriate solution to accommodate offshore oil and gas production.

If new infrastructure were needed, it would be built either as infill within an existing industrial or port area or within an area recently designated for this type of development. A greater impact on the existing physical landscape would be experienced in those areas not already used for oil and gas production. For instance, the construction of the pipeline landfall could involve clearing land, preparing a ROW, and digging and backfilling trenches. Additional clearance could be necessary in order to accommodate the new onshore pipeline, as well. These types of activities or similar ones could alter the physical composition of the landscape, thus potentially limiting the intended, actual, or future use of a parcel. If needed, this type of construction would have extensive impacts in lands used for subsistence hunting or other similar activities.

Additional indirect impacts concern those associated with climate change. The southern half of Alaska has glacial characteristics that are complicated by erodible glacial deposits and high tides, which may impact infrastructure associated with oil and gas development. Cook Inlet already has a 10-m (30-ft) tidal range at its northern extreme and an eroding shoreline of glacially deposited bluffs (Smith and Levasseur 2002).

New facilities may be sited in different locations in response to anticipated rises in sea level, increased storm frequency and intensity, and temperature changes. Other activities that might be undertaken in response to real or potential climate change–induced rises in sea level include facility relocation, the construction of seawalls and storm surge barriers, and land acquisitions to create buffer areas (IPCC 2007).

Consequently, indirect impacts on land use, development patterns, and infrastructure could include locating further inland and/or strengthening foundations or building materials of existing facilities. These actions potentially could increase costs associated with development or force the construction of new facilities rather than the reuse or expansion of existing properties associated with oil and gas production. These decisions may be influenced by the potential for increased flooding and/or erosion, as well. For instance, climate change is expected to add approximately $5–10 billion to the State infrastructure budget depending on the climate change scenario under consideration. In addition, cost estimates for shoreline protection and village relocation continue to rise (CIER 2007). Costs would be largely for maintaining or replacing roads, runways, and water and sewer systems (Larsen et al. 2007).

Production Operations. Routine operations would include production well operation, onshore facility operation, and vessel and aircraft traffic, as well as the transport of oil from offshore to onshore locations using pipelines.

<u>Local Land Use/Comprehensive Planning and Development Patterns.</u> Once offshore oil and gas facilities were in operation,[20] only slight changes to land use, development patterns, and infrastructure would be expected, because a majority of the activities would be located offshore, with some activity occurring within onshore bases and transportation facilities.

In addition, as shown in Table 4.4.1-3, no new shore bases, processing facilities, or waste disposal facilities are associated with the proposed action. Since existing infrastructure would be used to the extent possible, the anticipated use of onshore facilities during normal operations would not be expected to generate noticeable changes to the current setting that would impact the overall land use, development patterns, or infrastructure of Cook Inlet.

<u>Loss of Use to Existing Landowners or Users.</u> Once offshore oil and gas facilities are in operation, a temporary or permanent loss of use would not be anticipated, because a sufficient number of facilities already are located within Cook Inlet to support the increased oil and gas development. At times, some access may be restricted within surrounding lands to accommodate a brief alteration in normal operations (e.g., an emergency response).

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[20] For the purposes of this evaluation, normal operations exclude events leading up to the production of offshore oil and gas.

Furthermore, the use of individual properties in the vicinity of the operating platforms may be affected indirectly if excessive noise and air emissions were generated from equipment and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles), or if a small increase in the amount of trash and debris washing ashore were to result from the activities. These occurrences may cause disturbances or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level and extent of impact would depend on the specific location within the Cook Inlet.

Physical and/or Infrastructural Composition. To the extent possible, existing facilities would be used and new facilities would be built only where necessary, once initial construction was completed. Since the anticipated new development is modest, large changes to the physical and/or infrastructural composition of Cook Inlet during the operation phase would not be expected.

Decommissioning. When activities for oil and gas become uneconomical to continue production operations or when a lease expires, many of the structures built for production would be dismantled, shut down, or converted to other uses. Typical government regulations require that offshore structures be cut off below the mud line and entirely removed, while pipelines often are left in place due to the high cost of removal. Offshore wells would be cemented in, and sea bottom well sites would be dragged to remove obstructions (Kenai Peninsula Borough 2008). Due to the physical nature of these activities, land use, development patterns, and infrastructure might be impacted directly. These impacts generally would be site-specific. In some cases, a return to pre-exploration and preconstruction conditions might not be feasible.

Local Land Use/Comprehensive Planning and Development Patterns. Depending on the location of the production wells and associated infrastructure, decommissioning activities onshore might be regulated by local land use, zoning, and comprehensive planning initiatives or requirements. In turn, local planning initiatives often account for developments of this nature in future planning. For instance, the continued use of the facilities after production could impact planned development in a positive manner, either by providing an opportunity for reuse of facilities or allowing for additional or future oil and gas activities (MMS 2007c).

Loss of Use to Existing Landowners or Users. No permanent loss of use is anticipated to occur during the decommissioning/reclamation phase. Some temporary loss might occur if road or area closures were necessary to accommodate equipment, workers, or specific deconstruction activities. If feasible, access would be restored to its preconstruction or operations state.

During decommissioning, the use of individual properties in the vicinity of the activities may be affected indirectly if excessive noise and air emissions were generated from equipment and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles), or if a small increase in the amount of trash and debris washing ashore were to result from the activities. These occurrences may cause temporary disturbances or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level and extent of impact would depend on the specific location.

Physical and/or Infrastructural Composition. In addition, potential changes to the physical and infrastructural makeup of Cook Inlet could occur. Any equipment added may be removed; other defunct equipment also could be removed. Impacts on land use and infrastructure would be site-specific. Moreover, if any offshore or onshore infrastructure were deemed a visual intrusion within the landscape for the duration of the project, removal of the structure during decommissioning would remove the feature, and thus help to alleviate the impact (MMS 2003a).

Impacts of Expected Accidental Events and Spills. The risk of a spill is present whenever crude oil or petroleum products are handled. Oil spills could be associated with the exploration, development, production, storage, and/or transportation processes and might occur from losses of well control or pipeline or tanker accidents. As shown in Table 4.4.2-1, approximately 1 large spill $\geq$1,000 bbl, 1 to 3 small spills $\geq$50 but $<$1,000 bbl, and 7 to 15 small spills $<$50 bbl, are anticipated to occur as part of new development within Cook Inlet. From 1999 to 2008, 18 crude oil spills of 380 L (100 gal) or more from pipelines, platforms, onshore production facilities, storage facilities, and marine tankers have occurred in Cook Inlet. Six of these were more than 1,900 L (500 gal) (ADNR 2009b).

Based upon knowledge acquired from previous spills, potential impacts to land use and infrastructure resulting from an oil spill would likely include moderate temporary stresses of the spill response on existing community infrastructure, increased boat and air traffic to respond to the spill and cleanup operations, and restrictions of access to a particular area while the cleanup is conducted (MMS 2007d). These stresses could lead to a temporary loss of use of certain parcels both for their intended and actual uses, but generally no permanent land use categorization changes.

Within Cook Inlet, a geographic response strategy (GRS) has been formulated to account for 17 sites within the central Cook Inlet, 18 sites for the southwest, 21 sites for Kachemak Bay, and 22 sites for the southeast. Strategies within this plan focus on minimizing the environmental damage, using a small response footprint, and selecting sites for equipment deployment that would not cause further harm (ADNR 2009b).

Impacts of an Unexpected Catastrophic Discharge Event. A CDE in the Cook Inlet Planning Area would be an unexpected, low-probability event (see Sections 4.3.3 and 4.4.2.2). The PEIS analyzes the impacts of an unexpected CDE in the Cook Inlet Planning Area that has a volume of 75 to 125 thousand bbl and lasts from 50 to 80 days (Table 4.4.2-2). These events have the potential to impact future development patterns if irreversible changes to the land composition occur within certain areas. For example, one of the largest events of this type occurred in 1989; it consisted of the *Exxon Valdez* discharge. This event led to the closure or disruption of many Cook Inlet businesses, including fisheries (ADNR 2009b).

A CDE would likely be a result of oil transport from a tanker carrying Arctic and Cook Inlet OCS oil from the Valdez terminal to U.S. ports (see Section 4.4.2.1 for additional information). In most cases, a worst-case oil discharge from an exploration facility, production facility, pipeline, or storage facility would be restricted by the maximum tank or vessel storage capacity or by a well's ability to produce oil.

Potential impacts to land use and infrastructure resulting from an unexpected CDE would likely include moderate to high temporary stresses of the spill response on existing community infrastructure and services (e.g., water and sanitation), increased boat and air traffic to respond to the spill and cleanup operations, and restrictions of access to a particular area while the cleanup is conducted (MMS 2007d). A CDE also may indirectly impact land use in the long term, as the local government would need to respond to increased demands for service, disruptions of normal business operations, increased use of municipal facilities, and increased costs associated with response activities (Russell et al. 2001). Some of these impacts may lead to more permanent changes in the way land is used within Cook Inlet, such as closure or disruptions of business as occurred for the *Exxon Valdez* event (ADNR 2009b).

Community impacts surrounding the *Exxon Valdez* event, for instance, included "infrastructure overloads, disruption to economic and occupational structures, and interrupted civic processes" (Gill et al. 2012). Numerous communities within the Cook Inlet region were directly oiled by the discharge (Russell et al. 2001). This has left subsurface oil in a relatively unweathered state, including a presence in recreational and commercial sites. The remaining oil may discourage the future use of some of these locations, as people may wish to avoid known patches of oil, potential locations in which oil may be present, and places where the oil has fully degraded (NOAA 2010e).

Immediately following the *Exxon Valdez* discharge, local communities were faced with initial housing and lodging shortages and excessive demands for services, as cleanup workers inundated the response areas (Gill et al. 2012). These additional stresses were largely a result of the remote nature of the communities affected; in some cases, these communities lacked airstrips, ports, and other support services necessary for conducting a large-scale response (Nuka Research and Planning Group 2007a).

Based on the studies of the *Exxon Valdez* event, the degree of impact on land use and infrastructure is influenced by many factors, including, but not limited to, spill location, spill size, type of material spilled, prevailing wind and current conditions, the vulnerability and sensitivity of the land use and infrastructure, and the response capability. As shown by the response to the *Exxon Valdez* event, some existing infrastructure is in place to be able to address this type of event. This would limit the potential for much larger effects to occur; however, some impacts associated with indirect uses of land still are apparent today from the *Exxon Valdez* event, thereby making the potential impacts associated with a CDE likely greater than one occurring in the GOM.

Impact Conclusions.

Routine Operations. Oil and gas exploration, development, and production activities in the Cook Inlet Planning Area would be a continuation of longstanding activities the area. The proposed action would not introduce new kinds of activities that would alter existing land uses. Routine operations associated with the addition of new oil and gas leases within Cook Inlet would result in negligible to minor impacts on land use, development patterns, and infrastructure. While Cook Inlet currently supports some oil and gas production, some minor impacts on land use, development patterns, and infrastructure would be anticipated to occur as a result of new leases. These impacts would vary in intensity dependent on specific location within the inlet. The existing infrastructure would help to limit the intensity of the impacts.

Expected Accidental Events and Spills. Expected accidental events and spills could have both direct and indirect effects on land use, depending on the type, size, location, and duration of the incident. If oil spills were to occur and were to contact the coast, overall impacts on land use and existing infrastructure typically would be minor (especially for small spills).

An Unexpected Catastrophic Discharge Event. In the unlikely event of a low-probability CDE within Cook Inlet, moderate impacts onland use, development patterns, and infrastructure would be expected. Major impacts would not be expected, in part because infrastructure exists in some locations to address this type of event. This would limit the potential for much larger effects to occur; however, impacts would likely be greater than those expected for the GOM planning areas.

4.4.10.3 Alaska – Arctic

Oil and gas production within the Arctic as a whole is not as developed as that in the GOM and Cook Inlet; however, this region includes the Beaufort Sea Planning Area, which has well-developed oil and gas industry infrastructure on adjacent land and in State waters. For instance, the Prudhoe Bay complex is located adjacent to the Beaufort Sea Planning Area. This is part of a large oil producing field, which contains extensive infrastructure (MMS 2007d).

As indicated in Table 4.4.1-4, oil production is anticipated to include 0.2 to 2.1 Bbbl within the Beaufort Sea and the Chukchi Sea. Therefore, a number of routine activities would be necessary to more fully develop this industry in order to provide for additional production within the Beaufort and Chukchi Seas region. As noted for the other areas, these activities have the potential to impact existing and future land use, development patterns, and infrastructure.

Impacts of Routine Operations. Routine activities include exploration, development, production, and decommissioning. Impacts on land use, development patterns, and infrastructure within the Beaufort and Chukchi Seas regions from each of these activities are presented below.

Seismic Explorations and Exploratory Drilling. Activities associated with exploration typically include a seismic survey, exploratory well construction, and aircraft and vessel traffic.

<u>Local Land Use/Comprehensive Planning and Development Patterns.</u> Seismic explorations and exploratory drilling would not directly impact land use, development patterns, and infrastructure, because a majority of the activities would be located offshore. During this phase, existing and future land use categorizations would remain largely unchanged.

<u>Loss of Use to Existing Landowners or Users.</u> Activities associated with seismic explorations and exploratory drilling could potentially affect access or use of a particular land area, to a limited extent. Some temporary safety-related restrictions on access might be

necessary both onshore and offshore; however, these restrictions likely would last only as long as the exploration activities.

For this area of Alaska, a scattered exploration pattern may be necessary due to the lack of existing oil and gas infrastructure. For this type of exploration pattern, more frequent and longer-duration helicopter and support boat trips would be needed than if a clustered pattern of exploration were utilized. For instance, platforms located beyond the landfast ice zone would require substantial helicopter support, especially during the developmental drilling phase, because they would be unreachable by ice roads. In addition, platforms located in the landfast ice zone could be served by vehicles traveling over ice roads (MMS 2007d). Local access to these transportation modes could be affected, to a limited extent, to account for the additional trips and traffic associated with this type of exploration. This would result in a perceived loss of use for some people either living, visiting, or working within the area.

Perceived loss of land or use might also increase among tribal communities, local inhabitants, and visitors within the coastal areas of the Beaufort and Chukchi Seas. Since offshore exploration includes the placement of wells and the production of drilling muds and cuttings, which may be discharged into the marine environment, some people using the coastal area may perceive the effects of the drilling as a disruption to their regular activities. If the perceived disruption or “nuisance” becomes too intense, users may relocate to other parts of the coast in order to conduct their regular activities. Thus, the actual use of the land may be impacted, even if the intended land use designation or categorization is not altered.

For example, as indicated in Section 4.4.13.3, residents of the Chukchi Sea communities have noted a concern over the loss of a subsistence lifestyle and the imposition of additional demands on communities to maintain new infrastructure either directly or indirectly related to oil and gas exploration and eventual production. “Residents of the Chukchi Sea coastal communities have been remarkably consistent in their primary concerns during the more than 20 years of public hearings and meetings on State and Federal oil development on the North Slope” (BOEMRE 2011j). Sections 4.4.13.3.1 and 4.4.14.3.1 provide additional information on the impacts to subsistence and tribal communities within the Arctic region resulting from oil and gas activities.

In addition, the use of individual properties in the vicinity of the exploration activities may be affected indirectly if excessive noise and air emissions were generated from equipment and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles), or if a small increase in the amount of trash and debris washing ashore were to result from the activities. These occurrences may cause disturbances or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level and extent of the indirect impacts would depend on the specific location within the Arctic region (BOEMRE 2011j).

<u>Physical and/or Infrastructural Composition.</u> As noted in Table 4.4.1-4, approximately 6–20 exploration and delineation wells and 40–280 development and production wells would be drilled within the Arctic. Machinery and staging area improvements would be needed in order to accommodate equipment and workers associated with these exploration activities. The increase in physical infrastructure likely would be very small at this stage of oil and gas development due

to the temporary nature of the exploration activities and the anticipated use of existing facilities, where available.

Onshore and Offshore Construction. Similar to the exploration phase, onshore and offshore construction have the potential to impact local land use and comprehensive planning and existing and planned development; access and use of particular properties; and the physical and infrastructural composition of the Beaufort and Chukchi Seas.

As indicated in Figure 4.4.10-2, activities associated with this phase often include production well placement, pipeline placement, onshore construction, and aircraft and vessel traffic. Per the proposed development scenario within the Arctic region, approximately 1–5 platforms are anticipated, along with 16–130 km (10–80 mi) of onshore pipeline. No new pipeline landfalls or shore bases are anticipated. This section provides a discussion of impacts associated with land use as they pertain to onshore and offshore construction.

Local Land Use/Comprehensive Planning and Development Patterns. Due to the minimal level of current oil and gas development within the whole of the Beaufort and Chukchi Seas, existing land use plans and designations may not provide for areas that are able to accommodate new leases. Therefore, changes to land use and comprehensive planning decisions, such as a conditional use permit or zoning change, are predicted as a result of the leasing and subsequent development activities, including construction. The need to address existing land use would depend on the specific location selected for onshore construction and on the activity to be conducted (e.g., the construction of onshore pipeline routes or new transportation routes).

For instance, according to the North Slope Borough (NSB) comprehensive plan, five major zoning districts are present, including the Village, Barrow, Conservation, Resource Development, and Transportation Corridor (MMS 2007b). “All areas within the NSB are in the Conservation District, unless they are specifically designated within the limited boundaries of a village or Barrow, a unitized oil field within the Resource Development District, or within the Trans-Alaska Pipeline System (TAPS) corridor” (MMS 2007b). As indicated by this statement, major land uses generally are divided between subsistence use and petroleum-resource extraction (MMS 2007b).

Due to the recognition of oil and gas activities, all of the NSB land management regulations address oil and gas leasing activities, including onshore and offshore (MMS 2007b). Therefore, within the NSB, conditional use permits may be requested that would allow for specific, temporary activities; in some cases, the more permanent development associated with production would require that a master plan be prepared describing anticipated activities. In addition, use of non-Federal land within the NSB may require rezoning from the Conservation District to the Resource Development District or Transportation Corridor (MMS 2007b).

While not a direct cause and effect relationship, if changes to overall land use categorizations or planning initiatives were needed to begin construction and subsequent development of oil and gas facilities, future development patterns could be impacted. If onshore construction were to occur within the Arctic region, various government agencies and jurisdictions would be involved in the change. Land ownership within the North Slope area consists of overlapping ownership interests, at times vague boundary descriptions, and informal or unrecorded land transfers. Surface and subsurface ownership interests are held by the Federal Government, State government, the borough, villages, regional and village Native corporations, and private individuals, including Native allotments. As in many areas, surface and subsurface owners may differ, particularly in communities and Native allotments (URS Corporation 2005).

In addition, if new infrastructure would be needed onshore, some facilities and infrastructure would be subject to other local, State, and/or other Federal permitting and regulations, including provisions for the siting of facilities. Specific timelines and requirements would vary by location, as BOEM typically is not the permitting or regulating agency for development activities that occur onshore.

Loss of Use to Existing Landowners or Users. Onshore and offshore construction generally has the potential to interfere with or prevent use by existing owners or users within areas not already used for oil and gas activities (see Section 4.4.13.3 and 4.4.14.3 regarding impacts on subsistence activities). While the use of existing facilities generally is preferred over new construction, few of these facilities exist within the whole of the Arctic region as compared to the GOM and Cook Inlet. As previously indicated, the Chukchi Sea Planning Area has relatively little established infrastructure, while well-developed oil and gas facilities are located within the Beaufort Sea Planning Area, such as at the Prudhoe Bay complex. Therefore, during construction, a temporary loss of access to some users may occur. Restrictions on access may be put in place as safety precautions or to allow certain activities to occur. Depending on the location of the activities, these restrictions could be lifted after construction was completed.

Users of surrounding lands also may be inconvenienced by closure or restrictions on access routes or within areas used for subsistence activities during construction. For instance, if platforms were constructed in part onshore, some marine subsistence hunters may have to avoid or navigate around them when preparing their crafts from an onshore location. Another example would include the construction of temporary roads for exploration drilling or permanent roads that may be constructed as a result of proposed activities. While roads could increase access to previously inaccessible areas, they also could also create community-development, land use-planning, or fish and game-management problems (ADNR 2009b). Consequently, the perceived impact associated with these restrictions or closures may weigh more heavily on communities using surrounding lands for subsistence activities than recreational users or tourists (see Sections 4.4.13.3.1 and 4.4.14.3.1 for additional information regarding subsistence activities).

In addition, the use of individual properties in the vicinity of the construction activities may be affected indirectly if excessive noise and air emissions were generated from equipment and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles), or if a small increase in the amount of trash and debris washing ashore were to result from the activities. These occurrences may cause disturbances or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level and extent of impact would depend on the specific location within the Arctic.

Physical and/or Infrastructural Composition. The physical presence of the shore-based and pipeline infrastructure within the Arctic region would represent an initial industrialization of the area and a long-term and significant change in land use patterns. This would result due to the change from an isolated and often pristine environment to one that supports oil and gas infrastructure. While new technologies and practices tend to be less damaging than those associated with past activities, the addition of these facilities has the potential to permanently alter the land use within the region (AMAP 2010).

In areas already developed with oil and gas infrastructure, such as in the Beaufort Sea Planning Area, the construction of oil and gas infrastructure would represent a continuation of industrial/commercial activity; however, in areas lacking existing infrastructure, it would account for a more substantial change in the industrial/commercial activity and diversity of individual villages (MMS 2007b). The extent of the impacts associated with these activities ultimately would depend on the specific location within the Arctic and the particular community in which facilities would be placed.

Impacts on infrastructural composition also would result from the development of onshore pipeline and a permanent road network in locations that do not already have existing oil and gas facilities. Depending on the location of a pipeline landfall, the path of an associated road to the Trans-Alaska Pipeline System (TAPS) might open up areas not previously reached by permanent roads. The positive benefits of this construction would be to aid future ice road and permanent road construction, as well as providing a connection to the North Slope communities (MMS 2007d). Some of the negative impacts of roadway construction would be the interference with subsistence uses and animal movement and the potential for increased traffic (see Sections 4.4.13.3.1 and 4.4.14.3.1 for more information).

Additional indirect impacts concern those associated with climate change. Much of the infrastructure that would be needed to support oil and gas facilities in the Beaufort and Chukchi Seas likely would cross or be located within the coastal zone, an area vulnerable to climate change impacts (Clow et al. 2011). Siting of new facilities, therefore, may need to account for potential changes resulting from rises in sea level, increased storm frequency and intensity, and temperature changes. Frost heave and thaw settlement also should be accounted for in the development of oil and gas facilities (Instanes 2007).

One of the more noticeable effects would be the thawing of permafrost on land. This can cause erosion, buckled roads, and broken pipelines that could affect the oil and gas industry (Johnston 2010). In the Arctic, facilities often use permafrost as a solid foundation for buildings, pipelines, and roads, and for containing waste materials. The anticipated design lifetime for structures in permafrost regions is typically 30–50 years. Within this time frame, the structure should be able to function as designed with normal maintenance costs, if potential changes to permafrost are considered (Instanes 2003). Warming, for instance, may degrade permafrost, which can harm existing facilities and prevent the use of permafrost in the future (AMAP 2007; MMS 2007d). "Projected climate change is very likely to have a serious effect on existing infrastructure in areas of discontinuous permafrost. Permafrost in these areas is already at temperatures close to thawing, and further temperature increases are very likely to result in extremely serious impacts on infrastructure" (Instanes 2007).

Consequently, indirect impacts on land use, development patterns, and infrastructure can include locating further inland and/or strengthening foundations or building materials of existing facilities. These actions potentially can increase costs associated with development or force the construction of new facilities rather than the reuse or expansion of existing properties associated with oil and gas production. These decisions also may be influenced by the potential for increased flooding and/or erosion.

Production Operations. Routine operation activities would consist of production well operation, onshore facility operation, and vessel and aircraft traffic. It also would include the transport of oil from offshore to onshore locations using ships or pipelines (see Figure 4.4.10-3). As indicated in Section 4.4.1.3, the PEIS assumes that the most likely locations for the occurrence of activities would be in areas that already have been leased in recent sales. One to 15 helicopter trips and 1 to 15 vessel trips would be anticipated.

Local Land Use/Comprehensive Planning and Development Patterns. Once in operation,[21] only very small changes to land use, development patterns, and infrastructure would be expected, since a majority of the activities would be located offshore, and no additional construction would be anticipated. In general, the production of oil and gas would need to be consistent with Federal, State, and local planning initiatives.

Loss of Use to Existing Landowners or Users. Once in operation, an additional loss of use is not anticipated. At times, some access may be restricted within surrounding lands to accommodate a brief alteration in operations or a peak in normal activities, or to conduct maintenance.

During operation, the use of individual properties in the vicinity of the operating platforms may be affected indirectly if excessive noise and air emissions were generated from equipment and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles), or if a small increase in the amount of trash and debris washing ashore were to result from the activities. These occurrences may cause disturbances or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level and extent of impact would depend on the specific location within the Arctic. For instance, in locations where subsistence activities occur, the impacts may be more noticeable and have a larger impact on certain communities as compared to other areas of the Arctic; a discussion of these impacts is provided in Sections 4.4.13.3.1 and 4.4.14.3.1.

Physical and/or Infrastructural Composition. To the extent possible, no new facilities would be built during normal operations. Therefore, the potential to create lasting changes to the physical and/or infrastructural composition of the Arctic region during the operation phase would be limited.

[21] For the purposes of this evaluation, normal operations are considered exclusive of events leading up to the production of offshore oil and gas.

Decommissioning. When activities for oil and gas production operations become uneconomical to continue, or when a lease is expired, many of the structures built for production are dismantled, shut down, or converted to other uses. Decommissioning activities in the Arctic typically involve permanently plugging wells (with cement), removing wellhead equipment, and removing the processing module from the platform. Pipelines also must be decommissioned, which involves cleaning the pipeline, plugging the ends, and leaving it in place, buried within the seabed. Onshore pipelines may be used for other purposes, if not removed (MMS 2008b). All decommissioning activities would abide by Federal regulations. Due to the physical nature of these activities and the length of the leases, land use, development patterns, and infrastructure may be impacted directly. These impacts, however, generally would be site-specific. In some cases, pre-exploration and preconstruction conditions may not be able to be reestablished.

Local Land Use/Comprehensive Planning and Development Patterns. Depending on the location of the production wells and associated infrastructure, decommissioning activities onshore may be regulated by local land use, zoning, and comprehensive planning initiatives or requirements.

In turn, local planning initiatives often account for developments of this nature in future planning due to the length of operation. For instance, the continued use of the facilities after production could impact planned development in a positive manner, either by providing an opportunity for reuse of facilities or by allowing for the potential for additional or future oil and gas development.

Loss of Use to Existing Landowners or Users. No permanent loss of use is anticipated to occur during the decommissioning/reclamation phase. Some temporary loss may occur if road or area closures are necessary to accommodate equipment, workers, or specific activities associated with this type of process. Access to and the physical composition of the industrial/port areas typically would be restored to its preconstruction or operations state to the extent possible.

In addition, the use of individual properties in the vicinity of the decommissioning activities may be affected indirectly if excessive noise and air emissions were generated from equipment and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles), or if a small increase in the amount of trash and debris washing ashore were to result from the activities. These occurrences may cause disturbances or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level and extent of impact would depend on the specific location within the Arctic.

Physical and/or Infrastructural Composition. In addition, potential changes to the physical and infrastructural composition of the Beaufort and Chukchi Seas would occur. Any equipment added may be removed; other defunct equipment also could be removed. These alterations would be site-specific. Moreover, if any offshore or onshore infrastructure were deemed a visual intrusion within the landscape for the duration of the project, removal of the structure during decommissioning would remove the feature, and thus alleviate the intrusion (MMS 2003a).

Impacts of Expected Accidental Events and Spills. One anticipated effect of oil and gas development within the Arctic is to extend infrastructure (e.g., landfalls and platforms) and associated activities westward. As a result of this construction, new areas of Alaska adjacent to the Beaufort and Chukchi Seas would be exposed to the potential effects of crude oil spills. Approximately 3 large spills ≥1,000 bbl, 10 to 35 small spills ≥50 bbl but <1,000 bbl, and 50 to 190 small spills <50 bbl, may be expected to occur with proposed development in the Beaufort and Chukchi Sea Planning Areas (Table 4.4.2-1). Consequently, crude oil spill-response equipment and personnel would be needed in those locations (MMS 2007d).

Expected accidental spills of oil or other chemicals are most likely to occur during the transfer of material from one vessel to another or to or from shore. These spills tend to be small and relatively easily contained. Other accidental spills could result from collisions or wrecks made more likely by an increase in marine traffic. The size and severity of such spills depend on the nature and location of the incident. Accidental spills could also result from the loss of well control or damage to pipelines. The effects of an oil spill vary with the size, location, and timing of the spill, along with the type of oil released.

As with other areas of Alaska, potential indirect impacts on land use and infrastructure resulting from small or large spills would likely include moderate temporary stresses from the spill response on existing community infrastructure; oil contamination at a coastal area; increased boat and air traffic to respond to the spill and cleanup operations; and restrictions of access to a particular area while the cleanup is conducted (MMS 2007d). These occurrences could lead to a temporary loss of use of certain parcels for both their intended and actual uses.

Impacts of an Unexpected Catastrophic Discharge Event. A CDE is an unexpected, very-low-probability accident that may occur during oil and gas development on the OCS (see Sections 4.3.3 and 4.4.2). For the Arctic region, the PEIS analyzes unexpected CDEs that range in size from 1.4 to 2.2 million bbl in the Chukchi Sea Planning Area and last 40 to 75 days, and from 1.7 to 3.9 million bbl in the Beaufort Sea Planning Area and that last 60 to 300 days (Table 4.4.2-2).

A CDE would have similar types of effects as spills of other magnitudes; however, the degree of impact would be more severe. For instance, the length of time in which the impacts would be experienced generally would be longer for this type of event (MMS 2007d; BOEMRE 2011j). Likewise, communities that are in close proximity to the event may experience a displacement of existing sociocultural patterns that could affect how they use the land (BOEMRE 2011j). Other changes may include the temporary and/or permanent usurpation of fishing grounds, port congestion/competition for berthing space, increased demand for services and housing, and increased vessel traffic. A CDE also can lead to delays in other infrastructure projects and the use of reserves and investments in local communities to pay for cleanup efforts rather than other planned projects (Picou et al. 2009). In particular, this type of event would have major effects on communities using land for subsistence activities. These impacts are discussed in detail in Section 4.4.13.3.2.

Responses to an unexpected CDE in the Arctic also would be complicated by the region's remote location and limited existing infrastructure (Nuka and Pearson 2010). For example, the closest major port on the U.S. Arctic coastline (i.e., Unalaska in the Aleutian Islands) is approximately 2,407 km (1,496 mi) from Point Barrow. Furthermore, only limited docking facilities are present along the Arctic coast; shallow water depths along the shoreline also make vessel access difficult. In addition, the few communities that are located in the Arctic are not connected to each other or to the rest of the State by onshore roadways. The few major airstrips that could handle cargo aircraft also are not connected to highways or docks (Kelso 2010). According to a Nuka and Pearson (2010) publication, a CDE on the scale of the DWH event likely would cripple the existing infrastructure in the Arctic.

As discussed for the GOM and the Cook Inlet, the degree of impact on land use and infrastructure is influenced by many factors, including, but not limited to, spill location, spill size, type of material spilled, prevailing wind and current conditions, the vulnerability and sensitivity of the land use and infrastructure, and the response capability. Due to the lack of existing spill response infrastructure within parts of the Arctic and the remote nature of the region, the degree of impact on land use and infrastructure within the Arctic likely would be moderate to major, if a CDE were to occur.

Impact Conclusions.

Routine Operations. Within the Arctic, minor to moderate impacts would be anticipated to result from the development of new oil and gas leases within the Beaufort and Chukchi Seas. Existing land use and infrastructure likely would be able to accommodate new leases. In general, land use changes would be needed only in locations where new onshore pipeline routes would be constructed and in areas requiring new transportation networks (MMS 2007b).

Expected Accidental Events and Spills. Expected accidental events and spills could have both direct and indirect effects on land use, depending on the type, size, location, and duration of the incident. If oil spills were to occur and were to contact the coast, overall impacts on land use and existing infrastructure typically would be minor (especially for small spills).

An Unexpected Catastrophic Discharge Event. In the unlikely event of a low-probability CDE within the Arctic, moderate to major impacts to land use, development patterns, and infrastructure would be expected. Impacts would be greater in areas with little infrastructure in place to handle accidents and where a greater reliance is placed on coastal activities for subsistence. There is limited existing infrastructure in place in the Arctic to be able to address this type of event; consequently, impacts of an unexpected CDE to land use would likely be greater in the Arctic than in the GOM and Cook Inlet Planning Areas.

4.4.11 Potential Impacts on Commercial and Recreational Fisheries

4.4.11.1 Gulf of Mexico

Impacts of Routine Operations.

Commercial Fisheries. Routine operations could affect commercial fisheries by causing changes in the distribution or abundance of fishery resources, reducing the catchability of fish or shellfish, precluding fishers from accessing viable fishing areas, or causing losses of or damage to equipment or vessels. Between 200 and 450 new platforms would be established under the proposed action, with up to 2,500 ha (6,177 ac) of seafloor likely to be disturbed by offshore platforms and up to 11,500 ha (28,417 ac) by pipelines. Impacts on commercial fishing activities would vary depending on the nature of a particular structure, the phase of operation, the fishing method or gear, and the target species group. Impacts would be higher for drifting gear such as purse nets, bottom longlines, and pelagic longlines than for trawls and handlines (MMS 2005f). Nevertheless, areas in which commercial fishing would be affected are small relative to the entire fishing area available to surface longlines or purse seiners.

To avoid potential conflicts and to maintain safety at large deepwater structures, a safety zone for vessels longer than 30 m (100 ft) may be established up to 500 m (1,640 ft) around each production platform, which would encompass up to approximately 80 ha (198 ac) of surface area per platform. The Fisherman's Contingency Fund, established under OSCLA, can compensate fisherman for property and economic losses related to obstructions caused by oil and gas development in the OCS. The Fund is composed of assessments paid by offshore oil and gas operations and administered by the NMFS (see www.nmfs.noaa.gov/mb/financial_services/fcf.htm).

Federal regulations (30 CFR 250.702(I)) require that, during decommissioning, all wellheads, casings, pilings, and other obstructions be removed to a depth of at least 5 m (15 ft) below the mud line or to a depth approved by the District Supervisor; the size of the area left untrawlable due to abandoned components would represent only a fraction of the total area excluded by oil and gas operations. Longlining would still be possible following decommissioning and removal because surface waters would not be affected by the presence of the remaining underwater components.

The impact of oil and gas structures on commercial fisheries at various depth ranges can be estimated using data in the Offshore Environmental Cost Model (OECM) (BOEMRE 2010c). The model assumes that there will be buffer zones of up to 0.8 km (0.5 mi) around new oil and gas structures, decreasing the area of ocean available for fishing. Although harvesting levels are not affected by offshore structures and pipelines, as these levels are below federally mandated levels, it is assumed that fishing activity will continue in areas still open for fishing, with existing harvesting levels remaining. Assuming that platforms would be placed in multiple depth ranges, rather than all platforms in a single depth range, OECM indicates that there will be an increase in fishing costs in the majority of depth ranges in each planning area. A platform placed in a depth range that produces decreasing fishing costs means that an additional platform in the depth range would reduce the cost impacts of platforms placed in other depth ranges.

The impacts of oil and gas development on commercial fishing costs would vary considerably by planning region and placement depth (Table 4.4.11-1). In the Western Planning Area, the largest cost increases would occur with structures located in water between 150 and 300 m (492 and 984 ft) deep, with an annual increase of $93 in costs from a single structure; a single structure in each depth range would increase annual costs by $147. In the Central Planning Area, overall increases in costs would be much larger at $1,080 per year, with the largest increase coming with a single structure placed in water between 150 and 300 m (492 and 984 ft). Cost impacts in the Eastern Planning Area would be minimal, at $2 per year with a structure in each depth range. In each of the planning areas, single structures would have relatively insignificant impacts compared to fishery revenues in each depth range.

Under the proposed action alternative, between 44 and 80 platforms would be located in the depth range 0 to 60 m (0 to 197 ft) in the Western Planning Area, with between 122 and 257 such platforms in the Central Planning Area. Offshore oil and gas structures placed within this depth range would increase annual commercial fishing costs by between $1,993 and $3,819 in the Western Planning Area, while reducing costs by between $2,507 and $11,243 in the Central Planning Area. No data is currently available on the placement of offshore platforms in the Eastern Planning Area, and consequently, their impact on commercial fishing costs.

Recreational Fisheries. The level of impacts on recreational fisheries in the GOM due to routine operations under the proposed action would be similar to impacts during the previous lease period. Biological resources that serve as the basis for recreational fisheries in the GOM are expected to be only minimally affected by activities associated with routine operations. Construction activities would primarily affect soft bottom species such as red drum, sand sea trout, and spotted sea trout that are sought by anglers in private or charter/party vessels. Such conflicts would be temporary, however, as fishes would eventually return to disturbed areas. The presence of offshore platforms may have a positive effect on the availability of recreational fishing opportunities. During 1999, for example, approximately 20% of private boat fishing trips, 32% of charter boat fishing trips, and 51% of party boat fishing trips in the western and central GOM (Alabama, Mississippi, Louisiana, and Texas) took recreational fishers within 91 m (300 ft) of oil or gas structures (Hiett and Milon 2002), as the presence of structures is known to aggregate pelagic (e.g., king mackerels, tunas, and cobia) and reef-associated fish species (e.g., red snapper, gray triggerfish, and amberjack) that are targeted by many recreational fishers.

Impacts of Expected Accidental Events and Spills.

Commercial Fisheries. Under the proposed action, up to 8 large spills greater than 1,000 bbl, between 35 and 70 spills between 50 bbl and 1,000 bbl, and up to 400 small spills less than 50 bbl could occur within the northern GOM. Most of the fish species inhabiting shelf or oceanic waters of the GOM have planktonic eggs and larvae (Ditty 1986; Ditty et al. 1988; Richards and Potthoff 1980; Richards et al. 1993). Certain species, such as triggerfishes, deposit demersal eggs but have larvae that take up residence in the water column, meaning that these species would also be affected by oil spills. Depending on the location and timing of particular

TABLE 4.4.11-1 Impacts of a Single Oil and Gas Structure on Commercial Fisheries, by Placement Depth ($2010)

	Western Planning Area		Central Planning Area		Eastern Planning Area	
Placement Depth Range	Fishery Revenue ($m)[a]	Cost Impact ($)	Fishery Revenue ($m)[a]	Cost Impact ($)	Fishery Revenue ($m)[a]	Cost Impact ($)
0 to 60 m	103.4	41.24	153.5	–165.82	64.4	–0.52
60 to 150 m	22.6	16.73	40.4	21.00	17.7	0.24
150 to 300 m	8.3	92.89	26.1	916.09	9.4	–0.92
300 to 1,500 m	74.4	–5.95	180.3	224.17	22.3	2.15
More than 1,500 m	45.4	2.11	402.7	84.91	54.4	0.76
All depths	254.1	147.03	803.1	1,080.40	168.2	1.70

[a] Average harvest values for the period 2006 to 2009.

Source: BOEMRE 2010c.

spills, effects would be greater if local water currents retained planktonic larvae and floating oil within the same water mass for extended periods of time. In deepwater areas, adults of highly migratory fish species, including pelagic species such as tunas, sharks, and billfish, would move away from surface oil spills. Pelagic larvae and neuston would not be able to move away from the spilled oil on the surface and would most likely be killed or injured. However, these impacts are not expected to cause population reductions in most commercially exploited species. In coastal areas, long-term but temporary degradation of estuarine habitat could occur if a large coastal area was oiled following a large or very large oil spill. Although some wetland areas may not recover completely, it is anticipated that spills considered possible as a result of the proposed action are not likely to substantially threaten the overall viability of wetland habitats used by commercially important species. On the basis of the potential level of impacts on coastal habitats including wetlands and submerged seagrass beds under the proposed action, major declines in fish population are not likely to occur.

In general, the level of effects from accidental spills would depend on the location, timing, and volume of spills in addition to other environmental factors. Small spills would be unlikely to affect a large number of fish or commercial fishing before dilution and weathering reduced concentrations; therefore, they would not have long-term effects on commercial fisheries in the GOM. It is anticipated that any single large spill would affect only a small proportion of a given fish population within the GOM and that fish resources would not be affected in the long term. However, localized effects on commercial fishing could result as a consequence of reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods.

***Recreational Fisheries*.** The magnitude of effects from accidental spills would depend on the location, timing, and volume of spills, in addition to other environmental factors. Small spills that may occur under the proposed action are unlikely to affect a large number of fish or have a substantial effect on recreational fishing before dilution and weathering reduced concentrations of oil in the water. Consequently, it is anticipated that small spills would not have substantial or long-term effects on recreational fishing in the GOM. Any single large spill would likely affect only a small proportion of a given fish population within the GOM, and it is unlikely that fish resources would be affected in the long term. However, spills could have localized effects on recreational fishing as a consequence of contamination of fish tissues, degradation of aesthetic values that attract fishers, or temporary closure of fishing areas. On the basis of the number and size of spills assumed for the proposed action, persistent degradation of shorelines and waters are not likely to occur; therefore, impacts on recreational fishing are not expected to be significant. Impacts of spills on subsistence resources are also discussed in Section 4.4.13 and 4.4.14.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes a CDE in the GOM planning areas that ranges in size from 0.9-7.2 million bbl and has a duration of 30–90 days (Table 4.4.2-2). The magnitude of effects from a CDE would depend on the location, timing, and volume of the oil associated with the event. Oil from a CDE could contact intertidal habitat and subsequently contaminate or reduce the abundance of commercial and recreational species that depend on nearshore habitat. However, it is likely that an event would only affect a small proportion of fish species population, and it is unlikely that fish resources would be affected in the long term. See Sections 4.4.7.3.1 and 4.4.7.5.1 for a discussion of the potential impacts of a CDE on fish and invertebrate populations in the GOM.

Following a CDE, in the short term there would be local or regional effects on commercial fishing that as a result of reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods, and on recreational fishing as a consequence of contamination of fish tissues, the degradation of aesthetic values that attract fishers, and the likely temporary closure of fishing areas. For example, the DWH event had immediate effects on the GOM fishing industry between April and November 2010, with up to 40% of Federal waters being closed to commercial fishing in June and July (Congressional Research Service 2011) and between 25% and 95% of State waters closed to fishing (Congressional Research Service 2011). The impact of the DWH event on fishery landings is still being investigated (McCrea-Strub et al. 2011). Because consumer perceptions of GOM seafood and seafood products may affect demand, future sales of GOM fisheries' production may be lost (Congressional Research Service 2010). A CDE, such as that followed the DWH accident, could have more noticeable impacts on recreational fishing activity, as well as on individuals and firms that depend on angler spending. Spill effects can be mitigated to some extent through financial compensation and through policies of Federal and State fisheries management agencies.

Impact Conclusions.

Routine operations. Routine operations could affect commercial fisheries by causing temporary changes in the distribution or abundance of fishery resources, by reducing the catchability of fish or shellfish, precluding fishers from accessing viable fishing areas, or causing losses of or damage to equipment or vessels. No population-level effects or long-term loss of fishery resources are expected to result from routine operations in the GOM. Impacts on commercial and recreational fisheries from routine Program activities are expected to be minor.

Expected Accidental Events and Spills. The magnitude of effects from accidental spills would depend on the location, timing, and volume of spills, in addition to other environmental factors. Small spills that may occur under the proposed action are unlikely to affect a large number of fish or have a substantial effect on recreational fishing before dilution and weathering reduced concentrations of oil in the water. Consequently, it is anticipated that small spills would have little effect on commercial and recreational fishing. Any single large spill would likely affect only a small proportion of a given fish population within the GOM, and it is unlikely that fish resources would be affected in the long term. However, large spills could have localized effects on commercial fishing that could result as a consequence of reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods, and on recreational fishing as a consequence of contamination of fish tissues, degradation of aesthetic values that attract fishers, or temporary closure of fishing areas. Oil from large or very large spills could contact intertidal habitat and subsequently contaminate or reduce the abundance of commercial and recreational species that depend on nearshore habitat. Impacts from a large spill could be long-term, but are not expected to result in the long-term loss of fishery resources. Impacts on fisheries from an accidental spill could range up to moderate.

An Unexpected Catastrophic Discharge Event. In the event of a CDE, fishery recoveries could be impacted on a manner similar to that from a large spill. However, a larger proportion of a fish population could be affected, and impacts could be much more long-term in duration. Overall, impacts on commercial and recreational fishing from a CDE are expected to be moderate.

4.4.11.2 Alaska – Cook Inlet

Impacts of Routine Operations.

Commercial Fisheries. With one to three new platforms to be established under the proposed action, up to 4.5 ha (11 ac) of seafloor would be disturbed by offshore platforms, and up to 210 ha (519 ac) by pipelines. Impacts on commercial fishing activities would vary, depending on the nature of a particular structure, the phase of operation, fishing method or gear, and target species group. Routine operations could affect commercial fisheries by causing changes in the distribution or abundance of fishery resources, by reducing the catchability of fish or shellfish, by precluding fishers from accessing viable fishing areas, or by causing losses of or damage to equipment or vessels. It is anticipated that routine operations would not result in detectable effects on overall populations of fishery resources in Cook Inlet. Temporary displacement of fishery resources from localized areas could occur as a consequence of noise and activities associated with construction activities during development; however, these resources would be expected to return once construction disturbances have been terminated. Following platform construction, there could be some highly localized long-term changes in fish densities and species diversity in the vicinity of platforms due to attraction of some invertebrate and fish species.

Some exploration, development, and production activities have a potential to result in space use conflicts with commercial fishing activities. Seismic exploration vessels towing long cables have had a history of conflicts with the commercial fishing industry in Cook Inlet (MMS 2003a), including losses of crab pots, longlines, or other gear. In some cases, commercial fishing vessels could be excluded from normal fishing grounds to avoid the potential for gear loss. In addition, some studies have found a temporary reduction in fisheries' catch during or following seismic surveys (Skalski et al. 1992; Engås et al. 1996; reviewed in Popper and Hastings 2009). Such conflicts can sometimes be avoided by conducting seismic surveys during closed fishing periods or closed seasons. A potential also exists for loss of gear or access to fishing areas when floating drill rigs used for exploration are being moved and during other vessel operations.

Offshore construction of platforms could infringe on commercial fishing activities by excluding commercial fishing from adjacent areas due to safety considerations. It is assumed that up to three production platforms could be constructed as a consequence of leasing in the Cook Inlet Planning Area. If it is assumed that a safety zone of 500 m (1,640 ft) is maintained by larger vessels around each production platform, commercial fishing could be excluded from up to 160 ha (395 ac) of surface area within the planning area. Drilling discharges associated with exploration activities would likely affect only a small area near a drilling platform, and are not expected to interfere with commercial fishing. During development and production phases, potential effects of such discharges would cease because all muds, cuttings, and produced water would be discharged into wells instead of being released to open waters. Potential effects of platform construction and operation are expected to be highly localized.

Construction of pipelines can result in entanglement hazards for some types of fishing gear. The presence of an offshore pipeline would not typically interfere with the use of longlines, purse seines, drift nets (MMS 2004a), or beach seines. However, a bottom trawl, such as those employed by the commercial groundfish industry in Cook Inlet, has a potential to become snagged on exposed pipelines. It is estimated that up to 241 km (150 mi) of additional offshore pipeline could result from lease sales in the Cook Inlet Planning Area, thereby increasing the potential for snagging on pipelines by bottom trawling equipment, unless subsea pipelines are buried in trenches.

It is anticipated that the small increase in vessel activity that could occur as a result of additional lease sales in Cook Inlet under the proposed action (up to six additional trips per week) would not measurably affect commercial fishing opportunities, catchability of fish and shellfish resources, or navigation by commercial fishing vessels.

The impact of oil and gas structures on commercial fisheries at various depth ranges can be estimated using data from the OECM (BOEMRE 2010c). The model assumes that there will be buffer zones of up to 0.8 km (0.5 mi) around new oil and gas structures, decreasing the area of ocean available for fishing. Although harvesting levels are not affected by offshore structures and pipelines, as these levels are below federally mandated levels, it is assumed that fishing activity will continue in areas still open for fishing, with harvesting levels remaining. Assuming that platforms would be placed in multiple depth ranges, rather than all platforms in a single depth range, OECM indicates that there will be an increase in fishing costs in the majority of depth ranges in each planning area. A platform placed in a depth range that produces decreasing fishing costs means that an additional platform in the depth range would reduce the cost impacts of platforms placed in other depth ranges.

The impacts of oil and gas development on commercial fishing costs would vary considerably by placement depth (Table 4.4.11-2). In the Kodiak area, the largest cost increases would occur with structures located in water between 300 and 1,500 m (984 and 4,921 ft) deep, with an annual increase of $34 in costs from a single structure; a single structure in each depth range would increase annual costs by $44. In the Cook Inlet area, the largest increase would come with a single structure placed in water between 150 and 300 m (492 and 984 ft), with an overall increase in costs of $57 per year. In each of the areas, single structures would have relatively insignificant impacts compared to fishery revenues in each depth range.

***Recreational Fisheries*.** In general, routine operations associated with exploration, development, or production activities could affect recreational fisheries by causing changes in the distribution or abundance of fishery resources, by reducing the catchability of fish and shellfish, by precluding fishers from accessing viable fishing areas, or by causing losses of or damage to equipment or vessels. It is anticipated that routine operations would not result in detectable effects on overall populations of fishery resources in Cook Inlet. Temporary displacement of fishery resources from localized areas could occur as a consequence of noise and bottom-disturbing activities associated with routine operations. Following platform construction, there could be long-term localized changes in fish densities and species diversity due to the attraction of some invertebrate and fish species to platforms.

Seismic surveys could temporarily affect the behavior of some targeted species, thereby affecting catch rates in the immediate area of the surveys. Some recreational anglers could decide to avoid areas during seismic surveys due to the potential for loss of fishing gear, due to the increased vessel activity, or because of perceived or actual changes in catchability. It is estimated that new areas in the Cook Inlet Planning Area could be subjected to seismic surveys during the Program. However, given the relatively small proportion of the available Cook Inlet area that would be affected at any particular time, it is not anticipated that seismic surveys would greatly disrupt recreational fishing activities.

Offshore construction of platforms could infringe on some recreational fishing activities by excluding recreational fishing boats from adjacent areas for safety considerations. It is assumed that up to three production platforms could be constructed as a consequence of lease sales in the Cook Inlet Planning Area. However, the area lost to recreational fishing would be limited to the immediate footprint of the platforms plus a small safety zone surrounding each platform; only a very small proportion of available recreational fishing areas in Cook Inlet would be affected. The presence of such platforms could also benefit anglers by aggregating some pelagic or groundfish species.

Vessel traffic to provide support to OCS activities could increase by one to three trips per week. This would constitute a very small increase in overall vessel traffic in Cook Inlet. The potential increase in daily helicopter trips in the Cook Inlet area would not be expected to affect recreational fishing activities. Disturbances of recreational fishing opportunities from other activities associated with routine operations (e.g., pipeline construction) are also expected.

TABLE 4.4.11-2 Impacts of a Single Oil and Gas Structure on Commercial Fisheries, by Placement Depth ($2010)

	Kodiak		Cook Inlet	
Placement Depth Range	Fishery Revenue ($m)[a]	Cost Impact ($)	Fishery Revenue ($m)[a]	Cost Impact ($)
0 to 60 m	15.6	–3.34	7.3	–0.04
60 to 150 m	43.7	9.87	2.6	3.88
150 to 300 m	22.8	3.32	7.0	53.50
300 to 1,500 m	23.4	34.07	0.1	0.0
More than 1,500 m	1.3	0.26	0.0	0.0
All depths	106.9	44.18	17.0	57.35

[a] Average harvest values for the period 2006 to 2009.

Source: BOEMRE 2010c.

Impacts of Unexpected Accidental Events and Spills.

***Commercial Fisheries*.** Fisheries resources could become exposed to oil as a consequence of accidental oil spills. One large spill greater than 1,000 bbl, up to 3 spills between 50 and 1,000 bbl, and up to 15 small spills less than 50 bbl could occur in the Cook Inlet area from the proposed action.

Although pelagic fishes would be less likely to be affected than fishes in shallow subtidal or intertidal areas, oil spills could contaminate gear used for commercial fishing, such as purse seines and or drift nets. A large oil spill before or during the season when such fishing gears are in use could result in closures of some short-period, high-value commercial fisheries in order to protect gears or harvests from potential contamination. Lines from longline fisheries for halibut, Pacific cod, black cod, and other fish species could also be affected by oil. Some lines and buoys fouled with small amounts of oil could be unfit for future use. Although it is unlikely that a trawler would be operating in an oiled area, the trawl catches could be contaminated by oil and rendered unfit for consumption if the trawler did pass through such an area.

The bays and beaches of Cook Inlet have a number of setnet sites where gillnets are anchored to the beach or slightly offshore, and are used to harvest salmon and herring. Oil spills could damage setnet fisheries, as evidenced by the *Exxon Valdez* oil spill in 1989. While only a relatively small volume of weathered oil entered the lower Cook Inlet region as a result of the *Exxon Valdez* spill, the commercial salmon fishery was closed to protect both gear and the harvest from possible contamination.

Multiple small spills or a single large spill could cause declines in subpopulations of some species inhabiting the Cook Inlet Planning Area, although the level of effects would depend on a variety of factors. It is anticipated that there would be no long-term effects on overall fish populations in the central Gulf of Alaska. However, even localized decreases in stocks of fish could have effects on some commercial fisheries by reducing their catch or increasing the amount of effort or the distances that must be traveled to obtain adequate catches. Even if fish stocks are not reduced as a consequence of a spill, specific fisheries could be closed due to actual or perceived contamination of fish or shellfish tissues. Larger spills in Cook Inlet would probably result in the area being temporarily closed to commercial fishing until cleanup operations or natural processes reduced oil concentrations in fishery areas to levels considered safe. The Cook Inlet commercial shellfish industry is likely to be affected by closures because such a spill would be likely to affect shellfish in nearshore subtidal and intertidal areas. Fisheries for shellfish that occur in deeper waters, where oil residues seldom reach, are less likely to be closed. Shellfish from deeper areas could become commercially unacceptable for market due to actual or perceived contamination and tainting.

Closure of Cook Inlet to commercial fishing activities could result in considerable loss of income. Based on analyses conducted by MMS for Cook Inlet oil spills of the same sizes assumed for large spills in this analysis and assumptions about the value of commercial fisheries in Cook Inlet, it was estimated that a large oil spill in lower Cook Inlet could result in economic losses to commercial fisheries for up to 2 yr (MMS 2003a), and, depending on the timing and location of a spill, it was also considered possible that the fishery could be closed for a whole season, resulting in a 100% loss for a given year.

***Recreational Fisheries*.** Recreational fishery resources could be exposed to oil as a consequence of accidental oil spills. Up to 1 large spill greater than 1,000 bbl, up to 2 spills between 50 and 1,000 bbl, and up to 10 small spills less than 50 bbl could occur in the Cook Inlet area from the proposed action.

While it is anticipated that these spills would not affect the overall populations of fishes in the central Gulf of Alaska, some fish stocks in localized areas of Cook Inlet could be affected. Populations of intertidal organisms could be depressed measurably for a year or more in intertidal areas contacted by spilled oil. Oil contacting beaches could affect clam gathering by depressing clam populations or tainting tissues of clams. The magnitude of such effects would depend upon many factors, including the volume of oil spilled, weather conditions, prevailing currents, locations, oil spill response actions, and whether the oil reached sensitive habitats for fishery resources. Declines in localized fish stocks could affect recreational fishing success and businesses associated with providing recreational and sport fishing opportunities.

An oil spill could result in a closure of ports in an effort to protect the ports and vessels from being oiled. Oil spills could potentially cause economic losses for boat owners and anglers by contaminating vessels and fishing gear. Oiled vessels would need to be cleaned and oiled gear either cleaned or replaced; potential individual costs are expected to be relatively small. It is anticipated that many anglers would choose to fish in alternate areas in the event of port closures. Charter operators could be inclined to temporarily avoid going out of port into Cook Inlet to avoid fouling their gear and vessels with oil. Public perception of oil spill damage could temporarily reduce the number of anglers. If so, anglers would likely target alternate fishing areas until they deemed that the quality of the fishing experience in the oil spill area had returned to previous conditions.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes a CDE in the Cook Inlet Planning Area that ranges in size from 75 to 125 thousand bbl and has a duration of 50 to 80 days (Table 4.4.2-2). The magnitude of effects from a CDE would depend on the location, timing, and volume of the oil associated with the event. Oil from a CDE could contact intertidal habitat and subsequently contaminate or reduce the abundance of commercial and recreational species that depend on nearshore habitat. Very large oil spills could have greater impacts, especially if the oil reached large areas of intertidal habitat. Studies following the *Exxon Valdez* oil spill suggest that a CDE could have the potential to reduce or contaminate populations of recreationally popular salmon and shellfish in heavily oiled areas for more than 10 years. For example, pink salmon had elevated egg mortality for at least 4 years after the spill (Peterson et al. 2003), and littleneck and butter clam populations were reduced for a decade after the spill, although much of the slow recovery may have resulted from cleanup methods used in intertidal areas (*Exxon Valdez* Oil Spill Trustee Council 2009a). Contamination of shellfish may persist even after populations recover. Species less dependent on intertidal soft sediments, such as rockfish, are less likely to be affected. Impacts of spills on subsistence resources are discussed in Section 4.4.13 and Section 4.4.14.

Following a CDE, in the short term, there would be local or regional effects on commercial fishing that as a result of reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods, and on recreational fishing as a consequence of contamination of fish tissues, the degradation of aesthetic values that attract fishers, and the likely temporary closure of fishing areas. Because consumer perceptions of seafood and seafood products may affect demand, future sales of fisheries' production may be lost following a CDE. A CDE, such as that following the *Exxon Valdez* accident, could have more noticeable impacts on recreational fishing activity, as well as on individuals and firms that depend on angler spending, although studies of recreational visitation in Alaska after the accident indicated that while consumer perceptions of the spill and its impact in visitor surveys were negative, only a small percentage of visits were actually affected (see Section 3.13.6). Spill effects can be mitigated to some extent through financial compensation and through policies of Federal and State fisheries management agencies.

Impact Conclusions.

Routine Operations. Routine operations could affect commercial fisheries by causing changes in the distribution or abundance of fishery resources, by reducing the catchability of fish or shellfish, precluding fishers from accessing viable fishing areas, or causing losses of or damage to equipment or vessels. No population-level effects or long-term loss of fishery resources are expected to result from routine operations in Cook Inlet. Impacts on commercial and recreational fisheries from routine Program activities are expected to be minor.

Expected Accidental Events and Spills. The magnitude of effects from accidental spills would depend on the location, timing, and volume of spills, in addition to other environmental factors. Small spills that may occur under the proposed action are unlikely to affect a large number of fish or have a substantial effect on recreational fishing before dilution and weathering reduced concentrations of oil in the water. Consequently, it is anticipated that small spills would have little effect on commercial and recreational fishing. Any single large spill would likely affect only a small proportion of a given fish population within Cook Inlet, and it is unlikely that fish resources would be affected in the long term. However, large spills could have localized effects on commercial fishing that could result as a consequence of reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods, and on recreational fishing as a consequence of contamination of fish tissues, degradation of aesthetic values that attract fishers, or temporary closure of fishing areas. Oil from large or very large spills could contact intertidal habitat and subsequently contaminate or reduce the abundance of commercial and recreational species that depend on nearshore habitat. Impacts from a large spill could be long-term. Impacts on fisheries from an accidental spill could range up to moderate.

An Unexpected Catastrophic Discharge Event. In the event of a CDE, fishery recoveries could be affected in a manner similar to that from a large spill. However, a larger proportion of a fish population could be affected, and impacts could be much more long-term in duration. Overall, impacts on commercial and recreational fishing from a CDE are expected to be moderate.

4.4.11.3 Alaska – Arctic

Impacts of Routine Operations. There is a relatively small salmon fishery in Kotzebue Sound in Hope Basin, but there are no commercial fisheries in the Chukchi Sea Planning Area where routine operations would occur (MMS 2006b). Consequently, no impacts from routine operations are anticipated. The single commercial fishery in the Beaufort Sea is for cisco and whitefish on the Colville River during the summer and fall months. The potential for negative effects on this fishery would be related to the timing of exploration and development activities and the proximity of those activities to the mouth of the Colville River. Because exploration and development of this area has already occurred, it is considered unlikely that there would be substantial levels of additional development as a result of the proposed action. In addition, impacts would be limited in scope as a result of adherence to mitigation measures and compliance with Federal, State, and local requirements and protective measures. Therefore, impacts on this fishery are also anticipated to be limited in scope. Similarly, impacts on recreational fisheries from routine operations are not anticipated, as little recreational fishing occurs in the Beaufort Sea and Chukchi Sea Planning Areas (NPFMC 2010).

Although commercial fishing is limited in the Beaufort Sea and Chukchi Sea Planning Areas, commercial fishing in the Arctic may become more viable if predicted warming trends continue. There is evidence that commercially harvested species such as snow crab, walleye pollock, and yellowfin sole are expanding northward (NMFS 2009b). If, in the coming decades, commercially viable populations develop in the Arctic and if commercial fishing is permitted in Federal waters, oil and gas developments have the potential to affect these activities, as described in Sections 4.4.11.1.1 and 4.4.11.2.1.

Impacts of Unexpected Accidental Events and Spills. Up to 3 large spills greater than 1,000 bbl, between 10 and 35 spills between 50 and 1,000 bbl, and up to 190 small spills of less than 50 bbl could occur in the Beaufort and Chukchi Sea areas from the proposed action.

Recreational fishing in the Beaufort and Chukchi Sea Planning Areas is very limited and generally occurs only at larger population centers. However, where and when recreational fishing does occur, an oil spill could reduce fishing activity or contaminate fishery resources. Commercial fishing in the Beaufort and Chukchi Sea Planning Areas is restricted to the Colville River. The occurrence of an oil spill near commercial fishing areas during the fishing season could have effects on particular fisheries and the local economies that depend on them. Oil spills typically result in the closure of fishing grounds and reduced or lack of harvest. Even if harvest continues, the perception of a tainted product could reduce the economic value of fish harvested in the vicinity of an oil spill or could even cause fish to be removed from markets.

Spills could foul fishing gear, result in fish contamination and mortality, and potentially close some fishing grounds or entire fisheries for one or more years. A large spill could also increase competition on alternative fishing areas that remain open, resulting in increased costs and/or reduced harvests for individual fishermen. There is a reduced chance of a spill occurring during pulse fisheries of short duration, such as those for salmon, herring, or whitefish, because of the relatively short period of time that such fisheries are open. However, if a spill were to occur during operation of such a fishery, potential impacts would include a total loss of commercial fishing harvest due to the inability to switch to an alternative fishing time or area. Impacts of spills on subsistence resources are discussed in Section 4.4.13 and Section 4.4.14.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes a CDE in the Chukchi Sea Planning Area that ranges in size from 1.4-2.2 million bbl and has a duration of 40–75 days, and a CDE in the Beaufort Sea Planning Area with a volume of 1.7-3.9 million bbl and a duration of 60–300 days (Table 4.4.2-2). The magnitude of effects from a CDE would depend on the location, timing, and volume of the oil associated with the event. Oil from a CDE could contact intertidal habitat and subsequently contaminate or reduce the abundance of commercial and recreational species that depend on nearshore habitat. However, it is likely that an event would only affect a small proportion of fish species population. Although commercial and recreational fishing in the Arctic region are of minor economic significance, in the short term, there would be local and regional economic impacts resulting from reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods, and on recreational fishing as a consequence of contamination of fish tissues, the degradation of aesthetic values that attract fishers, and the likely temporary closure of fishing areas.

Because consumer perceptions of seafood and seafood products may affect demand, future sales of fisheries' production may be lost following a CDE. A CDE, such as that following the *Exxon Valdez* accident, could have more noticeable impacts on recreational fishing activity, as well as on individuals and firms that depend on angler spending, although studies of recreational visitation in Alaska after the accident indicated that while consumer perceptions of the spill and its impact in visitor surveys were negative, only a small percentage of visits were actually affected (see Section 3.13.6). Spill effects can be mitigated to some extent through financial compensation and through policies of Federal and State fisheries management agencies.

Impact Conclusions.

Routine Operations. Routine operations could affect commercial fisheries by causing changes in the distribution or abundance of fishery resources, by reducing the catchability of fish or shellfish, precluding fishers from accessing viable fishing areas, or causing losses of or damage to equipment or vessels. Commercial and recreational fisheries in the Beaufort Sea and Chukchi Sea Planning Areas are relatively small and localized. Impacts on these fisheries are unlikely, since OCS activities would not occur in the immediate area near these fisheries. Impacts to commercial and recreational fisheries from routine Program activities are expected to be minor.

Expected Accidental Events and Spills. The magnitude of effects from accidental spills would depend on the location, timing, and volume of spills, in addition to other environmental factors. Small spills that may occur under the proposed action are unlikely to affect a large number of fish or have a substantial effect on recreational fishing before dilution and weathering reduced concentrations of oil in the water. Consequently, it is anticipated that small spills would have little effect on commercial and recreational fishing. Any single large spill would likely affect only a small proportion of a given fish population within the Beaufort and Chukchi Seas. However, large spills could have localized effects on commercial fishing that could result as a consequence of reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods, and on recreational fishing as a consequence of contamination of fish tissues, degradation of aesthetic values that attract fishers, or temporary closure of fishing areas. Oil from large or very large spills could contact intertidal habitat and subsequently contaminate or reduce the abundance of commercial and recreational species that depend on nearshore habitat. Impacts from a large spill could be long-term. Impacts on fisheries from an accidental spill could range from negligible to moderate.

An Unexpected Catastrophic Discharge Event. In the event of a CDE, fisheries recoveries could be impacted on a manner similar to that from a large spill. However, a larger proportion of a fish population could be affected, and impacts could be much more long-term on duration. Overall, impacts on commercial and recreational fishing from a CDE are expected to be moderate.

4.4.12 Potential Impacts to Tourism and Recreation

4.4.12.1 Gulf of Mexico

4.4.12.1.1 Impacts of Routine Operations. In addition to the continuing use of existing onshore support and processing facilities, between 4 and 6 new pipeyards, less than 12 new pipeline landfalls, and as many as 12 new gas processing facilities are projected to be built as a result of the Program. Additional offshore construction could include increased noise and traffic, air and water pollution, impacts on residential property values, and land use changes. As it is likely that onshore facilities would be placed near other commercial areas zoned for such development, certain coastal areas could also be closed temporarily to accommodate the construction of new facilities, while underground pipeline construction could occur near important recreational areas. Routine operations would have limited effects on recreation and tourism, with potential adverse aesthetic impacts on beach recreation and sightseeing and potential positive impacts on diving and recreational fishing.

The proposed action is expected to result in 300 to 600 service-vessel trips and 2,000 to 5,500 helicopter operations weekly. Although service vessels are assumed to use established nearshore traffic lanes and helicopters are assumed to comply with areal clearance restrictions at least 90% of the time, additional helicopter and vessel traffic would add a low level of noise pollution that could affect beach users. Routine OCS traffic can cause disturbances to recreational resources, particularly beaches, through increased levels of noise, debris, and rig visibility. There may also be minor space-use conflicts with recreational fishermen during the initial phases of the proposed action and low-level environmental degradation of fish habitat, which would negatively impact recreational fishing activity. However, these negative effects would likely be outweighed by the beneficial role that oil rigs serve as artificial reefs for fish populations. The degree to which oil platforms will become a part of a particular State's rigs-to-reefs program will be an important determinant of the degree to which the proposed action will impact recreational fishing activity in the long term.

The broader economic implications of the proposed action would be felt primarily on the GOM coast of Texas. The Texas coastline features an important barrier island system that supports a broad range of beach-related activity, and the visual, debris, and noise related issues could impact beach-related activity at these locations.

4.4.12.1.2 Impacts of Expected Accidental Events and Spills. Up to 8 large spills greater than 1,000 bbl, between 35 and 70 spills between 50 and 1,000 bbl, and up to 400 small spills less than 50 bbl could occur in the GOM from the proposed action. It is reasonable to expect that most of these spills will occur in deepwater areas located away from the coast, based on the established trend for oil and gas activity to move into deep waters located for the most part at a substantial distance from the coast.

Temporary impacts would occur if an oil spill reached a beach or other recreational use area. The magnitude of these impacts would depend on factors such as the size and location of the spill, and would likely be greatest if the spill occurred during the peak recreational season. A number of studies (see Section 3.1.3) have shown that there could be a one-time seasonal decline in tourist visits of 5 to 15% associated with a major oil spill.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes an unexpected CDE with an assumed volume of 0.9-7.2 million bbl and a duration of 30–90 days (Table 4.4.2-2). The effects from a CDE would likely include beach and coastal access restrictions; restrictions on visitation, fishing, or hunting while cleanup is being conducted; and aesthetic impacts associated with the event itself and with cleanup activities. These impacts are expected to be temporary, with the magnitude dependent on the location and size of the event and the effectiveness of cleanup operations. Longer-term impacts may also be substantial if tourism were to suffer as a result of the real or perceived impacts of the event, or if there were substantial changes to tourism and recreation sectors in the region as a result of the event.

Impact Conclusions.

Routine Operations. Routine operations would have minor, short-term negative effects on recreation and tourism, with potential adverse aesthetic impacts on beach recreation and sightseeing and potential positive impacts on diving and recreational fishing in the GOM coast. Although the proposed action has the potential to directly and indirectly affect recreational resources along the GOM coast, the small scale of OCS activities relative to the scale of the existing oil and gas industry, as well as the distance oil platforms would be from shore, are such that the potential impacts on recreational resources are likely to be minor.

Expected Accidental Events and Spills. Expected accidental spills could have temporary impacts if an oil spill reached a beach or other recreational- or subsistence-use areas in the GOM. The magnitude of these impacts would depend on factors such as the size and location of the spill, and would likely be greatest if the spill occurred during the peak recreational season. Small spills of less than 1,000 bbl could have negligible to minor impacts, while large spills of more than 1,000 bbl could have minor to moderate impacts.

An Unexpected Catastrophic Discharge Event. The effects of an unexpected CDE would likely include beach and coastal access restrictions; restrictions on visitation, fishing, or hunting while cleanup is being conducted; and aesthetic impacts associated with the event itself and with cleanup activities. These impacts are expected to be temporary, with the magnitude dependent on the location and size of the event and the effectiveness of cleanup operations. A CDE could result in minor to moderate impacts. Longer-term impacts may also be substantial if tourism were to suffer as a result of the real or perceived impacts of the event, or if there were substantial changes to tourism and recreation sectors in the region as a result of the event.

4.4.12.2 Alaska – Cook Inlet

4.4.12.2.1 Impacts of Routine Operations. Although no new pipe yards, pipeline landfalls, or gas processing facilities would be built as a result of the proposed 5-yr program, additional offshore construction could include increased noise and traffic, air and water pollution, impacts on residential property values, and land use changes. Oil and gas development under the proposed action in the south central Alaska region would occur in the vicinity of previous development. The additional development would not alter the character of the area, because similar infrastructure is already present. Effects on scenic quality would be temporary and localized, and would be most noticeable during heavy periods of industrial activity, such as during drilling or pipelaying. Temporary closure of certain areas to recreation would likely be necessary, but would be limited in size and duration. An increase in the amount of trash and debris washing ashore may also occur as a result of the development. The frequency of helicopter and vessel traffic to and from the new platforms would be consistent with that of existing platforms, but would contribute marginally to the impact on scenic quality and add to the industrial noise. The magnitude of these impacts would vary with the distance of these activities from existing parks and wildlife refuges, primary recreational use areas, and cruise line paths. During the short period of construction, the increased workforce could impact lodging accommodations for tourists during peak times; however, impacts would depend on the timing and location of the activities and the availability of a local workforce.

4.4.12.2.2 Impacts of Expected Accidental Events and Spills. One large spill greater than 1,000 bbl, up to 3 spills between 50 and 1,000 bbl, and up to 15 small spills less than 50 bbl could occur in the Cook Inlet area from the proposed action. These oil spills would be responded to primarily by existing response facilities along the coast and existing shore bases according to spill response protocols. Potential impacts on recreation and tourism resulting from an oil spill would likely include direct land use impacts (e.g., from oil contamination at a coastal area), access restrictions to a particular area (e.g., no fishing or hunting while cleanup is conducted), and aesthetic impacts of the spill itself and cleanup operations. These impacts are expected to be temporary, but could last an entire season. However, because of public perceptions resulting from the *Exxon Valdez* oil spill in Prince William Sound, tourism in the region may respond more strongly than would tourism in other regions. The magnitude of the impacts would depend on the location and size of the spill and the effectiveness of cleanup operations.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes an unexpected CDE in the Cook Inlet Planning Area with an assumed volume of 75-125 thousand bbl and a duration of 50–80 days (Table 4.4.2-2). Such a CDE could result in beach and coastal access restrictions; restrictions on visitation, fishing, or hunting while cleanup is being conducted; and aesthetic impacts associated with the event itself and with cleanup activities. These impacts are expected to be temporary, with the magnitude dependent on the location and size of the event and the effectiveness of cleanup operations. Longer-term impacts may also be substantial if tourism were to suffer as a result of the real or perceived impacts of the event, or if there were substantial changes to tourism and recreation sectors in the region as a result of the event.

Impact Conclusions.

Routine Operations. Routine operations would have minor, short-term negative effects on recreation and tourism, with potential adverse aesthetic impacts on sightseeing, boating, fishing, and hiking activities in the Cook Inlet area.

Expected Accidental Events and Spills. Expected accidental spills could have temporary impacts if an oil spill reached a beach or other recreational- or subsistence-use areas in the Cook Inlet area. The magnitude of these impacts would depend on factors such as the size and location of the spill, and would likely be greatest if the spill occurred during the peak recreational season. Small spills of less than 1,000 bbl could have negligible to minor impacts, while large spills of more than 1,000 bbl could have minor to moderate impacts.

An Unexpected Catastrophic Discharge Event. The effects of an unexpected CDE would likely include beach and coastal access restrictions; restrictions on visitation, fishing, or hunting while cleanup is being conducted; and aesthetic impacts associated with the event itself and with cleanup activities. A CDE could result in minor to moderate impacts. These impacts are expected to be temporary, with the magnitude dependent on the location and size of the event and the effectiveness of cleanup operations. Longer-term impacts may also be substantial if tourism were to suffer as a result of the real or perceived impacts of the event, or if there were substantial changes to tourism and recreation sectors in the region as a result of the event.

4.4.12.3 Alaska – Arctic

4.4.12.3.1 Impacts of Routine Operations. Although no new pipe yards, pipeline landfalls, or gas processing facilities would be built as a result of the proposed 5-year program, additional offshore construction could include increased noise and traffic, air and water pollution, impacts on residential property values, and land use changes. Oil and gas development activities could result in impacts on recreation and tourism in the Arctic region. The main recreation and tourism activities that could be impacted by routine oil and gas operations would be sightseeing, hiking, and rafting. Fishing in this region is primarily a subsistence activity rather than a recreational activity. Impacts on sightseeing might be viewed as being negative, with adverse aesthetic impacts from offshore platforms and possible increases in construction projects for gas processing facilities and new offshore pipelines to connect to existing onshore pipelines in the Chukchi Sea area. Impacts on these recreational activities would depend on the proximity of the new construction to the recreational use areas (such as whether they are in view of existing parks and refuges).

The additional development would not alter the character of the area, as similar infrastructure is already present. Effects on scenic quality would be temporary and localized, and would be most noticeable during heavy periods of industrial activity, such as during drilling or pipelaying. Temporary closure of certain areas to recreation would likely be necessary, but would be limited in size and duration. An increase in the amount of trash and debris washing ashore may also occur as a result of the development. The frequency of helicopter and vessel traffic to and from the new platforms would be consistent with that of existing platforms, but would contribute marginally to the impact on scenic quality and add to the industrial noise. The magnitude of these impacts would vary with the distance of these activities from existing parks and wildlife refuges and primary recreational use areas. During the short period of construction, the increased workforce could impact lodging accommodations for tourists during peak times; however, impacts would depend on the timing and location of the activities and the availability of a local workforce.

4.4.12.3.2 Impacts of Expected Accidental Events and Spills. Up to 3 large spills greater than 1,000 bbl, up to 35 spills between 50 and 1,000 bbl, and up to 190 small spills of less than 50 bbl could occur in the Beaufort and Chukchi Sea area from the proposed action. These spills would be responded to primarily by existing response facilities along the coast and existing shore bases according to spill response protocols. Potential impacts to recreation and tourism resulting from an oil spill would likely include direct land use impacts (e.g., from oil contamination at a coastal area), access restrictions to a particular area (e.g., no fishing or hunting while cleanup is being conducted), and aesthetic impacts (e.g., view of spill and cleanup activities). These impacts are expected to be temporary, and the magnitude of the impacts would depend on the location and size of the spill and the effectiveness of cleanup operations. The greatest potential impacts would occur from large spills in shallow water. The potential for impact would likely decrease with decreasing spill size and increasing water depth.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes a CDE that ranges from 1.9 to 2.2 million bbl in the Chukchi Sea Planning Area, and from 1.7 to 3.9 million bbl on the Beaufort Sea Planning Area (Table 4.4.2-2). A CDE could result in beach and coastal access restrictions; restrictions on visitation, fishing, or hunting while cleanup is being conducted; and aesthetic impacts associated with the event itself and with cleanup activities. These impacts are expected to be temporary, with the magnitude dependent on the location and size of the event and the effectiveness of cleanup operations. Longer-term impacts may also be substantial if tourism were to suffer as a result of the real or perceived impacts of the event, or if there were substantial changes to tourism and recreation sectors in the region as a result of the event.

Impact Conclusions.

Routine Operations. Routine operations would have minor, short-term negative effects on recreation and tourism, with potential adverse aesthetic impacts on sightseeing, hiking, and rafting activities in the Chukchi Sea and Beaufort Sea Planning Areas.

Expected Accidental Events and Spills. Temporary impacts would occur if an oil spill reached a beach or other recreational- or subsistence-use areas in the Arctic. The magnitude of these impacts would depend on factors such as the size and location of the spill, and would likely be greatest if the spill occurred during the peak recreational season. Small spills of less than 1,000 bbl would have negligible to minor impacts, while large spills of more than 1,000 bbl would have minor to moderate impacts.

An Unexpected Catastrophic Discharge Event. The effects of an unexpected CDE would likely include beach and coastal access restrictions; restrictions on visitation, fishing, or hunting while cleanup is being conducted; and aesthetic impacts associated with the event itself and with cleanup activities. A CDE could result in minor to moderate impacts. These impacts are expected to be temporary, with the magnitude dependent on the location and size of the event and the effectiveness of cleanup operations. Longer-term impacts may also be substantial if tourism were to suffer as a result of the real or perceived impacts of the event, or if there were substantial changes to tourism and recreation sectors in the region as a result of the event.

4.4.13 Potential Impacts to Sociocultural Systems

4.4.13.1 Gulf of Mexico

As discussed in Section 3.4.1.1, the counties in the GOM coastal commuting zone include a diverse mixture of social classes, cultures, ethnic groups, and communities. They also include a well-established oil and gas industry and support structure focused mainly in Louisiana and Texas. The activities covered under the Program would tend to maintain existing onshore facilities rather than require new ones (MMS 2006a, 2008a). While oil and gas facilities are dispersed along the central and western coast of the GOM, they are not spread evenly. Terrebonne, Plaquemine, and Lafourche parishes in Louisiana are the heart of the oil and gas support industry (MMS 2008a) with Port Fourchon catering to 90% of all GOM deepwater production (BOEMRE 2011a).

4.4.13.1.1 Impacts of Routine Operations. Routine OCS gas and oil operations include exploration, development, operation, and decommissioning. Although tied to the shore by aircraft, supply vessels, and pipelines, these activities occur well offshore and in increasingly deeper water. The global nature of deepwater activities has contributed to cultural heterogeneity among the gas and oil workforce with the importation of migrant workers. A recent study reports that industry employers often hire foreign-born Mexican and Laotian workers in upstream support sectors such as ship and fabrication yards (Hemmerling and Colton 2004). The greater distance of deepwater platforms from coastal communities has resulted in workers being drawn from a wider range of locations in the GOM region, making the ties between local subcultural groups and the offshore industry less consistent. The move farther offshore into deep water has also led to longer offshore work shifts and to more "on call" schedules for many workers, including technical experts and mariners (Austin et al. 2002). In the past, development of infrastructure within coastal wetlands has contributed to the shrinking of wetlands and loss of land in Louisiana, resulting in a loss of both subsistence and commercial wild resource harvesting areas. However, most new production will be able to tie into the existing pipeline system, so it is unlikely that many new pipeline channels will need to be dredged. Current practice is for pipeline channels to be backfilled, reducing wetland erosion and partitioning of habitat (Hemmerling and Colton 2004).

4.4.13.1.2 Impacts of Expected Accidental Spills. Accidental spills, including oil spills, chemical spills, vessel collisions, and loss of well control, are possible under the Program (MMS 2008a) (see Section 4.4.2). Between 200 and 400 spills of 50 bbl or less, 35 to 70 spills between 50 and 1,000 bbl, and 4 to 8 large spills greater than 1,000 bbl are posited for the GOM Program. Most accidental spills on this scale are likely to be short term and localized. Those occurring well offshore are likely to be cleaned up or dissipate before reaching shore, and would thus have little effect on onshore communities (MMS 2006a). Those occurring in coastal waterways involving OCS support vessels or pipelines (BOEMRE 2011a) would have localized effects on wild resources harvested either commercially or for subsistence purposes. Intertidal and estuarine habitats, where shellfish are harvested and the juveniles of harvested species develop, are the most vulnerable (see Sections 4.4.6 and 4.4.7). Most adult fish species seem to be better able to avoid oiled waters. Impacts from small and moderate coastal spills are likely to have localized and short-lived effects. Large spills (over 1,000 bbl), and especially spills of sufficient size to overwhelm cleanup and booming efforts, would have a notable effect on communities dependent on harvesting renewable wild resources either commercially or for subsistence purposes.

Impacts of an Unexpected Catastrophic Discharge Event. A CDE would be considered an unexpected, low-probability event unlikely to occur during routine operations. The PEIS analyzes a CDE that ranges in size from 0.9 to 7.2 million bbl and would last from 30 to 90 days (Table 4.4.2-2). A CDE would have major sociocultural consequences for populations employed in offshore oil and gas production or in commercial fishing and shrimping, along with those engaged in subsistence harvesting, and would result in negative and long-lasting social effects (BOEMRE 2011b). Unlike devastation from hurricanes or other natural disasters that tend to bring communities together to face a common tragedy, oil spills tend to have divisive effects. Technical disasters such as oil spills are perceived as preventable, have a person or organization viewed as primarily responsible, and often can lead to litigation that can last for years (Picou et al. 2009). For example, during the DWH release, large areas of the GOM were closed to all shrimping and fishing (NMFS 2010b, 2011c). Fisheries in Federal waters remained closed from 2 to 11 months (NMFS 2011e), while pockets of Louisiana coastal waters in the Mississippi Delta and Bay Baptiste remain closed (LDWF 2012). The loss of work placed financial stress on workers in that industry. Some, but not all, shrimpers and fishing boats were employed in the cleanup, creating a division between those who received some financial relief through the cleanup effort and those who did not. The loss of income and potential loss of some subsistence sources create emotional stress stemming from financial stress, often resulting in depression and post-traumatic stress disorder in those who depend on the renewable resources of the sea for their livelihood. An increase in sociological disorders such as domestic violence, substance abuse, and suicide was observed in communities affected by the *Exxon Valdez* spill (Picou and Arata 1997). Similar patterns appear to be emerging among populations that are heavily dependent on fishing along the GOM coast (Picou et al. 1999; Picou 2010), especially among fishing communities already hard hit by Hurricane Katrina (Yeoman 2010). Methods for mitigating social stress by creating a therapeutic community based on a model developed for the *Exxon Valdez* spill are being implemented in the GOM (SAMHSA 2010; MASGC 2011).

While only a small portion of those who live along the northern coast of the GOM are engaged in subsistence harvesting, if oil from a CDE were to reach the shore, it could affect the barrier islands and wetlands important to the harvesting of subsistence resources, including waterfowl, fish, shrimp, and shellfish. If coastal fisheries were contaminated or closed, it would have an effect on subsistence harvesting. As a result of the DWH event, close to 30,000 emergency advance payment claims were filed based on the loss of subsistence resources (BOEMRE 2011a). Loss of subsistence resources has economic, nutritional, and cultural consequences. While Federal authorities have declared GOM fish, shrimp, and shellfish from areas contaminated by oil from the DWH event safe to consume (Ylitalo et al. 2012), there is some evidence that populations, such as subsistence fishers, whose diet includes a relatively large amount of seafood, may be at greater risk (Rotkin-Ellman et al. 2012).

Impact Conclusions.

Routine Operations. Few impacts on GOM sociocultural systems are anticipated from the proposed action. The oil and gas industry is well-developed along the coast, and the proposed action is more likely to support the existing industry than to create industry growth. Any expansion of deepwater activities will result in jobs that require longer, unbroken periods of work offshore, specialized skills, and potential in-migration of part of the workforce. Such changes can affect workers, their families, and the communities in which they reside. Impacts on sociocultural systems from routine Program activities in the GOM planning areas are expected to be minor.

Expected Accidental Events and Spills. Small spills are likely to have small, localized, and short-lived effects. Most would occur during transfer of material, such as refueling, or as the result of collisions. Routine transfers are boomed and thus mitigated. Impacts would be minor. Most spills would occur far from shore and would be cleaned up or dissipate before reaching shore, resulting in minor effects. However, small spills in coastal waters could affect localized intertidal resources used by subsistence harvesters. While there would be local impairment of the resource, cleanup should be possible and the resource as a whole should remain viable. Impacts would therefore be moderate.

The impact of a large release from tankers, platforms, or pipelines would depend on its distance from shore, proximity to important fisheries, and the effectiveness of containment and cleanup. Impacts would be moderate to major. Access to fisheries may be temporarily disrupted — a moderate impact. The viability of some resources could be threatened if the spill reached an important estuarine or intertidal area, and impacts would be major.

An Unexpected Catastrophic Discharge Event. In the unlikely event of a low-probability CDE, there would be major economic repercussions for the oil and gas industry, commercial fishers, and subsistence harvesters. If oil from a CDE were to reach the shore, impacts on estuarine and intertidal resources would be unavoidable and could be moderate to major. Long-term closure of fisheries would be likely. These could result in social and cultural stress, leading to possible social pathologies. GOM subsistence harvesters make up a relatively small segment of the coastal population and replacement food resources are more available than for subsistence harvesters in Alaska, so while the impact of the loss of subsistence resources would be moderate for the coastal population as a whole, it would be locally major for populations that depend on subsistence harvesting for a significant proportion of their diet.

4.4.13.2 Alaska – Cook Inlet

Finding and developing oil and gas resources on the Cook Inlet OCS has the potential to create adverse effects on sociocultural systems and subsistence, the severity of which would vary depending on the timing, location, and scale of the activity. Many negative consequences could be minimized through appropriate mitigation procedures. The most central of these is establishing and maintaining communication among local governments, Native villages, oil companies, and appropriate Federal agencies, including both government-to-government consultation in compliance with legal requirements and U.S. Department of the Interior (USDOI) policy (USDOI 2011) and ongoing dialogue leading to adaptive management of adverse effects.

The areas surrounding the Cook Inlet Planning Area are demographically diverse, including isolated subsistence-based Alaska Native villages, towns that rely primarily on commercial fishing, and ethnically and economically diverse cities partly dependent on the oil industry. There have been oil and gas operations in Cook Inlet since the late 1950s, and the surrounding area is home to a well-established gas and oil infrastructure that could accommodate much of any newly developed resource. As discussed in Section 4.4.1.2, under the proposed action, no new shore bases would be constructed, and one new pipeline landfall and possibly one new natural gas processing facility would be built.

Rural communities in the area benefit from oil and gas development throughout the State. However, currently the Federal Government does not share revenues from oil and gas leasing on the OCS with the States, although Alaska has received Federal Coastal Impact Assistance Program (CIAP) funding, because it is an OCS State (Hess 2011; BOEMRE 2011k). Benefits from revenue sharing would only occur if Congress authorizes the sharing of OCS revenues with the OCS States. If such sharing were to occur, OCS activities could be expected to have effects on Alaskan rural communities, through various State programs, proportionate to the percentage of the State budget that relies on revenues from OCS oil and gas production and that is allocated to the affected communities. For the period of the Program, the allocated revenues from OCS oil and gas production would be relatively small.

4.4.13.2.1 Impacts of Routine Operations. Routine operations under the Program would include exploration for oil and gas resources, development of the resources including infrastructure, operation of facilities, and decommissioning of facilities. Each of these phases is characterized by different levels of activity, different extent, and different timing. Because the region as a whole has already undergone oil and gas development, each of these phases can take advantage of and tie into existing infrastructure and can draw on an existing pool of experienced workers (MMS 2003a). The Cook Inlet area has already experienced the impacts of oil and gas development, and would also experience both the positive and negative effects of increased population and employment from the proposed OCS activities. Most area communities are ethnically diverse, with Caucasian majority populations. Alaska Native communities tend to be more remote and more difficult to access than non-Native communities, and would be somewhat buffered from the impacts of the routine operations of the proposed action.

Exploration activities include seismic surveys and the drilling of test wells, activities that are typically conducted from self-contained vessels. Exploration crews would be drawn from an existing pool of trained oil and gas workers in the Cook Inlet area. In-migration for these jobs is expected to be minimal and to have little effect on the current ethnic composition or social structure of the area (MMS 2003a). Exploration activities would likely be supported from existing air and marine facilities on the Kenai Peninsula. No additional facilities would be required. Industrial activities associated with exploration would not be new to the area, but would continue existing operations. There would be very little in-migration for exploration jobs because of the existing trained labor pool and the fact that exploration rig crews are normally contracted with the vessel. Exploration activities are not expected to result in measurable changes in the availability or accessibility of subsistence resources.

Exploration activities could have temporary effects on subsistence harvesting, but are not expected to result in measurable changes in the availability or accessibility of subsistence resources. Cook Inlet personal use and subsistence fisheries are important to all residents of South Central Alaska. Since the Cook Inlet Planning Area lies outside of the Anchorage-Mat-Su-Kenai Peninsula Nonsubsistence Use Area, effects on personal use fishing are not expected. Most of upper Cook Inlet north of Ninilchik is included in the Anchorage-Mat-Su-Kenai Peninsula Nonsubsistence Use Area. While subsistence fishing is not authorized by the Alaska Board of Fisheries in this area, personal use fisheries, open to all Alaska residents who have lived in the State for at least a year, do exist on the Kenai and Kasilof Rivers and Fish Creek that provide an important food source for many families in the Mat-Su-Anchorage-Kenai area (SCADA 2011). More remote subsistence fisheries are accessible to rural communities where customary and traditional uses of fish and wildlife are a principal characteristic of the economy, culture, and way of life. These include Alaska Native communities (ADFG 2011), such as the community of Tyonek, on the west shore of Cook Inlet, and Port Graham and Nanwalek, located on the southern Kenai Peninsula and the Alaska Native communities along the northwestern shore of Kodiak Island.

The effects of exploration on subsistence fishing would be similar to the effects discussed for recreational and commercial fishing in Section 4.4.11.2. Seismic exploration vessels tow long lines that could be entangled with seines, gillnets, long lines, and other gear used by subsistence fishers (MMS 2003a), who may choose to avoid seismic vessels to prevent the loss of gear and thus be kept from their normal fishing grounds. Fishers may also choose to avoid floating exploratory drilling rigs being moved from one location to another for safety reasons and to prevent the loss of gear. Seismic surveys could temporarily affect the behavior of some targeted species, thereby temporarily affecting catch rates in the immediate area of the surveys. Some subsistence fishers could decide to avoid areas during seismic because of perceived or actual changes in catchability. New areas in the Cook Inlet Planning Area could be subjected to seismic surveys during the Program. However, given the relatively small proportion of the available Cook Inlet area that would be affected at any particular time, it is not anticipated that seismic surveys would greatly disrupt subsistence fishing activities. Platform installation activities associated with exploration, including the noise and movement of aircraft, could temporarily displace seals and possibly some whales from installation sites. It is estimated that displaced animals would return to normal behavior and distribution once the operation is complete (MMS 2003a). Effects on subsistence harvesting would vary with the size and duration of the operation.

There would be some direct effects on the subsistence harvest from noise and drilling discharges. Under Federal authority, limited sea mammal harvest and subsistence halibut (and some other non-salmon species) fishing can take place in Cook Inlet. Alaska Natives can hunt marine mammals under the MMPA. Traditionally, beluga whales have been one of the most important marine mammal subsistence resources taken from Cook Inlet at Tyonek. However, this population has experienced a sharp decline and is now endangered. Under current co-management agreements, subsistence harvesting has been suspended to allow the population to recover (Allen and Angliss 2011). After recovery, belugas would once again be available for the village of Tyonek to hunt. Proposed actions should have limited effects upon this potential harvest. While belugas occasionally inhabit areas where exploration noise and disturbance could occur, in recent years their use of such areas appears to have been low. In summer, belugas tend to be concentrated in the extreme upper inlet outside the planning area.

The drilling of exploratory wells would have a limited impact on fish species (see Section 4.4.7.3.2) and subsistence fishers. The estimated volume of drilling discharges from exploration wells would have no effect on fish other than bottom dwellers in the immediate area (within 100 m [328 ft]) of the well at the time of discharge (see Section 4.4.7.1). Drilling muds and cuttings may temporarily limit access of subsistence fishers to some parts of their traditional fishing areas, since the fishers would be required to remain at least 500 m (1,640 ft) away from the drilling platform for safety reasons. Only a very small portion of the available subsistence fishing areas in Cook Inlet would be taken up.

Impacts on marine and coastal birds from exploration activities would be limited to the effects of helicopter flights on nesting or roosting individuals directly or in close proximity to regular flight paths. Effects would be temporary and could include abandonment of roosting or foraging areas, nest abandonment, and lower reproductive success. These effects could last from 1 to 2 years if birds adapt and for the life of the project if they fail to do so (MMS 2003a). Cook Inlet is an important seabird breeding area. All Alaska Native communities surrounding the Cook Inlet Planning Area report the harvesting of seabird eggs and marine and coastal birds including migratory waterfowl (Table 3.14.2-2). This localized, probably temporary, displacement of bird populations from traditional subsistence harvest areas would affect subsistence bird and egg harvesters by reducing the availability of the resource and/or requiring harvesters to extend their harvesting range. It is not expected that any resource would become unavailable or that there would be an overall population decrease (MMS 2003a).

Sociocultural effects could result from development and production phases, if the resulting employment were to cause a migration into the area that is beyond the capacity of existing sociocultural systems to absorb, or if subsistence harvest patterns were changed. Although new development is likely to create jobs, many of these jobs could be filled from the reservoir of skilled petroleum industry workers in the Cook Inlet area (particularly on the Kenai Peninsula) or filled by others who would commute from outside the area and return home at the end of their shifts or contracted work assignments (MMS 2003a). The characteristics of any new population segment are likely to be compatible with the towns and cities in which they choose to reside. It is not likely that they will choose to reside in isolated Alaska Native villages, unless they are of Alaska Native heritage. Any in-migration should do little to change existing sociocultural patterns.

Because oil and gas industry infrastructure already exists in and around Cook Inlet, new construction would be limited to tying new production wells to the existing system. This could entail the construction of new offshore platforms, offshore and onshore pipelines, and a new landfall. Increased turbidity from the construction of platforms and pipelines could disturb pelagic fish important to subsistence fishers and commercial fishers alike, and displacing the fish from their preferred habitat and decreasing their catchability by subsistence fishers. However, disturbance or displacement should be short term — limited to the time of construction and a few hours or days thereafter. The drilling structures themselves may result in changes in species distribution as offshore structures attract and protect some species (MMS 2003a). Cuttings and fluids from production wells would be treated and disposed of in the well. Longlines and hand-held trolls used for bottom fishing and gear such as beach and purse seines could snag on submerged pipelines, causing some loss of gear for subsistence fishers.

A small increase in vessel activity to support platforms (up to six additional trips per week) is anticipated. This small increase should not measurably affect subsistence harvesting opportunities, catchability of fish and shellfish resources, or navigation by subsistence fishers.

Noise associated with drilling rig and support vessel traffic, helicopter flights, platform construction and operation, pipeline construction, and vessel traffic to and from drilling platforms could temporarily disturb belugas, particularly in the winter when they are more often in the lower inlet. While the beluga population in the inlet is in decline and the Cook Inlet stock is endangered, routine industry activities have not been found to contribute significantly to this decline (MMS 2003a). The effects of increased routine industry activity on beluga populations are assessed in Section 4.4.7.1.1.

Effects on marine and coastal birds important to subsistence harvesters would result from helicopter flights and would be similar to those described above for exploration activities.

Airborne and underwater noise would be the main sources of disturbance for marine mammals harvested by Alaska Native communities. Noise and disturbance would come from flights and vessel traffic to platforms, offshore pipelaying, platform installation, and very local costal habitat modification at the pipeline landfall. There would also be brief temporary displacement of terrestrial mammals harvested by some communities (see Table 3.14.2-2) (e.g., brown bears and moose) on the Kenai Peninsula from helicopter flights and supply vessel traffic between platforms and onshore facilities.

Effects from well abandonment and decommissioning on wildlife important to subsistence harvesters would be similar to those from construction.

4.4.13.2.2 Impacts of Expected Accidental Events and Spills. The activities associated with the proposed action are susceptible to oil spills and natural gas releases. While developers are required to submit oil spill response plans, the *Exxon Valdez* oil spill has shown that a very large discharge event can overwhelm existing plans and cause damage to resources important to subsistence harvesters, affect fish populations important to commercial fishers, and have sociological impacts in affected communities.

Accidental spills of oil or other chemicals are most likely to occur during the transfer of material from one vessel to another or to or from shore. These spills tend to be small and more easily contained. Other accidental spills could result from collisions or wrecks. The size and severity of such spills depend on the nature and location of the incident. Accidental spills could also result from the loss of well control or damage to pipelines.

It is assumed that as many as 15 very small oil spills (50 bbl or less), 3 small oil spills between 50 and 1,000 bbl, and 1 large spill greater than 1,000 bbl could occur under the Program (see Section 4.4.2). While most small spills are likely to be contained, even small spills may have effects on subsistence resources. Because small amounts of oil spread out rapidly over the ocean surface, forming a thin sheen, and tend to break up into small patches and streamers, an oil spill has to be at least several barrels, perhaps as many as 50, before birds important to subsistence hunters would be at risk. A limited number of birds would be lost. Small oil spills would have some effects on mammals sought by subsistence hunters, such as harbor seals, other marine mammals, and terrestrial mammals, with perhaps the loss of a few individuals to oiling and small amounts of transient and local contamination. Subsistence harvesters would consider animals from an oiled context to be tainted and would be less likely to harvest them. Recovery from small spills would probably require no more than a year (MMS 2003a). Effects would vary, depending on the location and timing of the spill.

One large spill (over 1,000 bbl but less than 75,000 bbl) is assumed here. Effects would vary depending on the timing and location of the spill. Effects of a large spill are likely to be greatest in parts of the Cook Inlet Planning Area that are relatively confined, since oil is more likely to reach the shore and affect important intertidal zones that support the young of many fish species as well as shellfish that form a part of the subsistence harvest. Fishes most likely to be affected by large spills include many that are important to subsistence fishers. They include those that migrate extensively, such as the Arctic cisco; those with strong ties to the streams where they were spawned, such as the Dolly Varden; and those tied to nearshore environments (see Section 4.4.7.2.2). Because pelagic species of fishes in Cook Inlet are relatively abundant and widely distributed in waters across much of the central Gulf of Alaska, even a large oil spill (up to 4,600 bbl) is not likely to cause population-level impacts on most fish populations inhabiting the central Gulf of Alaska (i.e., South Alaskan Peninsula, Kodiak Archipelago, Shelikof Strait, Cook Inlet, and Prince William Sound).

A pipeline or platform spill in Cook Inlet could affect subsistence activities on the Kenai Peninsula, Kodiak Island, and the Alaska Peninsula. If a natural gas loss of well control occurred below or on the water surface, with possible explosion and fire, subsistence resources such as fish, birds, and beluga whales in the immediate vicinity of the loss of well control could be killed. Natural gas and gas condensates that did not burn would be hazardous to any organism exposed to high concentrations. Natural gas vapors and condensates disperse rapidly and would not likely affect subsistence resources beyond the immediate area. High concentrations would not occur if the loss of well control occurred on the top of a platform where dispersal would occur more rapidly. Effects from losses of natural gas well control are likely to be short-term and local, lasting a year or less and extending for about 1.6 km (1 mi) (MMS 2003a).

Impacts of an Unexpected Catastrophic Discharge Event. A CDE in the Cook Inlet Planning Area would be a possible, but low-probability event under the 5-year plan. The PEIS analyzes an unexpected CDE in the Cook Inlet Planning Area that ranges from 75 to 125 thousand bbl and lasts from 50 to 80 days (Table 4.4.2-2). A CDE in the waters of south central Alaska and the resulting cleanup are likely to have consequences for sociocultural systems and could have long-lasting social and psychological repercussions. The sociocultural impacts would include effects upon resources that are used in some way by local residents (i.e., subsistence, tourism, recreation, and elements of quality of life) and economic losses for commercial fishers and support businesses. In past very large spills, the loss of livelihood for both commercial and subsistence fishers resulted in depression and an increase in suicide and other pathological behavior, as did participation in protracted litigation resulting from the spill (Picou et al. 2009; Fall 2009; Fall et al. 2009).

Cleanup efforts resulting from a CDE would result in short-term increases in population and economic opportunities, as well as increased demand on community services and increased stress to smaller communities. In communities based on commercial fishing, the increased demand on community services would coincide with a decrease in tax revenues as income from commercial fishing declines. Competition for employment in the cleanup process would create division within communities (Picou et al. 2009).

It is likely that a CDE would damage resources important to subsistence harvesters and affect fish populations important to commercial fishers. It would reduce the availability and/or accessibility of subsistence resources. Resources subject to such impacts include those that are most significant for the area — fish and shellfish — as well as marine mammals and, to some extent, terrestrial mammals. Birds and marine plants (seaweed) would also be at-risk resources that are used locally. Alaska Native subsistence harvesters would consider marine mammals from an oiled context to be tainted and would be less likely to harvest them. Since the waters of the Cook Inlet Planning Area are relatively confined, oil from a CDE is likely to reach the shore and affect important intertidal zones that support the young of many fish species as well as shellfish that form a part of the subsistence harvest. Fishes most likely to be affected by a CDE include many that are important to subsistence fishers. They include those that migrate extensively, such as the Arctic cisco; those with strong ties to the streams where they were spawned, such as the Dolly Varden; and those tied to nearshore environments. Impacts on fish can propagate throughout the food web, affecting birds and marine mammals.

A CDE has the potential for long-lasting effects on subsistence-based Native villages and communities. However, Native communities have proven to be flexible and adaptive, mitigating to some extent immediate losses of subsistence harvest resources. Of great concern to Native wild food harvesters regarding oil spills is the contamination of the natural environment. After the *Exxon Valdez* spill, Alaska Natives were fearful that marine and nearshore resources had been tainted, placing more trust in traditional environmental knowledge than government agencies. Harvesting of traditional resources dropped off and Alaska Natives relied on stored foods from previous seasons, augmented by relief supplies of traditional foods supplied by unaffected villages with whom they had traditional ties and exchange relationships. Nonetheless, over time, social ties appear to have weakened. In the years following the spill, harvesting slowly rebounded, but the composition of the harvest changed, attributed both to long-term loss of resources and continuing fears of tainting (Fall 2009). Nanwalek Native Tom Evans reported in 2003 that "our resources have not recovered" (MMS 2003c). Other sociocultural effects included changes in wild food preferences; changes in traditional roles and status in the communities; disruption of the instruction of children in traditional subsistence knowledge and practices; and thus, the disruption of the transmission of Alaska Native culture and conflicts with outsiders (MMS 2003a).

Cleanup efforts would also affect subsistence resources. While cleanup strategies would reduce the amount of spilled oil in the environment, thus mitigating negative effects to some extent, disturbance and displacement of subsistence resources would increase from cleanup activities such as offshore skimmers, workboats, barges, aircraft overflights, and *in situ* burning. Deflection of resources resulting from the combination of a CDE and cleanup efforts could persist beyond one season, perhaps lasting several years. As a result, subsistence harvests and subsistence users would suffer nutritional and cultural impacts (MMS 2003a). In addition to effects on subsistence, during the *Exxon Valdez* cleanup, archaeological resources important to Alaska Native cultures were damaged or stolen (Picou et al. 2009).

As is evident from the *Exxon Valdez* event, cleanup efforts can be quite disruptive socially, psychologically, and economically for an extended period of time. While the magnitude of impacts declines rapidly in the first year or two after a large spill, long-term effects continue to be evident. Technological disasters, such as oil spills, have been shown to have more divisive community effects than natural disasters (Picou et al. 2009). Such effects can be reduced by the early implementation of coping and mitigation measures (Picou et al. 1999). One important coping measure is the establishment of, and local participation in, an effective spill-response effort that has been formulated into an explicit spill-response plan. Such local programs do have a number of benefits. They provide local employment, a sense of local empowerment, and a means for local resident/oil industry communication. Another coping measure is the establishment of intervention programs such as peer listening programs based on community participation (MMS 2003a; Picou et al. 1999, 2009; Picou 2010).

Impact Conclusions.

Routine Operations. Oil and gas exploration, development, and production activities in the Cook Inlet Planning Area would be a continuation of long-standing economic characteristics of the area. The proposed action would not introduce new kinds of activities that would alter existing socioeconomic systems. The relatively small number of new residents that would come into the area because of the proposed action should likewise not alter existing sociocultural systems. These activities are not likely to affect commercial fishing (see Section 4.4.11.2); however, they may periodically result in temporary and localized displacement of subsistence resources or limit access by subsistence hunters, making the subsistence harvest more difficult, but no resource would experience an overall decrease in population, and no harvest would be curtailed for part of the harvest season. Impacts on sociocultural systems from routine Program activities in the Cook Inlet Planning Area are expected to be minor.

Expected Accidental Events and Spills. Because portions of the Cook Inlet Planning Area are relatively confined, spills from accidents are more likely to reach the shore, potentially contaminating important intertidal and estuarine zones. The impacts of small spills would vary from minor to moderate depending on the size, location, and timing of the spill. Impacts from small spills could be mitigated with prompt cleanup. Populations of resources important to subsistence harvesters that lose some individuals to local oiling are likely to recover in less than a year.

A large oil spill could contact areas where important subsistence resources are present and have moderate to major impacts. Some harvest areas and resources in these locations would be too contaminated to harvest. Some subsistence resource populations could be reduced, although pelagic fish species would not be expected to suffer population-level loses. As a result of tainting, an even larger array of resources could be rendered unavailable for use by Alaska Natives. Tainting concerns in communities nearest the spill could seriously curtail traditional practices for harvesting, sharing, and processing resources and threaten pivotal practices of traditional Alaska Native cultures. Harvesting, sharing, and processing of subsistence resources would continue but would be hampered to the degree these resources were contaminated. In the case of contamination, harvests would cease until such time as local subsistence hunters perceived resources to be safe.

An Unexpected Catastrophic Discharge Event. In the event of an unexpected, low-probability CDE, there would be unavoidable impacts on commercial and subsistence harvesting of marine resources leading to community divisions and sociopathic behavior. There would be major and long-lasting impacts on the affected communities. Loss of resources important to subsistence harvesters, including intertidal resources, migrating fishes, and fishes with strong ties to the shore, would be affected. Oil spill cleanup would increase overall effects by displacing subsistence species, altering or reducing subsistence hunter access, and altering or extending the length of time required for subsistence harvesting.

4.4.13.3 Alaska – Arctic

As was the case for Cook Inlet, finding and developing oil and gas resources on the Arctic OCS has the potential for creating adverse effects on sociocultural systems and subsistence. Such effects would be similar in nature but would vary in magnitude depending on the timing, location, and scale of the event or activity. Many of the subsistence use areas are discussed or identified in Sections 3.14, 4.3.2, and 4.6.1. Many negative consequences could be minimized through appropriate mitigation procedures. The most central of these would be establishing and maintaining communication among Native villages, oil companies, and appropriate Federal agencies, including both government-to-government consultation in compliance with legal requirements and USDOI policy (USDOI 2011) and ongoing dialogue leading to adaptive management of adverse effects.

As discussed in Section 3.14.3.1, the northern and northwestern coasts of Alaska are the home of indigenous Iñupiaq communities confronted with increasing industrialization tied to mineral extraction. While it is clear that industrialization in northern Alaska has had important economic and social effects, until now, the industrial workforce building and operating the expanding oil and gas extraction facilities has been largely non-local and transient, residing in self-sufficient enclaves far removed from Alaska Native villages and, for the most part, placing little strain on village government resources. However, as expressed by Alaska Natives in scoping meetings (BOEMRE 2011c–f), as oil and gas production infrastructure expands both onshore and onto the OCS, the indigenous villagers feel their traditional subsistence-based lifeway is being constrained and their cultural values threatened. Commenters on the Draft PEIS recalled the loss of former hunting grounds around Prudhoe Bay.

As expressed by Carla Sims Kayotuk in the 2011 Kaktovik scoping meetings: “I do not want to see that [sociocultural] change for our community. It has changed some, but I don’t want to see any more negative changes happen. And I strongly believe that if offshore development, even onshore development [continues], that’s going to happen and our community will never be the same again. And I know change happens. Culture changes, traditions change, but I think it’s going to be a very negative impact on us” (BOEMRE 2011c).

The Iñupiat, like other coastal Alaska Natives, are closely tied to the land and the sea. Subsistence harvesting and the distribution of the subsistence harvest through kin and social networks based on cultural ideals of community and sharing are core values of Iñupiaq culture. To the extent that oil and gas activities in or close to Alaska Native villages adversely affect the subsistence harvest or limit cultural continuity, they have a negative impact on Iñupiaq sociocultural systems. In addition, new development may result in an influx of outsiders who do not share Iñupiaq values and mores, resulting in stress on indigenous sociocultural systems. For example, all Iñupiaq villages on the North Slope are “dry,” and in some of them the importation of alcohol is illegal. These values may not be shared by oil workers coming from outside Iñupiaq communities.

The Iñupiat harvest a wide range of wild animal and plant resources including bowhead and beluga whales, seals, walrus, polar bears, fish, waterfowl, and caribou (see Section 3.14.3.1). For coastal communities, the most iconic harvests are the bowhead and beluga whale hunts. These lie at the heart of Iñupiaq social system and sense of cultural identity.

“If you ever see this young kid as a young man [become] a whaler, it’s like an individual that lives in [the city], has a dream of becoming a pilot or [having] a career of some sort. But when you are a Native, it’s always been being a provider to the community, be a hunter. That’s the culture of Iñupiat. Pass on the traditions that’s been passed on to us for thousands of years,” said Isaac Nukapigak from the village of Nuiqsut (BOEMRE 2011d).

Native Alaskans often refer to the Chukchi and Beaufort Seas as the Iñupiaq garden or Garden of Eden and are extremely concerned about loss of resources from oil spills and pollution, and from changes in patterns of wildlife migration resulting from industrial activities. In the words of Raymond Aguvluk, a local resident, at the 2011 Wainwright scoping meeting for this PEIS “We eat from out there, you know. And [are] you guys going to send us chicken or steak? No way. We love our garden out there” (BOEMRE 2011e).

Marine mammals and fish are the resources of most concern, as they constitute a major part of the subsistence harvest and typically are the resources most likely to be directly affected by oil and gas activities on the OCS. Land mammals, particularly caribou, are also important subsistence resources. In most cases, they would be affected most by transportation pipelines and other support infrastructure tied to OCS development. However, if oil and gas activities on the OCS resulted in a loss of, the tainting of, or prevented access to, marine subsistence resources, subsistence hunters would likely turn to terrestrial sources, increasing pressure on caribou, moose, other land mammals, freshwater fishes, and waterfowl. Oil spills that have occurred elsewhere in Alaska have resulted in negative consequences for subsistence resources and activities, but routine exploration, development, and operation could also potentially result in negative effects.

4.4.13.3.1 Impacts of Routine Operations. Routine oil and gas operations may be divided into four categories or phases: exploration, development, operations, and decommissioning. Exploration on the OCS, whether using seismic surveys or test wells, is done from largely self-contained ocean-going vessels, and in the past has had little direct impact on the infrastructure of local communities (MMS 2007b; MMS 2008b). However, exploration ships do require onshore support facilities. Exploration in the Beaufort Sea using existing facilities at Prudhoe Bay/Deadhorse and Barrow would result in little new impact. Conversely, exploration plans filed for the Chukchi Sea include development of an onshore base in Wainwright that would use some village infrastructure and services. With a staff of 22 to 64 individuals, it would include a helipad, fuel storage, lift and hoist facilities near existing boat ramps, and temporary housing for vessel crews weathered in while being changed (Shell 2009a, b). In anticipation, the local village corporation has built crew quarters (Burwell 2011; Anchorage Daily News 2010). Having a shore base in a village would likely increase interaction between transient workers and Alaska Natives in Wainwright, , with the potential for changing cultural dynamics, including conflicts arising from differing behavioral norms and the adoption of Western cultural traits by indigenous communities. The presence of the onshore base would also provide some employment opportunities for Alaska Natives (Shell 2009b). Cultural conflicts may be minimized through cultural awareness orientation stipulated in lease contracts so in-migrant workers are made aware of Alaska Native cultural values including the importance of the subsistence harvest to local communities. Lease stipulations would require developers to submit plans that orient new in-migrant workers to the local Alaska Native culture, including subsistence, in advance (MMS 2007b).

Of great concern to local populations is the noise created by seismic survey airguns and test drilling rigs during exploration and their potential for disturbing or driving away the migratory sea mammals upon which subsistence communities depend. Iñupiat whalers generally agree that whales and other marine mammals are more sensitive to noise than Western scientific studies suggest and will avoid noise sources, and that they have been disturbed from their normal patterns of behavior by past seismic and drilling activities. According to Kaktovik whaling captain George Kaleak, Sr., “The sound can go over 50 miles, and whales can hear it” (BOEMRE 2011c). Noise and other associated activities can make whales less predictable and more dangerous to those who hunt them. They can be deflected from their usual migration routes into deeper, more dangerous waters, where they are more difficult to take and bring home successfully. Deflection of whales from their migratory paths not only makes whaling more difficult, it makes it more expensive. The added distance that must be traveled to and from a successful hunt is likely to result in added fuel costs, and has the potential for lost wages, resulting in time taken away from regular jobs (NMFS 2011f). Whalers from Barrow, Nuiqsut, and Kaktovik have been especially vocal on this issue, as they are most likely to be directly affected by such activities during the fall open water season.

Isaac Nukapigak, a Nuiqsut whaling captain explained at scoping meetings held in 2011: “At one point, I remember us being out there for 7 weeks and didn’t meet our quota because of [oil and gas exploration] activities and weather prediction where our subsistence hunt and the whales were disrupted because of this heavy activity going on in the Beaufort. We had to go 30 miles north. That's where we finally were able to see whales because there was so much activity east of Cross Island. And that time we had no choice because a whale was got 35 miles north of Cross Island because of … safety [in] these small boats that we go out in to harvest, weather prediction got bad on us. We had no choice but to let go of the whale even though we didn't want to. And that year was so harsh because we didn't meet our quota. It was very noticeable in this community. There was no whale meat stored in our cellars. People were hurting" (BOEMRE 2011d).

According to Tom Albert, a former non-Iñupiat senior scientist for the North Slope Borough Department of Wildlife Management, "When a captain came in to talk to me, I knew he was going to say that the whales are displaced [by noise] farther than you scientists think they are. But some of them would also talk about 'spookiness,' when the whales were displaced out there and when the whaler would get near them, they were harder to approach and harder to catch" (MMS 1997a).

That marine mammals are sensitive to noise disturbance is clear, although thresholds in terms of signal characteristics and distance have not been established for all species and can vary within a species depending on the nature of the sound, the age of the individual, its prior experience with the noise, and its current activity. The sounds of seismic airguns can be detected as far as 97 km (60 mi) away in deep water. Feeding bowhead whales tend to show less avoidance of sound sources than do migrating bowheads. Studies have shown that deflection from usual bowhead migration routes may start as far as 35 km (22 mi) from the noise source and persist for from 40 to 48 km (25 to 30 mi). Iñupiaq whaling captains report that bowhead pods divert from their migratory path at distances of 56 km (35 mi) from an active seismic operation and are displaced from the path by as much as 48 km (30 mi). Belugas are more sensitive to noise and are thought by Iñupiaq whalers to remember areas of past noise disturbance and avoid them (NMFS 2011f). Generally, such effects would be confined to the vicinity of the seismic vessel and to the actual time of operation. Seismic surveys would occur after July 1 in the open water season, and would thus not affect the spring whale hunt. Deferral of leasing from a corridor along the coast provides a sea mammal migration corridor in the Chukchi Sea. Villagers along the Beaufort coast have requested a similar deferral corridor (BOEMRE 2011d, f). Without mitigation in place, seismic surveys could affect the more important fall hunt and cause subsistence resources to be unavailable and have a major effect on subsistence harvesting. Lease stipulations for whaler-oil industry conflict avoidance agreements (CAAs) and other "non-disturbance" agreements have minimized such problems in the recent past so that noise and disturbance effects of single actions have been, and are expected to be, effectively mitigated. However, such agreements become more difficult to implement if multiple vessels are surveying at the same time. It is expected that required adaptive mitigation and management plans (AMMPs), the requirements of National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) incidental take authorizations, and required consultation with local communities would ensure that impacts on marine mammals would be minimal. Typical requirements include monitoring for the presence of sea mammals and ensuring that supply aircraft routinely fly above elevations that would disturb sea mammals (MMS 2007b; MMS 2008b). Impacts from noise generated during the exploration phase would be greatest along the north coast in the Chukchi Sea and Beaufort Sea Planning Areas and would only affect the northwest coast if whales remain deflected and do not resume their normal migratory paths.

Development would involve the construction of onshore and offshore infrastructure including gravel drilling pads, onshore and offshore pipelines, landfalls, pumping stations, roads, and additional facilities to house an influx of construction workers. While construction has the potential of providing additional local employment, the noise and human presence associated with construction activities are likely to have temporary and localized effects on some subsistence resources and, depending on the location of construction worker enclaves, place stress on the infrastructure of local communities. Operation of the facilities may require fewer workers than construction, many of whom are likely to be transient shift-workers based in other parts of Alaska. The sociocultural impact of these transient workers would depend on the location of new shore-based facilities, and associated enclaves. When a shore-based facility for Chukchi Sea exploration and development is established at Wainwright, it is likely to expand beyond that required for exploration, further increasing the interaction between transient workers and the previously relatively isolated Alaska Native population.

The potential direct and indirect effects of development in the Arctic would result from noise, and visual disturbances from the construction of pipelines and other offshore and shore-based facilities. Construction activities, including the delivery of fuel and supplies, are limited in time and space and can be scheduled to minimize impacts to subsistence resources. In the past, they have been effectively limited in specified areas during critical periods on subsistence use through industry/subsistence user cooperation (MMS 2008b). The need to install additional platforms in the Arctic could increase the areas and times where either industry or subsistence activities are restricted. This would increase the possibility for moderate to major harvest disruption. Disruption would be made worse if construction and production activities were concentrated in critical subsistence-use areas, which may include cabins and camps. Potential cumulative effects of multiple projects are discussed in Section 4.6.5.3. Increased traffic from supply ships would result in increased noise that sea mammals would avoid and an increased potential for ship-marine mammal strikes, since supply ships would have to travel through the same relatively confined passage as whales. The impact from harm done to whales or the deflection of whales would be felt in whaling communities all along the whale migration routes and in the inland communities that regularly exchange part of their inland subsistence harvest for marine products from coastal communities.

Onshore pipeline effects on subsistence would occur during a 1- or 2-year construction period. The major onshore pipeline to be constructed for the proposed action would connect Chukchi Sea oil production with the TAPS, affecting North Slope Borough communities, or to a possible deepwater port at Kotzebue, affecting subsistence harvesting in the Northwest Arctic Borough. Offshore pipeline effects on subsistence would generally be confined to the period of construction and could be mitigated through lease stipulations that would restrict industry activities during critical subsistence-use periods.

The potential disturbance effects of production operations may be more difficult to mitigate, because such activities would be longer term and operate year round. As with construction, the potential direct and indirect effects of routine OCS operations in the Arctic regions derive from noise, visual, and traffic disturbances from the operation of pipelines and other shore-based facilities.

Even when construction is complete, new infrastructure such as roads and pipelines could serve to restrict the movement of land mammals and the access by indigenous populations to onshore subsistence resources such as caribou herds. For example, a pipeline connecting the Chukchi Sea Planning Area with the TAPS would cross a large area that is currently undeveloped except for isolated and relatively small airstrips. This could restrict access by Nuiqsut subsistence hunters, who already could be restricted by oil and gas development in the Colville River delta the westward expansion of the Prudhoe Bay facilities, and the potential for development to their west in the National Petroleum Reserve in Alaska (BOEMRE 2011d). The potential impact of the pipeline on subsistence resource-use patterns, while unavoidable, can be at least partially mitigated and minimized with proper pipeline design, location, and routing. Potential effects of a pipeline on subsistence users (perceptions of areas they wish to avoid or that are difficult for them to access for hunting) can be addressed with design considerations (for instance, by elevating or burying segments of the pipeline) and by including subsistence users early in the consultation process. The most difficult potential onshore pipeline effects to mitigate would be those related to pipeline servicing and access. If a service road is constructed for this purpose, it would greatly increase impacts on caribou movement and access to subsistence resources on the western part of the North Slope (MMS 2007b). This effect would be greater if such a road were eventually opened to public access, on the model of the Dalton Highway. Roads are also reported to impose substantial maintenance costs on subsistence equipment (snow machines and sleds) and to present some safety issues (Impact Assessment, Inc. 1990). Current practices aim to minimize the construction of new roads. If pipeline servicing was conducted using aircraft, and perhaps ice roads or other ground transport in winter, such potential access effects would be minimized. Increased aircraft traffic in the summer could have a moderate effect on subsistence uses, but such impacts could be reduced through coordination with subsistence users.

The potential effect of pipelines on subsistence resources themselves (in terms of population and behavior) are discussed in Section 4.4.7.13. With regard to caribou, onshore facilities and activities associated with the proposed offshore development program in northern Alaska should have temporary impacts on individual caribou but almost no effects on caribou herds, although development may change their migration patterns and make them less accessible or less desirable. Caribou habituation to gravel pads and oil field infrastructure alters the value of the caribou to subsistence users, who view these habituated caribou as contaminated and not behaving correctly. Frank Long, Jr., stated in the Nuiqsut Alpine Satellite Development Project scoping meeting: “We will have the same problem we did in the Prudhoe Bay and the Kuparuk area with our caribou. Right now, I call our caribou that are existing around here that don’t go nowhere our ‘industrial dope addict caribou.’ They are already sick and nobody’s doing anything about them” (MMS 2007b).

Fish are another important subsistence resource. Most OCS petroleum industry activities would occur far from the freshwater or nearshore locations where subsistence harvests are concentrated. However, the construction of gravel causeways has the potential to affect fish migration routes. This can be mitigated by including culverts that allow the fish to pass through. Other effects would include potential reductions in fish populations (or health effects), which have been evaluated in Section 4.4.7.3.3.

Many Iñupiaq villagers take the long view of their presence in Arctic Alaska. The Iñupiat lived as subsistence hunters for centuries before the arrival of oil development and expect to remain after the oil and gas reserves have been depleted. They are concerned with decommissioning. The impacts of decommissioning are expected to be similar to those of the construction process. Likewise short-lived and spatially restricted, impacts of noise and traffic on subsistence resources may be mitigated through consultation and scheduling.

The principal sociocultural systems impacts of the proposed action in the Arctic would be due to developing a shore base within an Alaska Native community. Additional significant effects would be in the area of subsistence harvesting, with implications for health, population, and the economy. All of these topics, except for health, are discussed in other sections (see Sections 4.4.9, 4.4.10, and 4.4.14). Potential OCS activity would support these established trends. Activity under the proposed program could exert sociocultural effects at the Statewide, regional, and local levels. Income related to OCS development could be expected to support many of the preexisting State programs. At a regional level, OCS activity would constitute one component of continued economic development — primarily onshore and related to the Prudhoe Bay "oil patch" — which has become the prime source of support for most of the infrastructure and local economic development in the North Slope Borough. At a local level, communities might experience adverse sociocultural impacts if development leads to the establishment of shore based facilities, new onshore access routes into the communities, an influx of oil industry personnel into local communities, or local economic benefits from increased local employment opportunities.

Social systems and cultures are seldom, if ever, static. Many changes viewed as sociocultural concerns could also be seen as adaptive change. What is often perceived as the "erosion of cultural values" may only be a transformation or change in the behavioral expression of those values (modes of sharing, expressions of respect). On the other hand, some behavioral changes are more important indicators of cultural and value change than others. That is perhaps why public testimony on the impacts of petroleum development in Arctic Alaska — especially that of Alaska Native Elders — has focused on subsistence resources and practices, the relationship of people to the land and its resources, health, increased social pathologies, and the use (and loss) of Native languages. While OCS activity from the proposed action would only contribute incrementally to these effects, it should be recognized that these activities would occur within this context.

Some of the vectors of sociocultural change that have been commonly noted in studies of Arctic Alaska, lease sale documents, or testimony during the lease sale process can be briefly summarized as follows (see MMS 2008b, p. 4-327, and references therein):

- Changes in community and family organization (availability of wage-labor opportunities locally or regionally, ethnic composition, factionalism, household size);

- Institutional dislocation and continuity (introduction of new institutions, “loss” or de-emphasis of older or more traditional ones, and adaptation of new forms to old content or values, and vice versa);

- Changes in the patterns of overall subsistence activities (time allocation, access, effort, equipment, and monetary needs) and the potential disruption of subsistence harvest activities by industrial development;

- Changes in health measures (a combination of increased access to health care, changes in diet, increased exposure to disease, substance use and abuse, concern over possible exposure to contaminants of various sorts, and other factors);

- Perceived erosion of cultural values and accompanying behaviors (increased social pathologies such as substance abuse, suicide, and crime/delinquency in general; decreased fluency in Native languages; decreased respect for elders; less sharing); and

- Cultural “revitalization” efforts such as dance groups, Native language programs, and official and regular traditional celebrations (such as the reestablishment of *Kivgiq* [the Messenger Feast], for example, in the North Slope Borough and the Northwest Arctic Borough).

While these are all in some sense generalizations and “analytical constructs,” all are also supported by specific testimony of Native residents of the region. These dynamics are not generally viewed as specific to oil and gas development (let alone OCS), but rather as the overall context within which Iñupiat culture must continue to exist (MMS 2008b).

4.4.13.3.2 Impacts of Expected Accidental Events and Spills. The high degree of dependence of Arctic Alaska Native communities on the Beaufort and Chukchi Seas for their subsistence is reflected in the frequency and urgency with which they expressed their concerns over oil spills in the Arctic at public meetings. They are aware of the long-lasting consequences of the *Exxon Valdez* oil spill and of the scale of the effort that was required to cap and clean up after the DWH event in the GOM.

Oil spills have the most potential for adverse effects attributable to the proposed action. Negative effects on specific subsistence species, as well as on the more general patterns of subsistence resource use, persisted in Prince William Sound for years after the *Exxon Valdez* oil spill and the subsequent cleanup effort (Fall 2009).

Expected accidental spills of oil or other chemicals are most likely to occur during the transfer of material from one vessel to another or to or from shore. These spills tend to be small and relatively easily contained. Other accidental spills could result from collisions or wrecks made more likely by an increase in marine traffic. The size and severity of such spills depend on the nature and location of the incident. Accidental spills could also result from the loss of well control or damage to pipelines. The effects of an oil spill vary with the size, location, and timing of the spill, along with the type of oil released.

The Arctic environment is particularly vulnerable to the effects of both large and small oil releases, which are expected to persist longer in the environment because of the colder temperatures. An oil spill of more than 1,000 bbl could, depending on the time and location of the spill event, affect the subsistence use of marine mammals in the region where it occurs. In 1978, Thomas P. Bower, Sr., a whaler from Barrow, reported the results of a 1944 oil spill when a Liberty Ship, the *S.S. Jonathan Harrington*, ran aground southeast of Barrow and dumped fuel oil into the sea to lighten the ship:

According to Bower, about 25,000 gallons of oil were deliberately spilled into the Beaufort Sea in this operation. In the cold, Arctic water, the oil formed a mass several inches thick on top of the water. Both sides of the barrier islands in that area — the Plover Islands — became covered with oil. "That first year … I observed how seals and birds who swam in the water would be blinded and suffocated by contact with the oil. It took approximately 4 years for the oil to finally disappear.… I observed that for 4 years after that oil spill, the whales made a wide detour out to sea from these islands" (MMS 2007b).

Although this episode shows that a species can recover after 4 years without cleanup, those years are remembered by subsistence harvesters as a time when subsistence harvest was severely reduced.

It is assumed that as many as 190 very small oil spills (50 bbl or less) and between 35 and 70 small oil spills (more than 50 bbl but no greater than 1,000 bbl) would be associated with the Program in the Arctic (see Section 4.4.2). While most small spills are likely to be contained, small spills may have local effects on subsistence resources. Because small amounts of oil spread out rapidly over the ocean surface, forming a thin sheen, and tend to break up into small patches and streamers, an oil spill has to be at least several barrels, perhaps as many as 50, before birds important to subsistence hunters would be at risk. A limited number of birds would be lost. Small oil spills are estimated to have minor effects on mammals sought by subsistence hunters, such as harbor seals, other marine mammals, and terrestrial mammals, with perhaps the loss of a few individuals to oiling and some minor, transient, and local contamination. Subsistence harvesters would consider animals from an oiled context to be tainted and would be less likely to harvest them. Recovery from small spills would probably require no more than a year (MMS 2003a). Loss of a subsistence resource for a year would increase the stress on local communities, which would have to import more expensive foods to compensate (Fall et al. 2001), and could affect the stocks of terrestrial animals and freshwater fish as coastal hunters and fishers turn inland for subsistence food. The effects of prolonged exposure to elevated levels of petroleum hydrocarbons on fish are discussed in Section 4.4.7.3.3. The effects can be lethal or sublethal and have the greatest effect on eggs, larvae, and juveniles, particularly in intertidal zones.

As many as three large spills (over 1,000 bbl) could occur in the Beaufort Sea and Chukchi Sea Planning Areas under the proposed action. As the result of a large spill, the bowhead whale hunt could be disrupted, as could the beluga harvest and the more general and longer hunt for walrus. Animals could be directly oiled, or oil could contaminate the ice floes or onshore haulouts they use on their northern migration. Such animals could be more difficult to hunt because of the physical conditions. Animals could be "spooked" and/or wary, either because of the spill itself or because of the "hazing" of marine mammals, which is a standard spill-response technique in order to encourage them to leave the area affected by a spill. Oiled animals are likely to be considered tainted by subsistence hunters and would not be harvested, as occurred after the *Exxon Valdez* spill. This would also apply to terrestrial animals, such as bears that scavenge oiled birds and animals along the shore, or caribous that seasonally spend time along the shore or on barrier islands seeking relief from insects. Loss or tainting of marine mammals occurring off the north coast would affect subsistence communities all along the migration routes of the marine mammals, including Northwest Arctic Borough communities and whaling communities on islands in the Bering Sea. There would be a considerable ripple effect from losses in these communities, since coastal communities are tied into exchange networks that stretch inland as far as Anchorage.

Although developers must submit oil spill response plans and have spill response vessels available, there has been little experience with under-ice or broken-ice oil spills (Arctic Council 2009). While the concern is most typically phrased in terms of the potential effects of oil spills on whales and whaling, it can be generalized to a concern for marine mammals and ocean resources in general. Fishes most likely to be affected by large spills include many that are important to subsistence fishers. They include those that migrate extensively, such as the Arctic cisco; those with strong ties to the streams where they were spawned, such as the Dolly Varden; and those tied to nearshore environments, such as broad whitefish (see Section 4.4.7.3.3). Marine mammals and fish typically comprise 60% of a coastal Alaska Native community's diet. Pipeline and platform spills could also impact migrating anadromous fish in the river deltas, as well as species that use oiled coastal and nearshore habitat, such as nesting birds, breeding caribou, and the like. Overall, the impacts of oil spills on subsistence practices and resources would be variable, ranging from minor to major, depending on the size, location, and timing of the spill. As shown by the results of the *Exxon Valdez* spill, subsistence harvesters in unaffected areas are likely to share resources with impacted villages through established social networks. While local ties are regularly strengthened through mutual exchange, they can weaken when there is less to exchange (Picou et al. 2009).

Cleaning up a large spill is likely to have negative consequences as well. Cleanup activities and increased human presence could displace subsistence species from their usual harvesting locations. There are relatively few vessels on the northern and northwestern coasts of Alaska that could participate in the cleanup of a large spill. It is likely that whaling boats and their crews would be diverted for this purpose. Depending on the timing of the spill, this would make them unavailable for the whale hunt. While local villagers would be employed in the cleanup, it is likely that many additional workers would be necessary, placing stress on village facilities. An influx of outsiders is likely to result in some cultural conflict, stressing the local sociocultural systems.

As is evident from the *Exxon Valdez* oil spill event, such cleanup efforts can be disruptive socially, psychologically, and economically for an extended period of time. While the magnitude of impacts declines rapidly in the first year or two after a large spill, long-term effects continue to be evident (Picou et al. 2009). Such effects can be reduced by the early implementation of coping and mitigation measures (Picou et al. 1999). One important coping measure is the establishment of, and local participation in, an effective spill-response effort that has been formulated into an explicit spill-response plan. Such local programs do have a number of benefits. They provide local employment, a sense of local empowerment, and a means for local resident–oil industry communication. Another possible coping measure would be the establishment of intervention programs, such as peer listening programs based on community participation (MMS 2003a; Picou et al. 1999, 2009; Picou 2010).

A recent Oil Spill Risk Analysis (OSRA) that modeled the oil spill trajectory for spills in the Chukchi Planning Area suggests that the major impacts of an oil spill would be along the northern coast of Alaska and on the Russian coasts. Due to the predominantly southwesterly flow of ocean currents, the probability of an oil spill in the Chukchi Sea Planning Area reaching Kavilina, Kotzebue, or Shisharef is extremely low (BOEMRE 2011j).

Impacts of an Unexpected Catastrophic Discharge Event. A CDE is an unexpected, very-low-probability accident that may occur during oil and gas development on the OCS (see Sections 4.3.3 and 4.4.2). The PEIS analyzes unexpected CDEs that range in size from 1.4 to 2.2 million bbl in the Chukchi Sea Planning Area and last 40 to 75 days, and for 1.7 to 3.9 million bbl in the Beaufort Sea Planning Area and last 60 to 300 days (Table 4.4.2-2). Alaska Natives all along the northern and northwest coasts and whaling communities on islands in the Bering Sea have grave concerns about the possibility of a CDE. They are concerned that oil from such an event would spread quickly in the shallow Arctic waters, that oil companies lack the technology to clean up a spill in ice and lack an understanding of how dispersants would act in Arctic waters, and that there is not enough equipment nearby and insufficient infrastructure such as harbors and airports to handle the influx of people and material needed to clean up a CDE. They are particularly concerned about the effects of a spill in the whale migration path and the resulting loss and/or contamination of a major food source. The loss of whales as subsistence resources would be a blow to Alaska Native whaling communities. This loss could not be easily replaced by other resources and would have serious cultural ramifications as well (BOEMRE 2011j). In the words of Waska Williams at the 2011 Barrow scoping meetings, “In the event that a major spill happens, our way of life is in jeopardy” (BOEMRE 2011f).

Depending on the time and place it occurred, an unexpected CDE could have major effects on the marine mammals, fishes, migratory birds, and terrestrial mammals upon which Alaska Native subsistence harvesters depend. Oil is more likely to persist in the Arctic environment due to the colder temperatures prolonging the effects of such an event. A CDE could affect the subsistence harvest by altering the overall subsistence round (annual pattern of subsistence harvest activities) through displacement, real or perceived tainting, increased wariness of the harvested species, or increased risk and cost due to the necessity of traveling greater distances during the hunt. Direct contact with oil on barrier islands and coastal shorelines would create toxic environments for traditional subsistence resources. Onshore contact and spill response and cleanup have the greatest potential for disrupting the subsistence round. The instantaneous nature and magnitude of an unexpected CDE makes it difficult to “stock up” on subsistence resources in advance (BOEMRE 2011j).

A recent analysis of the potential effects of a CDE in the Chukchi Sea Planning Area suggests that a CDE may be divided into five phases: the initial event; offshore oil; onshore contact; spill response and cleanup; and long-term recovery (see BOEMRE 2011j and references therein). The initial event is likely to have localized direct impacts; however, there would probably be indirect impacts on subsistence harvest patterns resulting from images and news of the event causing distress to subsistence harvesters throughout the region, who would likely fear reduced or contaminated resources, contaminated habitats and harvest areas, reduction in the ability to harvest, and generally unsafe food.

Offshore resources could come into direct contact with released oil, and pollution from the spill may contaminate environmental resources. There could be a serious curtailment of subsistence if offshore oil contacted migrating or resident marine mammals. Seabirds and waterfowl that congregate in dense flocks and spend much of their time on the sea surface would be at greatest risk. Marine mammals such as seals, walrus, and polar bears would not likely be in the vicinity of an active drilling operation. The number of bowhead whales contacting spilled oil would depend on the duration, location, and timing of the spill and whales' ability or inclination to avoid contact. If oil were to get into leads or ice-free areas frequented by migrating bowheads, some portion of the population would be exposed to fresh oil. Prolonged exposure could kill some whales. The effects of a CDE on beluga whales, seals, and walrus could result from oiling of skin and fur, inhaling hydrocarbon vapors, ingesting oil-contaminated prey, losing food sources, and temporary displacement from some feeding areas. Any nearshore CDE would cause injury or death to these sea mammals, potentially cause them to move off their normal course, and make them unavailable for harvest. Any nearshore contact near Point Lay would disrupt beluga migration and deprive Point Lay of its primary subsistence hunt. If a large amount of oil contacted a large group of aggregating belugas, some deaths would occur (BOEMRE 2011j). If there is a serious reduction in the whale stock, the International Whaling Commission (IWC) could reduce or eliminate the quota of whales that can be taken by Alaska Native subsistence harvesters. This would have major effects throughout the Alaska Native communities that either harvest marine subsistence resources or trade with the communities that do. An oil spill affecting any part of the migration routes of the bowhead whale and other marine mammals could taint resources that are culturally pivotal to the subsistence way of life. Even if whales were available for the spring and fall hunt, fears of tainting would make bowheads less desirable and alter or halt the subsistence hunt.

Onshore contact would be even more serious. An oil spill contacting a coastal haul-out area would have a significant impact on walrus populations; a spill contacting denning polar bears would have a significant impact on polar bear populations. Oil could cause injury or death of these animals or cause them to alter their normal behavior, making them unavailable for harvest. Marine and coastal birds in the Pacific Flyway could potentially face substantial impacts if oil were to contact important bird habitats such as Kasegaluk Lagoon, Peard Bay, the barrier islands, the spring open-water lead system, or seabird nesting colonies at Cape Lisburne and Cape Thompson during periods of peak use. There could be significant mortality and sublethal effects to large numbers of birds. The loss of waterfowl populations to oil spills would cause harvest disruptions that would be significant to subsistence hunters who regard the spring waterfowl hunt to be of primary importance. Oil reaching intertidal or estuarine spawning and rearing habitats could result in significant adverse effects to some local breeding populations, which would require up to three generations to recover. Anadromous fish would be particularly hard hit if oil reached the mouths and deltas of anadromous streams and rivers. Local fish stocks would not be available to subsistence harvesters for years to come. Oiled shores would also have negative impacts on some terrestrial mammals, particularly scavengers ingesting oiled carcasses of seabirds on the shore and caribou exposed to oil when they seasonally seek relief from insect harassment on the shores and on barrier islands (BOEMRE 2011j).

An unexpected CDE originating in the Beaufort or Chukchi Sea region would produce impacts felt by communities remote from these planning areas and far removed from the spill. The same concerns about the integrity of subsistence resources, subsistence harvests, and subsistence food consumption would be shared by all the Iñupiat and Yup'ik communities in the North Slope Borough, the Northwest Arctic Borough, and the Bering Sea area; and by indigenous peoples on the Russian Chukchi Sea coast adjacent to the migratory corridor used by whales and other migrating species such as salmon stocks breeding in the Bering Sea region (BOEMRE 2011j).

> "Tainting concerns could seriously curtail the harvesting, sharing, and processing of subsistence resources, and these practices would be hampered to the degree these resources were contaminated. All areas directly oiled, areas to some extent surrounding them, and areas used for staging and transportation corridors for oil-spill response would not be used by subsistence hunters for some time following a spill. Oil contamination of beaches would have a profound impact on whaling because, even if bowhead whales were not contaminated, Iñupiat subsistence whalers would not be able to bring them ashore and butcher them on a contaminated shoreline. In the case of extreme contamination, harvests could cease until such time as resources were perceived as safe by local subsistence hunters. Because all communities would share concerns over the safety of these subsistence foods and the health of the whale stock, social stress would occur from the reduction or loss of preferred foods harvested in the traditional fashion and threaten a pivotal element of indigenous Alaska culture. The duration of avoidance by subsistence users would vary depending on the volume of the spill, the persistence of oil in the environment, the degree of impact on resources, the time necessary for recovery, and the confidence in assurances that resources were safe to eat. Such oil-spill effects would be considered significant."
> (BOEMRE 2011j)

The loss of subsistence harvest resources, particularly marine mammals, would adversely affect Alaska Native culture and society. As shown by the results of the *Exxon Valdez* spill (Picou et al. 2009; Fall et al. 2001), subsistence harvesters in unaffected areas are likely to share resources with impacted villages through established social networks. While local ties are regularly strengthened through mutual exchange, they can weaken when there is less to exchange.

Cleaning up a CDE would have negative consequences as well. Cleanup activities and increased human presence could displace subsistence species from their usual harvesting locations. There are relatively few vessels on the northern and northwestern coasts that could participate in the cleanup of a CDE. It is likely that whaling boats and their crews would be diverted for this purpose. Depending on the timing of the spill, this could make them unavailable for the whale hunt. During the *Exxon Valdez* cleanup, higher wages offered to cleanup workers resulted in local labor shortages (Fall et al. 1999). While local villagers would be employed in the cleanup, it is likely that many additional workers would be necessary, placing stress on village facilities. An influx of outsiders is likely to result in some cultural conflict, stressing the local sociocultural systems. As is evident from the *Exxon Valdez* oil spill event, such cleanup efforts can be disruptive socially, psychologically, and economically for an extended period of time.

The cleanup process itself could alter the behavior of animals important to subsistence harvesting. Disturbance to bowhead and beluga whales, seals, polar bears, caribou, fishes, and birds could increase. Offshore, skimmers, workboats, barges, aircraft overflights, relief-well-drilling activities, and *in-situ* burning during cleanup could cause whales to temporarily alter their paths. They could cause some animals, including seals in ice-covered or broken-ice conditions, to avoid areas where they are normally harvested or to become wary or more difficult to harvest. On and near shore, workers, boats, heavy equipment, and intentional hazing or capture of animals could disturb coastal resource habitat, displace species, or alter or restrict subsistence hunter access to these species and alter or extend the normal subsistence hunt. "Overall, oil-spill-cleanup activities…should be viewed as an additional impact, potentially causing displacement of subsistence resources and subsistence hunters" (BOEMRE 2011j).

After a CDE, it is likely that considerable stress and anxiety would occur over the loss of subsistence resources, contamination of habitat and subsistence resources, fear of the health effects of eating contaminated wild foods, fear of changes to harvest quotas, and the need to depend on the knowledge of others regarding environmental contamination. Individuals and communities would be increasingly stressed during the time it would take to modify subsistence-harvest patterns by selectively changing harvest areas (if such areas were even available), and there would be increased costs and risks associated with travel and hunting in unfamiliar areas. Associated cultural activities, such as the organization of subsistence activities among kinship groups and the relationships among those who customarily process and share subsistence harvests, would also be modified or would decline (BOEMRE 2011j).

> "Multiyear disruptions of subsistence-harvest patterns, especially to the bowhead whale, a pivotal subsistence resource to the Iñupiat culture, could disrupt sharing networks, subsistence task groups, and crew structures and would cause disruptions of the central Iñupiat cultural value: subsistence as a way of life. These disruptions also could cause a breakdown in sharing patterns, family ties, and the community's sense of well-being and could damage sharing linkages with other communities. Other effects might be a decreasing emphasis on subsistence as a livelihood, with an increased emphasis on wage employment, individualism, and entrepreneurism." (BOEMRE 2011j)

Impact Conclusions.

Routine Operations. Finding and developing oil and gas resources on the Arctic OCS has the potential to create adverse impacts on sociocultural systems and subsistence in the Arctic Planning Areas. Such impacts would range from minor to moderate for the routine Program activities, depending on the nature, timing, location, and scale of the activity. Many potential effects are expected to be limited or mitigable. Of greatest concern to the Alaska Natives who inhabit the area are threats to their subsistence base and way of life. Not only does subsistence harvesting provide them with a substantial portion of their food supply, but subsistence-related activities are central to their cultural identity. For many, the most iconic subsistence activity is the whale hunt.

Lease sales on the Arctic OCS are likely to result in the search for and development of oil and gas resources. These activities could have direct and indirect effects on Alaska Native subsistence practices and culture. Noise from seismic surveys and exploratory drilling has the potential to deflect whales and other marine mammals from their accustomed migration routes, making them more difficult to harvest. Effects can be reduced through cooperative scheduling and exploration design based on dialogue among the villages, oil companies, and Federal and State agencies. The noise and increased human presence resulting from the construction and operation of drilling pads, pipelines, and shore base facilities has the potential to disturb subsistence species, causing minor to moderate impacts. The increased presence of non-Natives in and around previously isolated villages increases the chance of cross-cultural misunderstanding and could result in financial and cultural stress on Native communities. Lease stipulations requiring conflict avoidance agreements between oil developers and Native villages, along with training of in-migrating work force, will reduce negative impacts. Impacts on freshwater fish and terrestrial subsistence species such as caribou from onshore pipelines can be ameliorated by cooperative planning efforts that take subsistence needs into account. Effects are likely to be compounded by concern over cumulative effects, which are discussed in Section 4.6.5.3.

Expected Accidental Events and Spills. Of greatest concern to the villagers are the effects of any oil spill. Potential impacts on sociocultural systems from accidents under the proposed action could vary from minor to major, depending on the size, location, and timing of a spill

Depending on their location, weather conditions, and the time of year, small spills would be more likely to be contained and cleaned up. Small spills are likely to have minor impacts on marine mammals. It is likely that some birds would be lost, but resources should recover in less than a year. Depending on its location, the loss of a resource for a year could be a major impact; however, in general, the impacts of a small spill are likely to be minor to moderate.

Depending on timing and location, a large spill could disrupt the beluga, bowhead, and walrus harvests. Animals could be oiled or spooked by hazing. Any major disruption of the sea mammal harvest would have major impacts. Important fish species could also be affected, as could seabirds, waterfowl, and land mammals that scavenge oiled individuals. Impacts could be major if intertidal zones, lagoons, and estuaries were oiled. Events occurring in the northern planning areas would be felt all along the migration routes of animals important to subsistence harvesters including harvesters of the Northwest Arctic Borough and those on offshore islands.

An Unexpected Catastrophic Discharge Event. The greatest impacts would occur in the unlikely event of a low-probability CDE. The impacts of a CDE would be most serious if the release occurred during a whale migration and affected the migration route. Contact with oil could result in the deaths of some individual animals. Native harvesters would perceive surviving oiled whales as tainted and would be hesitant to harvest them. A reduction in whale stock could result in the IWC reducing or eliminating whale quotas in the entire Alaska Arctic. The deaths of a large number of birds is possible and, if breeding populations were affected, could result in a serious reduction of the availability of waterfowl to subsistence harvesters all along the Pacific Flyway. Intertidal breeding populations could be decimated, resulting in a long recovery period. Anadromous fishes could be hard hit. In general, the impacts of such an unlikely spill would be major not only for the villages along the northern coast, but for all communities that depend on the sea mammals, fish, and birds that migrate to or through the Chukchi and Beaufort Seas and their shores.

An unexpected CDE would prove challenging for existing response capacity and capability, especially if the spill were under ice or in broken ice. The cleanup process itself has the potential to cause displacement of subsistence resources and subsistence hunters, and would have major impacts in the short term depending on the timing and duration of the displacement. The associated influx of cleanup workers is likely to overwhelm the resources of local communities and could result in cross-cultural conflicts.

4.4.14 Potential Impacts on Environmental Justice

4.4.14.1 Gulf of Mexico

4.4.14.1.1 Impacts of Routine Operations. In addition to the continuing use of existing onshore support and processing facilities, between 4 and 6 new pipe yards, up to 12 new pipeline landfalls, and as many as 12 new gas processing facilities are projected to be built as a result of the proposed 5-year Program. Impacts of new onshore construction impacts could include increased noise and traffic, air and water pollution, impacts on residential property values, and land use changes. Air emissions from onshore facilities and helicopter and vessel traffic traversing coastal areas will be highest in the areas containing the greatest amounts of infrastructure, which again will be Texas and Louisiana. Lesser amounts will occur in Mississippi and Alabama. No onshore infrastructure supporting OCS operations currently exists in Florida, and none will be built as a result of the proposed program.

It is assumed that 75% of the activity from the proposed 5-yr program will occur in deep and ultra-deep waters, with offshore air emissions greatest in the coastal areas of Texas and Louisiana, the areas with the greatest amounts of oil and gas activity, and lesser amounts in occurring in Mississippi and Alabama. The coastal areas of Florida are located so far from OCS activities that no environmental justice issues from offshore air emissions are expected to impact the coastal parts of the State.

The effects of the OCS program on air quality have been analyzed in Section 4.4.4. This analysis concluded that routine operations associated with the proposed 5-yr program would result in NO_2, SO_2, PM_{10}, and CO levels that are well within the National Ambient Air Quality Standards (NAAQS). Coastal effects from offshore activities are expected to be small, based on the established and increasing trend toward movement of oil and gas activities into deeper waters of the GOM.

The proposed 5-yr program will result in levels of infrastructure use and construction similar to that which has occurred in the GOM coast region during previous programs. These activities are not expected to expose residents to notably higher risks than currently occur. While the distribution of offshore-related activities and infrastructure indicates that some places and populations in the GOM region will continue to be of environmental justice concern, the incremental contribution of the proposed OCS program is not expected to affect those places and populations.

4.4.14.1.2 Impacts of Expected Accidental Events and Spills. Up to 8 large spills greater than 1,000 bbl, between 35 and 70 spills between 50 and 1,000 bbl, and between 200 and 400 small spills less than 50 bbl could occur in the GOM from the proposed action. It is reasonable to expect that most of these spills will occur in deepwater areas located away from the coast, based on the established trend for oil and gas activity to move into deep waters located for the most part at a substantial distance from the coast. However, according to MMS (2002b), the probability of an offshore oil spill occurring and impacting coastal populations is low. While the location of possible oil spills cannot be determined and while low-income and minority populations reside in some areas of the coast, in general the coasts are home to more affluent groups. Low-income and minority groups are not more likely to bear more negative impacts than other groups.

Chemical and drilling-fluid spills may be associated with exploration, production, or transportation activities that result from the proposed action. Low-income and minority populations might be more sensitive to oil spills in coastal waters than is the general population because of their dietary reliance on wild coastal resources, their reliance on these resources for other subsistence purposes such as sharing and bartering, their limited flexibility in substituting wild resources with those purchased, and their likelihood of participating in cleanup efforts and other mitigating activities. With the exception of a catastrophic accidental event, such as that which occurred following the DWH accident, the impacts of oil spills, vessel collisions, and chemical/drilling fluid spills are not likely to be of sufficient duration to have adverse and disproportionate long-term effects for low-income and minority communities in the analysis area.

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes a CDE that ranges in size from 0.9 to 7.2 million bbl and has a duration of 30–90 days (Table 4.4.2-2). In the GOM, a CDE could have impacts on low-income and minority communities, although the magnitude of impacts of a CDE would partly depend on the location, size, and timing of the event, and many of the long-term impacts of a CDE on low-income and minority communities are unknown. As studies of past oil spills have highlighted, different cultural groups would likely possess varying capacities to cope with catastrophic events (Palinkas et al. 1992), with some low-income and/or minority groups more reliant on subsistence resources and/or less equipped to substitute contaminated or inaccessible subsistence resources with those purchased in the marketplace. Because lower income and/or minority communities may live near and be directly involved with CDE cleanup efforts, the vectors of exposure can be higher for them than for the general population, increasing the potential risks of long-term health effects. To date, there have been no longitudinal epidemiological studies of possible long-term health effects for oil-spill cleanup workers. While the economic impacts of the DWH event have been partially mitigated by employers retaining employees for delayed maintenance or through the Gulf Coast Claims Facility (GCCF) program's emergency funds, the physical and mental health effects on both children and adults within these communities could potentially unfold for many years.

Impact Conclusions.

Routine Operations. The Program would result in levels of infrastructure use and construction similar to those that have already occurred along the GOM coast during previous programs. Routine Program operations are not expected to expose residents to notably higher risks than currently occur. While the distribution of offshore Program activities and infrastructure indicates that some places and populations in the GOM region will continue to be of environmental justice concern, the incremental contribution of the Program is not expected to affect those places and populations. Air emissions from the proposed program are not expected to result in air quality impacts on minority or low-income populations, with emissions from the proposed program not being expected to exceed the NAAQS in any affected area. Impacts on environmental justice from routine Program activities in the GOM Planning Areas are expected to be negligible.

Expected Accidental Events and Spills. Impacts from accidental oil spills expected in the GOM would not raise additional environmental justice concerns because of the movement of oil and gas activities farther away from coastal areas and the demographic pattern of more affluent groups (and fewer low-income and minority populations) living in coastal areas. Small spills less than 1,000 bbl would have negligible to minor impacts, while large spills (≥1,000 bbl) would have minor to moderate impacts.

An Unexpected Catastrophic Discharge Event. A CDE could have moderate to major impacts on low-income and minority communities, although the magnitude of impacts of a CDE would partly depend on the location, size, and timing of the event, and many of the long-term impacts of a CDE on low-income and minority communities are unknown.

4.4.14.2 Alaska – Cook Inlet

4.4.14.2.1 Impacts of Routine Operations. Although only one pipeline landfall and no new pipe yards or gas processing facilities would be built as a result of the Program, additional offshore construction could include increased noise and traffic, air and water pollution, impacts on residential property values, and land use changes. Much of the Alaska Native population resides in the coastal areas of Alaska. New offshore infrastructure resulting from this program could be located near areas where subsistence hunting occurs. The Program will result in levels of infrastructure use and construction similar to that which has occurred in the south central Alaska region during previous programs, and, in many of the same locations. These activities are not expected to expose residents to notably higher risks than those that currently occur.

Any adverse environmental impacts on fish and mammal subsistence resources from installation of infrastructure and routine operations of these facilities could have disproportionately higher health or environmental impacts on Alaska Native populations, particularly with regard to air quality impacts and impacts on animal species used for subsistence purposes.

Air emissions from onshore facilities and helicopter and vessel traffic traversing coastal areas will be highest in areas containing the greatest amounts of infrastructure. It is assumed that the majority of the activity from the Program will occur in deep and ultra-deep waters, with offshore air emissions greatest in the coastal areas with the greatest amounts of oil and gas activity, and lesser amounts occurring elsewhere. The effects of the OCS program on air quality have been analyzed in Section 4.4.4. This analysis concluded that routine operations associated with the proposed 5-yr program would result in NO_2, SO_2, PM_{10}, and CO levels that are well within the NAAQS. Coastal effects from offshore activities are expected to be small, based on the established and increasing trend toward movement of oil and gas activities into deeper waters.

Critical subsistence species that are most likely to be disturbed by noise-producing activities include bowhead and beluga whales, seals, fish, caribou, and birds. Noise disturbance would be associated with aircraft and vessel support of modifications to platform facilities, installation of oil and gas pipelines from platforms to shore, and the expansion of shore facilities. While OCS oil and gas activities are not expected to appreciably reduce any populations of subsistence species, it is possible that disturbance caused by these activities could alter the local availability of these resources to harvesters. These impacts would be considered short term and localized, and would not rise to the level of significant adverse effects.

4.4.14.2.2 Impacts of Expected Accidental Events and Spills. One large spill greater than 1,000 bbl, between 1 and 3 spills between 50 and 1,000 bbl, and up to 15 small spills less than 50 bbl could occur in the Cook Inlet area from the proposed action. It is reasonable to expect that most of these spills will occur in deepwater areas located away from the coast, based on the established trend for oil and gas activity to move into deep waters located for the most part at a substantial distance from the coast. The magnitude of impacts from such spills cannot be predicted, should they contact the coast, and depends on their location, size, and timing. However, according to MMS (2002b), the probability of an offshore oil spill occurring and impacting coastal populations is low. While the location of possible oil spills cannot be determined and while low-income and minority populations are resident in some areas of the coast, in general the coasts are home to more affluent groups. Low-income and minority groups are not more likely to bear more negative impacts than are other groups.

Subsistence activities of Alaska Native communities could be affected by accidental oil spills, with the potential health effects of oil spill contamination on subsistence foods being the main concern (Stephen Brand and Associates 2009). After the 1989 *Exxon Valdez* spill, testing of subsistence foods for hydrocarbon contamination between 1989 and 1994 revealed very low concentrations of petroleum hydrocarbons in most subsistence foods, and the U.S. Food and Drug Administration concluded that eating food with such low levels of hydrocarbons posed no significant risk to human health (Hom et al. 1999). Human health risks can be reduced through timely warnings about spills, forecasts about which areas may be affected, and even evacuating people and avoiding marine and terrestrial foods that may be affected. Avoidance of shellfish, which accumulate hydrocarbons, would be recommended, and Federal and State agencies with health care responsibilities would have to sample the food sources and test for possible contamination.

Whether subsistence users will use potentially tainted foods would depend on the cultural "confidence" in the purity of these foods. Based on surveys and findings in studies of the *Exxon Valdez* spill, Natives in affected communities largely avoided subsistence foods as long as the oil remained in the environment. Perceptions of food tainting and avoiding use lingered in Native communities after the *Exxon Valdez* spill, even when agency testing maintained that consumption posed no risk to human health (MMS 2006b).

The assessment and communication of the contamination risks of consuming subsistence resources following an oil spill is a continuing challenge to health and natural resource managers. After the *Exxon Valdez* spill, analytical testing and rigorous reporting procedures failed to convince many subsistence consumers because test results were often inconsistent with Native perceptions about environmental health. Any effective discussion of subsistence resource contamination must understand the conflicting scientific paradigms of Western science and traditional knowledge in addition to the vocabulary of the social sciences in reference to observations throughout the collection, evaluation, and reporting processes. True restoration of environmental damage, according to Picou and Gill (1996), "must include the re-establishment of a social equilibrium between the bio-physical environment and the human community" (Field et al. 1999; Nighswander and Peacock 1999; Fall et al. 1999). Since 1995, subsistence restoration resulting from the *Exxon Valdez* oil spill has improved by taking a more comprehensive approach by partnering with local communities and by linking scientific methodologies with traditional knowledge (Fall et al. 1999; Fall and Utermohle 1999).

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes a CDE that ranges in size from 75 to 125 thousand bbl and has a duration of 50–80 days (Table 4.4.2-20). In Cook Inlet, a CDE could have impacts on low-income and minority communities, although the magnitude of impacts of a CDE would partly depend on the location, size, and timing of the event, and many of the long-term impacts of a CDE on low-income and minority communities are unknown. As studies of past oil spills have highlighted, different cultural groups would likely possess varying capacities to cope with catastrophic events (Palinkas et al. 1992), with some low-income and/or minority groups more reliant on subsistence resources and/or less equipped to substitute contaminated or inaccessible subsistence resources with those purchased in the marketplace. Because lower income and/or minority communities may live near and be directly involved with catastrophic discharge event cleanup efforts, the vectors of exposure can be higher for them than for the general population, increasing the potential risks of long-term health effects. To date, there have been no longitudinal epidemiological studies of possible long-term health effects for oil spill cleanup workers.

Impact Conclusions.

Routine Operations. Much of the Alaska Native population in the Cook Inlet region resides in the coastal areas, and any new onshore and offshore infrastructure occurring under the Program could be located near these populations or near areas where subsistence hunting occurs. Any adverse environmental impacts on fish and mammal subsistence resources from Program infrastructure and routine operations could result in health or environmental justice impacts on Alaska Native populations, although impacts are expected to be minor.

Expected Accidental Events and Spills. Small spills up to 1,000 bbl would have negligible to minor impacts, while large spills (≥1,000 bbl) that affect subsistence resources could have moderate to major impacts on the Alaska Native population, particularly if the subsistence resources were diminished or tainted as a result of the spill.

An Unexpected Catastrophic Discharge Event. A CDE could have moderate to major impacts on low-income and minority communities, although the magnitude of impacts of a CDE would depend partly on the location, size, and timing of the event, and many of the long-term impacts of a CDE on low-income and minority communities are unknown. Long-term impacts on subsistence resources may be expected, however, and these may lead to longer and greater environmental justice impacts. Mitigation measures, cooperative agreements between Native and industry groups, and government-to-government consultations are designed to limit the effects from oil spills and routine operations.

4.4.14.3 Alaska – Arctic

4.4.14.3.1 Impacts of Routine Operations. Although only one pipeline landfall and no new pipe yards or gas processing facilities would be built as a result of the Program, additional offshore construction could include increased noise and traffic, air and water pollution, impacts on residential property values, and land use changes. Much of the Alaska Native population resides in the coastal areas of Alaska. Any new onshore and offshore infrastructure resulting from this program could be located near these populations or near areas where subsistence hunting occurs. The Program will result in levels of infrastructure use and construction similar to what has occurred in the Arctic region during previous programs. These activities are not expected to expose residents to notably higher risks than currently occur.

Air emissions from onshore facilities and helicopter and vessel traffic traversing coastal areas will be highest in the areas containing the greatest amount of infrastructure. It is assumed that the majority of the activity from the Program will occur in deep and ultra-deep waters, with offshore air emissions greatest in the coastal areas with the greatest amounts of oil and gas activity, and lesser amounts in occurring elsewhere. The effects of the OCS program on air quality have been analyzed in Section 4.4.4. This analysis concluded that routine operations associated with the Program would result in NO_2, SO_2, PM_{10}, and CO levels that are well within the NAAQS.

Any adverse environmental impacts on fish and mammal subsistence resources from installation of infrastructure and routine operations of these facilities could have disproportionately higher health or environmental impacts on Alaska Native populations, particularly with regard to air quality impacts and impacts on animal species used for subsistence purposes.

The NSB Municipal Code defines subsistence as "an activity performed in support of the basic beliefs and nutritional needs of the residents of the borough and includes hunting, whaling, fishing, trapping, camping, food gathering, and other traditional and cultural activities" (ADNR 1997). While this is, at best, a partial view of the significance of these activities to the Iñupiat (and more generally to Alaskan Natives) as individuals, culturally it stresses subsistence as a primary cultural and nutritional set of activities upon which Alaskan Natives depend.

Critical subsistence species that are most likely to be disturbed by noise-producing activities include bowhead and beluga whales, seals, fish, caribou, and birds. Noise disturbance would be associated with aircraft and vessel support of modifications to platform facilities, installation of oil and gas pipelines from platforms to shore, and the expansion of shore facilities. While natural gas development and production are not expected to appreciably reduce any populations of subsistence species, it is possible that disturbance caused by these activities could alter the local availability of these resources to harvesters. These impacts would be considered short term and localized, and would not rise to the level of significant adverse effects.

4.4.14.3.2 Impacts of Expected Accidental Events and Spills. Up to 3 large spills greater than 1,000 bbl, between 10 and 35 spills between 50 and 1,000 bbl, and up to 190 small spills of less than 50 bbl could occur in the Beaufort and Chukchi Sea area from the proposed action. The magnitude of impacts from such spills cannot be predicted, should they contact the coast, and depends on their location, size, and timing. However, according to MMS (2002b), the probability of an offshore oil spill occurring and impacting coastal populations is low. While the location of possible oil spills cannot be determined, and while low-income and minority populations are resident in some areas of the coast, low-income and minority groups are not more likely to bear more negative impacts than are other groups.

Subsistence activities of Native communities could be affected by accidental oil spills, with the potential health effects of oil spill contamination of subsistence foods being the main concern (Stephen Brand and Associates 2009). After the 1989 *Exxon Valdez* spill, testing of subsistence foods for hydrocarbon contamination between 1989 and 1994 revealed very low concentrations of petroleum hydrocarbons in most subsistence foods, and the U.S. Food and Drug Administration concluded that eating food with such low levels of hydrocarbons posed no significant risk to human health (Hom et al. 1999). Human health risks can be reduced through timely warnings about spills, forecasts about which areas may be affected, and even evacuating people and avoiding marine and terrestrial foods that may be affected. Avoidance of shellfish, which accumulate hydrocarbons, would be recommended, and Federal and State agencies with health care responsibilities would have to sample the food sources and test for possible contamination.

Whether subsistence users will use potentially tainted foods would depend on the cultural "confidence" in the purity of these foods. Based on surveys and findings in studies of the *Exxon Valdez* spill, Natives in affected communities largely avoided subsistence foods as long as the oil remained in the environment. Perceptions of food tainting and avoiding use lingered in Native communities after the *Exxon Valdez* spill, even when agency testing maintained that consumption posed no risk to human health (MMS 2006b).

The assessment and communication of the contamination risks of consuming subsistence resources following an oil spill is a continuing challenge to health and natural resource managers. After the *Exxon Valdez* spill, analytical testing and rigorous reporting procedures failed to convince many subsistence consumers, because test results were often inconsistent with Native perceptions about environmental health. Any effective discussion of subsistence resource contamination must understand the conflicting scientific paradigms of Western science and traditional knowledge in addition to the vocabulary of the social sciences in reference to observations throughout the collection, evaluation, and reporting processes. True restoration of environmental damage, according to Picou and Gill (1996), "must include the re-establishment of a social equilibrium between the bio-physical environment and the human community" (Field et al. 1999; Nighswander and Peacock 1999; Fall et al. 1999). Since 1995, subsistence restoration resulting from the *Exxon Valdez* oil spill has improved by taking a more comprehensive approach by partnering with local communities and by linking scientific methodologies with traditional knowledge (Fall et al. 1999; Fall and Utermohle 1999).

Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes a CDE in the Chukchi Sea Planning Area that ranges in size from 1.4 to 2.2 million bbl and has a duration of 40–75 days, and a CDE in the Beaufort Sea Planning Area with an assumed volume of 1.7-3.9 million bbl and duration of 60–300 days (Table 4.4.2-2). In the Arctic, a CDE could have impacts on low-income and minority communities, although the magnitude of impacts of a CDE would partly depend on the location, size, and timing of the event, and many of the long-term impacts of a CDE on low-income and minority communities are unknown. As studies of past oil spills have highlighted, different cultural groups would likely possess varying capacities to cope with catastrophic events, with some low-income and/or minority groups more reliant on subsistence resources and/or less equipped to substitute contaminated or inaccessible subsistence resources with those purchased in the marketplace. Because lower income and/or minority communities may live near and be directly involved with catastrophic discharge event cleanup efforts, the vectors of exposure can be higher for them than for the general population, increasing the potential risks of long-term health effects. To date, there have been no longitudinal epidemiological studies of possible long-term health effects for oil-spill cleanup workers.

Impact Conclusions.

Routine Operations. Much of the Alaska Native population in the Arctic region resides in the coastal areas. Any new onshore and offshore infrastructure occurring under the Program could be located near these populations or near areas where subsistence hunting occurs. Any adverse environmental impacts on fish and mammal subsistence resources from Program infrastructure and routine operations could result in health or environmental justice impacts on Alaska Native populations although impacts are expected to be minor.

Expected Accidental Events and Spills. Small spills up to 1,000 bbl would have negligible to minor impacts, while large spills (≥1,000 bbl) that affect subsistence resources could also have moderate to major impacts on the Alaska Native population, particularly if the subsistence resources were diminished or tainted as a result of the spill.

An Unexpected Catastrophic Discharge Event. A CDE could have moderate to major impacts on low-income and minority communities, although the magnitude of impacts of a CDE would depend partly on the location, size, and timing of the event, and many of the long-term impacts of a CDE on low-income and minority communities are unknown. Long-term impacts on subsistence resources may be expected, however, and these may lead to longer and greater environmental justice impacts. Mitigation measures, cooperative agreements between Native and industry groups, and government-to-government consultations are designed to limit the effects from oil spills and routine operations.

4.4.15 Potential Impacts to Archeological and Historic Resources

4.4.15.1 Gulf of Mexico

Archaeological resources in the GOM region that may be impacted by the proposed action include historic shipwrecks and inundated prehistoric sites offshore as well as historic and prehistoric sites onshore. Historic shipwrecks tend to concentrate in the shallow, nearshore waters of the GOM (CEI 1977; Garrison et al. 1989; Pearson et al. 2003); however, numerous recent discoveries of well-preserved historic shipwrecks in deepwater areas of the GOM have increased understanding of shipwreck potential on the OCS (Atauz et al. 2006; Church and Warren 2008; Church et al. 2004; Ford et al. 2008). BOEM has expanded its archaeological survey requirements to ensure the detection of these deepwater shipwrecks prior to approving bottom-disturbing activities in areas where it has reason to believe that archaeological resources might exist. Inundated prehistoric sites may exist on the continental shelf shoreward of about the 50-m (164-ft) isobath. The depth may increase as our understanding of the timing for the peopling of North America is pushed ever earlier.

Onshore historic properties include sites, structures, and objects such as historic buildings, forts, lighthouses, homesteads, cemeteries, and battlefields. Onshore prehistoric archaeological resources include sites, structures, and objects such as shell middens, earth middens, campsites, kill sites, tool manufacturing areas, ceremonial complexes, and earthworks.

Adverse effects on historic properties require mitigation. The appropriate mitigation would be developed through consultation among BOEM, the appropriate SHPO, and any Native American tribes who have an interest in the resources.

All archaeological sites identified through surveys conducted for BOEM permitting activities require avoidance or evaluation for listing on the NRHP. Only archaeological and historic resources that are determined eligible for listing on the NRHP require consideration during Federal undertakings (36 CFR Part 800).

4.4.15.1.1 Impacts of Routine Operations. Routine operations associated with offshore oil and gas fall into four stages: exploration, development, operations, and decontamination and decommissioning. Impacts can occur on archaeological and historic resources during any stage but would be most likely during the exploration and development stages when the seafloor is first altered by an activity. It is assumed that operations and decontamination and decommissioning would affect seafloor that had been previously altered by the earlier activities. The potential for impacting a cultural resource is dependent upon the specific activity and whether a cultural resource is present within the area of potential effect for that activity.

Routine activities associated with exploration and development that are likely to affect archaeological and historic resources include drilling wells, platform installation, and pipeline installation and anchoring, as well as onshore facility and pipeline construction projects. While the source of potential impacts will vary with the specific location and nature of the routine operation, the goal of archaeological resource management remains the protection and/or retrieval of unique information contained in intact archaeological deposits.

Direct impacts occur when permitted activities physically alter significant archaeological or historic resources. The result of direct impacts on shipwrecks would be the loss of archaeological data on ship construction, cargo, and the social organization of the vessel's crew, as well as loss of information on maritime cultures for the time period from which the ship dates. Other indirect impacts can result from the visual intrusion resulting from oil and gas development on the OCS and its effect on onshore historic properties. An indirect effect of oil and gas development on archaeological and historic resources is that metal debris from a permitted activity could settle near a shipwreck and could mask magnetic signatures of significant historic archaeological resources, making them more difficult to detect with magnetometers. Direct impacts from a routine activity on a prehistoric archaeological site could include destruction of artifacts or site features, as well as disturbance of the stratigraphic context of the site. This would result in the loss of archaeological data on prehistoric migrations, settlement patterns, subsistence strategies, and archaeological contacts for North America, Central America, South America, and the Caribbean.

Regulations in 30 CFR 550.194 allow the BOEM Regional Director to require that an archaeological report based on geophysical data be prepared, if there are indications that a significant archaeological resource may exist within a lease area. For historic resources, this decision can be based on whether a lease block falls within an area assessed as having a high potential for shipwreck occurrence, such as the entrances to historic ports and harbors, or on the

Regional Director's determination that a survey is warranted. For prehistoric resources, a survey is required if there is the potential for landforms to be present that could contain prehistoric material. If the survey finds evidence of a possible archaeological resource within the lease area, the lessee must either move the proposed activity to avoid the possible resource or conduct further investigations to determine whether an archaeological resource actually exists at the location. If an archaeological resource is present at the location of proposed activity and cannot be avoided, BOEM procedures require consultation with the State Historic Preservation Office to develop mitigating measures prior to any exploration or development.

BOEM has used predictive models based on various parameters to determine when and where archaeological surveys should be required. Studies conducted between 2006 and 2008 suggest that the models used in the past are not adequate (Church and Warren 2008; Ford et al. 2008; Atauz et al. 2006). These studies document significant effects on shipwrecks resulting from routine activities that occurred in areas where wrecks were not anticipated. As a result of these discoveries, BOEM may require surveys in all areas outside those already identified as having the potential for archaeology that could be affected by a project.

Federal, State, and local laws and ordinances, including the National Historic Preservation Act provide a process to facilitate the consideration of known sites and as-yet-unidentified archaeological resources in the planning phases of a proposed project. Where there is reason to believe that an archaeological resource might exist in a lease area, regulations require archaeological surveys to be conducted prior to permitting any activity that might disturb a significant archaeological site. When required, these archaeological surveys have been found to be effective in locating most archaeological resources prior to any construction on the OCS; however, even with surveys, there is the potential that a shipwreck or an inundated terrestrial site could be missed due to sedimentation on the wreck or other factors, resulting in a routine activity contacting a shipwreck or site. Such an event could result in the disturbance or destruction of unique or significant historic archaeological information.

4.4.15.1.2 Impacts of Expected Accidental Events and Spills. Impacts on archaeological and historical resources from an accidental oil spill can result from either direct contact of crude oil with archaeological material or from effects caused by cleanup workers and their equipment (i.e., anchor drags, dredging of contaminated soils, or unauthorized collecting by cleanup workers). The following are discussions of the potential effects from an accidental oil spill on various resource types based on location and water depth.

Shipwrecks in shallow waters and coastal historic and prehistoric archeological sites could be impacted by an accidental oil spill. Archaeological resource protection during an oil spill requires specific knowledge of the resource's location, condition, nature, and extent prior to impact; however, the GOM coastline has not been systematically surveyed for archaeological sites. Existing information indicates that, in coastal areas of the GOM, prehistoric sites occur frequently along the barrier islands and mainland coast and the margins of bays and bayous. Thus, any spill that contacted the land would involve a potential impact on a prehistoric site.

Shipwrecks can be affected by contact with crude oil. Shallow water shipwrecks often serve as artificial reefs when they are covered by corals and other organisms. The organisms that attach to the wreck protect the wood from deterioration. An oil spill could destabilize a balanced ecosystem covering the wreck, thus potentially increasing deterioration of the wreck until the wreck comes into equilibrium with its new environment. Some terrestrial studies have suggested that, while oil contamination of wood initially restricts deterioration, it can later increase deterioration (Ejechi 2003). It is not known how this situation would be altered in a marine environment. It is also not known whether dispersants used to break up concentrations of oil have any effect on shipwrecks or the ecosystem that forms on the wrecks (BOEMRE 2011a).

Should an oil spill contact a coastal historic site, such as a fort or a lighthouse, the major impact would be visual due to oil contamination of the site and its environment. Any effects from contact with oil to historic materials could be mitigated through cleaning of the historic material. The visual impact would most likely be temporary, lasting up to several weeks depending on the time required for cleanup. Gross crude oil contamination of shorelines is a potential direct impact that may affect archaeological site recognition. Heavy oiling conditions could conceal intertidal sites that may not be recognized until they are inadvertently damaged during cleanup (Whitney 1994). Crude oil may also contaminate organic material used in ^{14}C dating, and, although there are methods for cleaning contaminated ^{14}C samples, greater expense is incurred (Dekin et al. 1993; Brown 2011). An Alaskan study examining the effects of the 1989 *Exxon Valdez* oil spill on archaeological deposits revealed that oil in the intertidal zone had not penetrated the subsoil, apparently due to hydrostatic pressure (Dekin et al. 1993); however, because of the different environments, these results should not be translated into the GOM coastal environment without further study.

Spill Response and Cleanup. Cleanup activities have the potential to alter archaeological sites and shipwrecks. Inadvertent damage from anchors can greatly impact archaeological sites and shipwrecks (Church and Warren 2008). The potential amount of damage depends on several factors including the presence and density of shipwrecks and archaeological material in the area of activity, the number of vessels being employed in the cleanup activities, and whether offshore decontamination stations were needed and where these facilities were established. These types of impacts could be avoided or minimized if wreck locations are known. In 2007, 2,100 shipwrecks were reported to have been lost in the GOM; however, specific location information is known for only 233 of these wrecks (BOEMRE 2011a). This issue makes it difficult to avoid wrecks that are suspected to be in the area, but whose presence as yet remains unverified.

Another source of potential impact from oil spills is the harm that could result from unmonitored shoreline cleanup activities implemented by untrained volunteers and heavy equipment operators (Borrell 2010). Unmonitored booming, cleanup activities involving vehicle and foot traffic, mechanized cleanup involving heavy equipment, and high-pressure washing on or near archaeological sites pose risks to the resources. Unauthorized collecting of artifacts by cleanup crew members is also a concern, albeit one that can be mitigated with effective training and supervision. As Bittner (1996) described in her summary of the *Exxon Valdez* oil spill, "Damage assessment revealed no contamination of the sites by oil, but considerable damage resulted from vandalism associated with cleanup activities and lesser amounts were caused by the cleanup process itself."

The National Response Team's *Programmatic Agreement on Protection of Historic Properties during Emergency Response under the National Oil and Hazardous Substances Pollution Contingency Plan* clarifies interagency and regulatory aspects of archaeological site protection during oil spill response. The agreement was followed during the DWH event and it is assumed that the agreement was effective; however, no reports on the utility of the agreement for that event are currently available.

4.4.15.1.3 Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes a CDE that ranges in size from 0.9-7.2 million bbl with a duration of 30–90 days (Table 4.4.2-2). A CDE could result in minor to major impacts on a large number of archaeological and historic resources. Due to the large area affected by a catastrophic event, some resources such as coastal historic sites that are sensitive to prolonged contact with oil could be more heavily impacted. Cleanup crews would be needed in a greater number of locations. This could allow oil to be in contact with resources for a significant amount of time before cleanup efforts could be applied, which could result in impacts to these resources. A greater threat to archaeological and historic resources during a catastrophic discharge event would result from the larger number of response crews being employed. Historically most impacts to archaeological and historic resources during a spill response were the result of vandalism or physical damage from spill response activities (Bittner 1996; Reger et al. 2000). A CDE would result in major impacts to numerous archaeological and historic resources from response activities. The number of sites potentially susceptible to injury from a CDE is quite large. Given the number of resources to be considered and personnel limitations, timely monitoring of affected sites may not be possible (Reger et al. 2000).

Cleanup activities for a CDE may involve the use of chemical substances. These substances, depending on what chemicals are actually employed, may affect archaeological sites. For example, cleanup techniques for the DWH event included application of chemical agents. The full effect of the agents on archaeological sites and shipwrecks is unknown. However, some evidence exists that the use of these substances may result in the contamination of any carbon-14 samples, making the dating of sites difficult (Borrell 2010).

A CDE also may release large amounts of hazardous air pollutants (HAPS), such as benzene, toluene, and xylene, which are found in oil/water mixtures, emulsions called "mousse," or in fresh oil. While HAPs evaporate over time, they may result in indirect effects on historic structures. In addition, "crude oil also contains polyaromatic hydrocarbons (PAHs) that are highly toxic and, if they have penetrated building materials, can persist for long periods of time" (Chin 2010). Contamination of a structure with HAPS or PAHs could limit access to the resource until levels are reduced.

In addition, a CDE also has the potential to indirectly affect future archaeological and historic preservation efforts, due to the depletion of public funds that were redirected to cleanup activities. A CDE, such as the DWH event, typically covers a broad region and requires a short-term and intense effort to clean up and limit the immediate effects of the spill. Significant expenditure of public funds is required to cover upfront costs of these efforts, which ultimately could inhibit future planning and budgets for cultural resource management activities. In Louisiana, for instance, the Office of Cultural Development has indicated that "the Gulf oil spill has stretched resources thin and a discouraging budget climate that has already reduced the overall reach and effectiveness of State government now threatens to carve further into public services" (Louisiana Office of Cultural Development 2011).

The Programmatic Agreement on Protection of Historic Properties during Emergency Response under the National Oil and Hazardous Substances Pollution Contingency Plan would be followed during the response to a CDE. As mentioned above, it is assumed that the process identified in the agreement would be effective; however, no assessments of the agreement's application during the DWH event are available.

Impact Conclusions.

Routine Operations. Assuming compliance with existing Federal, State, and local archaeological regulations and policies, most impacts on archaeological resources resulting from routine activities under the proposed action should be avoided. BOEM may alter its requirements for archaeological surveys because currently, BOEM does not require the submission of archaeological reports based on high-resolution geophysical survey data in all lease-sale areas. Without the data analysis included in the archaeological reports, it is impossible to assess whether a proposed activity may affect an unknown cultural resource in the area of potential effect. When required, archaeological reports based on high-resolution geophysical data are believed to provide the information needed by BOEM to develop appropriate avoidance or mitigation strategies to protect cultural resources within the area of potential effect from impacts associated with oil and gas activities on the OCS. Impacts on archeological and historic resources from routine Program activities are expected to range from negligible to major.

Expected Accidental Events and Spills. In the case of expected accidental events and spills, some impacts on coastal historic and prehistoric archaeological resources could occur. The magnitude of the impacts would depend on the number of resources affected and on the significance and uniqueness of the information lost. Impacts can result from both direct contact with oil and from cleanup operations. Some impacts from direct contact with oil are expected when resources are present, and additional impacts are expected during cleanup activities. Impacts from small spills (<50 bbl) could range from negligible to major depending on the location of the spill in relation to sensitive resources. A similar situation is encountered with small spills up to 1,000 bbl. These spills could result in impacts ranging from negligible to major, depending on the location the spill in relation to sensitive resources. Large spills (≥1,000 bbl) could result in negligible to major impacts. As the size of the spill increases, the likelihood that a sensitive resource could be affected increases. However, given the irreplaceable nature of the resource, even the smallest spill, if occurring in close proximity to a sensitive resource, could result in major impacts. The difference between the scenarios is one of magnitude. Smaller spills are more likely to affect a single resource, whereas larger spills are more likely to affect numerous resources.

An Unexpected Catastrophic Discharge Event. In the event of a CDE which is not expected, some impacts on coastal historic and prehistoric archaeological resources could occur. Although it is not possible to predict the precise numbers or types of sites that would be affected, contact with archaeological sites would probably be unavoidable, and the resulting loss of information would be irretrievable. The magnitude of the impacts would depend on the number of resources affected and on the significance and uniqueness of the information lost. Impacts can result from both direct contact with oil and from cleanup operations. Some impacts from direct contact with oil from a CDE may be expected, and additional impacts may be expected during cleanup activities. Response actions associated with a CDE have the greatest potential for adversely affecting archeological and historic resources. Impacts from a CDE could range from minor to major. In the event of a CDE, many resources would likely be affected. There is a greater likelihood that more of the resources would be affected at a major level during a CDE.

4.4.15.2 Alaska – Cook Inlet

Archaeological and historic resources in the Alaska region include historic shipwrecks, submerged aircraft, inundated prehistoric sites offshore, and historic and prehistoric sites onshore. These resources have the potential to be affected by the proposed action. The locations of most of the cultural resources in Cook Inlet are currently unknown, but if any are discovered during OCS oil and gas activities, they would be subject to archaeological surveys, and other activities and mitigations required by applicable laws and BOEM policies. There is no current archaeological baseline study for Alaska on which to base decisions concerning where cultural resources should be present. An archaeological baseline study was done for Alaska in the mid-1980s (Dixon et al. 1986); however, this research was never updated and should be assessed for its validity when compared with current research and scientific findings. Some research attempting to identify landforms that may contain archaeological remains has been done in the Beaufort and Chukchi Seas, but no new studies have been conducted in Cook Inlet. Research on historic shipwrecks has identified 108 shipwrecks in Cook Inlet (Tornfelt and Burwell 1992). As discussed in Section 3.16.2, portions of Cook Inlet are subject to high-energy tidal movements (MMS 2003a). This high-energy environment may have destroyed some of the archaeological evidence that once existed in Cook Inlet, but this can only be verified through science-based methods of inquiry.

4.4.15.2.1 Impacts of Routine Operations. Routine activities associated with the proposed action that could affect cultural resources include well drilling, platform installation, pipeline installation, and onshore facility and pipeline construction projects that involve ground disturbance. Effects on cultural resources can be determined only on a case-by-case basis. Only through project-specific surveys can cultural resources be identified. The determination that a survey is required depends on several factors including the potential for landforms to exist that may contain archaeological sites (i.e., submerged coastlines) or archival records suggesting that shipwrecks could be present.

As previously discussed, regulations at 30 CFR 550.194 allow the BOEM Regional Director to require that an archaeological report based on geophysical data be prepared, if there are indications that a significant archaeological resource may exist within a lease area. For historic resources, this decision is based on whether a historic shipwreck is reported to exist within or adjacent to a lease area. For prehistoric resources, an analysis is completed prior to each lease sale to consider the relative sea level history, the depth of burial of the late Wisconsinan land surface (i.e., lands that could contain archaeological sites), the type and thickness of sediments burying the old land surface, and the severity of ice gouging at the present seafloor. Lease areas that are shown by this analysis to have the potential for prehistoric archaeological resources are required to have an archaeological survey prior to initiating exploration and development activities. If the survey finds evidence of a possible archaeological resource within the lease area, the lessee must either move the proposed activity to avoid the possible resource or conduct further investigations to determine whether an archaeological resource actually exists at the location. If an archaeological resource is present at the location of proposed activity and cannot be avoided, BOEM procedures require consultation with the State Historic Preservation Office to develop mitigation measures prior to any exploration or development.

Federal, State, and local laws and ordinances, including the National Historic Preservation Act and the Alaska Historic Preservation Act, provide a process to facilitate the consideration of known sites and as-yet-unidentified archaeological resources both onshore and offshore. Where there is reason to believe that an archaeological resource might exist in a lease area, regulations require archaeological surveys to be conducted prior to permitting any activity that might disturb a significant archaeological site. When required, these surveys have been found to be effective in locating most archaeological resources prior to any construction or offshore bottom-disturbing activity on the OCS. However, even with surveys there is the potential that a shipwreck or an inundated terrestrial site could be missed due to sedimentation on the wreck or other factors, resulting in a routine activity contacting a shipwreck or site. Such an event could result in the disturbance or destruction of unique or significant historic archaeological information. However, regulations in 30 CFR 550.194(c) require that if any archaeological resource is discovered, operations must be immediately halted in the area of the discovery and a report of the discovery must be made so that further investigation may determine the significance of the resource.

4.4.15.2.2 Impacts of Expected Accidental Events and Spills. Oil spills and their subsequent cleanup could impact the archaeological resources of the Alaska region directly and/or indirectly. The geologic history of specific shorelines generally affects the presence or absence, condition, and age of archaeological sites on or near Alaska region shorelines. However, some types of archaeological resources are present on or adjacent to nearly all Alaska region shorelines. Existing data indicate that archaeological resources are particularly abundant along Gulf of Alaska shorelines (Mobley et al. 1990).

Archaeological resource protection during an oil spill requires specific knowledge of the resource's location, condition, nature, and extent prior to impact. However, large portions of the Cook Inlet coastline have not been systematically surveyed for archaeological sites. While some response groups have compiled known archaeological site data in a form useful for mitigation during an emergency response (Wooley et al. 1997), these data have not been compiled for all areas of the Alaska region.

Gross crude oil contamination of shorelines is a potential direct impact that may affect archaeological site recognition. Heavy oiling conditions (Whitney 1994) could conceal intertidal sites that may not be recognized until they are inadvertently damaged during cleanup. Crude oil may also contaminate organic material used in ^{14}C dating, and, although there are methods for cleaning contaminated ^{14}C samples, greater expense is incurred (Dekin et al. 1993). However, many other anthropogenic sources of hydrocarbons and other possible contaminants also exist, so caution should always be taken when analyzing radiocarbon samples from coastal Alaska (see Reger et al. 1992). A study examining the effects of the 1989 *Exxon Valdez* oil spill on archaeological deposits revealed that oil in the intertidal zone had not penetrated the subsoil, apparently due to hydrostatic pressure (Dekin et al. 1993).

Spill Response and Cleanup. The major source of potential impact from oil spills resulting from the proposed action is the harm that could result from unmonitored shoreline cleanup activities implemented by untrained volunteers and heavy equipment operators (Borrell 2010). Cleanup activities could impact beached shipwrecks, or shipwrecks in shallow waters, as well as coastal historic and prehistoric archaeological sites. Unmonitored booming, cleanup activities involving vehicle and foot traffic, mechanized cleanup involving heavy equipment, and high-pressure washing on or near archaeological sites pose risks to the resources. Inadvertent damage from anchors can greatly alter archaeological sites and shipwrecks (Church and Warren 2008). The potential amount of damage depends on several factors including the presence and density of shipwrecks and archaeological material in the area of activity, the number of vessels being employed in the cleanup activities, and whether offshore decontamination stations were needed and where these facilities were established. These types of impacts could be avoided or minimized if wreck locations are known. Unauthorized collecting of artifacts by cleanup crew members is also a concern, albeit one that can be mitigated with effective training and supervision. As Bittner (1996) described in her summary of the 1989 *Exxon Valdez* oil spill, "Damage assessment revealed no contamination of the sites by oil, but considerable damage resulted from vandalism associated with cleanup activities, and lesser amounts were caused by the cleanup process itself."

The National Response Team's *Programmatic Agreement on Protection of Historic Properties during Emergency Response under the National Oil and Hazardous Substances Pollution Contingency Plan* clarifies interagency and regulatory aspects of archaeological site protection during oil spill response. The agreement also outlines the Federal On-Scene Coordinator's role in protecting archaeological resources, the type of expertise needed for site protection, and the appropriate process for identifying and protecting archaeological sites during an emergency response. The agreement was followed during the DWH event, and it is assumed that the agreement was effective; however, no reports on the utility of the agreement for that event are currently available.

4.4.15.2.3 Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes a CDE that ranges in size from 75-125 thousand bbl with a duration of 50–80 days (Table 4.4.2-2). A CDE could result in minor to major impacts on a large number of archaeological and historic resources. Due to the large area affected by a catastrophic event some resources such as coastal historic sites that are sensitive to prolonged contact with oil could be more heavily impacted. Cleanup crews would be needed in a greater number of locations. This could allow oil to be in contact with resources for a significant amount of time before cleanup efforts could be applied, which could result in impacts to these resources. A greater threat to archaeological and historic resources during a catastrophic discharge event would result from the larger number of response crews being employed. Historically most impacts to archaeological and historic resources during a spill response were the result of vandalism or physical damage from spill response activities (Bittner 1996; Reger et al. 2000). A catastrophic discharge event would result in major impacts to numerous archaeological and historic resources from response activities.

The number of sites potentially susceptible to injury from a CDE is quite large. Given the number of resources to be considered and personnel limitations, timely monitoring of affected sites may not be possible (Reger et al. 2000). Following the *Exxon Valdez* event, for instance, the oil-spill area likely contained more than 3,000 sites of archaeological and historic significance. Among these, at least 24 archaeological sites on public lands were known to have been adversely affected by cleanup activities, looting, or vandalism, all linked to the spill (*Exxon Valdez* Oil Spill Trustee Council undated). Other examples include reports from the Kodiak Island mayor's office, in which vandalism occurred almost immediately following the release from the *Exxon Valdez*. Cleanup crews that were hired to clean up the oil were found digging up artifacts and destroying remnants of the past inhabitants (Mason 2008).

Cleanup activities for a CDE may involve the use of chemical substances. These substances, depending on what chemicals are actually employed, may affect archaeological sites. For example, cleanup techniques for the DWH event included application of chemical agents. The full effect of the agents on archaeological sites and shipwrecks is unknown. However, some evidence exists that the use of these substances may result in the contamination of any carbon-14 samples, making the dating of sites difficult (Borrell 2010).

A CDE also may release large amounts of HAPs, such as benzene, toluene, and xylene, which are found in oil/water mixtures, emulsions called "mousse," or in fresh oil. While HAPs evaporate over time, they may result in indirect effects on historic structures. In addition, "crude oil also contains polyaromatic hydrocarbons (PAHs) that are highly toxic and, if they have penetrated building materials, can persist for long periods of time" (Chin 2010). Contamination of a structure with HAPS or PAHs could limit access to the resource until levels are reduced.

In addition, a CDE also has the potential to indirectly affect future archaeological and historic preservation efforts, due to the depletion of public funds that were redirected to cleanup activities. A CDE, such as the DWH event, typically covers a broad region and requires a short-term and intense effort to clean up and limit the immediate effects of the spill. Significant expenditure of public funds is required to cover upfront costs of these efforts, which ultimately could inhibit future planning and budgets for cultural resource management activities. In

Louisiana, for instance, the Office of Cultural Development has indicated that "the Gulf oil spill has stretched resources thin and a discouraging budget climate that has already reduced the overall reach and effectiveness of State government now threatens to carve further into public services" (Louisiana Office of Cultural Development 2011).

The *Programmatic Agreement on Protection of Historic Properties during Emergency Response under the National Oil and Hazardous Substances Pollution Contingency Plan* would be followed during the response to a CDE. As mentioned above, it is assumed that the process identified in the agreement would be effective; however, no assessments of the agreement's application during the DWH event are available.

Impact Conclusions.

Routine Operations. Assuming compliance with existing Federal, State, and local archaeological regulations and policies, most impacts on archaeological resources resulting from routine activities under the proposed action should be avoided. BOEM may alter its requirements for archaeological surveys because currently, BOEM does not require the submission of archaeological reports based on high-resolution geophysical survey data in all lease-sale areas. Without the data analysis included in the archaeological reports, it is impossible to assess whether a proposed activity may affect an unknown cultural resource in the area of potential effect. When required, archaeological reports based on high-resolution geophysical data are believed to provide the information needed by BOEM to develop appropriate avoidance or mitigation strategies to protect cultural resources within the area of potential effect from impacts associated with oil and gas activities on the OCS. Impacts on archeological and historic resources from routine Program activities are expected to range from negligible to major.

Expected Accidental Events and Spills. In the case of expected accidental events and spills, some impacts on coastal historic and prehistoric archaeological resources could occur. The magnitude of the impacts would depend on the number of resources affected and on the significance and uniqueness of the information lost. Impacts can result from both direct contact with oil and from cleanup operations. Some impacts from direct contact with oil are expected when resources are present, and additional impacts are expected during cleanup activities. Impacts from small spills (<50 bbl) could range from negligible to major depending on the location of the spill in relation to sensitive resources. A similar situation is encountered with small spills up to 1,000 bbl. These spills could result in impacts ranging from negligible to major depending on the location the spill in relation to sensitive resources. Large spills (≥1,000 bbl) could also result in negligible to major impacts as well. As the size of the spill increases, the likelihood that a sensitive resource could be affected increases. However, given the irreplaceable nature of the resource, even the smallest spill could result in major impacts if it occurred in close proximity to a sensitive resource. The difference between the scenarios is one of magnitude. Smaller spills are more likely to affect a single resource, whereas larger spills are more likely to affect numerous resources.

An Unexpected Catastrophic Discharge Event. In the event of a CDE which is not expected, some impacts on coastal historic and prehistoric archaeological resources could occur . Although it is not possible to predict the precise numbers or types of sites that would be affected, contact with archaeological sites would probably be unavoidable, and the resulting loss of information would be irretrievable. The magnitude of the impacts would depend on the number of resources affected and on the significance and uniqueness of the information lost. Impacts can result from both direct contact with oil and from cleanup operations. Based on experience gained from the *Exxon Valdez* oil spill, some impacts from direct contact with oil from even a CDE are expected, and additional impacts are expected during cleanup activities. Response actions associated with a CDE have the greatest potential for adversely affecting archeological and historic resources. Impacts from a CDE could range from minor to major. In the event of a CDE, many resources would likely be affected. There is a greater likelihood that more of the resources would be affected at a major level during a CDE.

4.4.15.3 Alaska – Arctic

Archaeological and historic resources in the Alaska region include historic shipwrecks, submerged aircraft, inundated prehistoric sites offshore, and historic and prehistoric sites onshore. These resources have the potential to be affected by the proposed action. Several factors must be considered when assessing any potential impacts on offshore resources in Alaska. First, the locations of most of the cultural resources in the Arctic are currently unknown; this is especially true of submerged cultural resources. If any are discovered during OCS oil and gas activities, they would be subject to archaeological surveys and other activities and mitigations required by applicable laws and BOEM policies. The goal of much of the archaeological research being done in the Arctic is to identify locations and landforms that have the potential to contain archaeological and historic resources. The focus on submerged prehistoric resources in Alaska is due to the theory that North America was first populated by nomadic hunters following game across the submerged land mass known as Beringia that once linked Asia with North America (Hoffecker and Elias 2003). A second factor is that, unlike the GOM region, there is no current archaeological baseline study for Alaska on which to base decisions concerning where cultural resources should be present. A third factor is that sea levels have risen over the last 13,000 years. Human activity tends to concentrate on coasts. Regions that were once coastal are now submerged. The coastline that existed 13,000 years ago is now found at roughly the 50-m (164-ft) bathymetry line (Darigo et al. 2007). It is thought that people first came to North America approximately 13,000 years ago. A fourth factor is that natural processes such as ice gouging may have modified much of the ocean bottom to the extent that many cultural resources no longer exist. Studies conducted in 2007 suggest some nearshore locations may remain intact due to shorefast ice, which kept the ice which normally would scrape the sea floor away from the coast. Other factors such as the amount of sediment that has collected on a location may improve the potential for some resources to remain intact.

4.4.15.3.1 Impacts of Routine Operations. Routine activities associated with the proposal that could affect cultural resources include well drilling, platform installation, pipeline installation, and onshore facility and pipeline construction projects that involve ground disturbance. Effects on cultural resources can be determined only on a case-by-case basis. Only through project-specific surveys can cultural resources be identified. The determination that a survey is required depends on several factors, including the potential for landforms to exist that may contain archaeological sites (i.e., submerged coastlines) or archival records suggesting that shipwrecks could be present.

Regulations at 30 CFR 550.194 allow the BOEM Regional Director to require that an archaeological report based on geophysical data be prepared if there are indications that a significant archaeological resource may exist within a lease area. For historic resources, this decision is based on whether an historic shipwreck is reported to exist within or adjacent to a lease area. For prehistoric resources, an analysis is completed prior to each lease sale to consider the relative sea level history, the depth of burial of the late Wisconsinan land surface (i.e., lands that could contain archaeological sites), the type and thickness of sediments burying the old land surface, and the severity of ice gouging at the present seafloor. Lease areas that are shown by this analysis to have the potential for prehistoric archaeological resources are required to have an archaeological survey prior to initiating exploration and development activities. If the survey finds evidence of a possible archaeological resource within the lease area, the lessee must either move the proposed activity to avoid the possible resource or conduct further investigations to determine whether an archaeological resource actually exists at the location. If an archaeological resource is present at the location of proposed activity and cannot be avoided, BOEM procedures require consultation with the State Historic Preservation Office to develop mitigation measures prior to any exploration or development.

Federal, State, and local laws and ordinances, including the National Historic Preservation Act and the Alaska Historic Preservation Act provide a process to facilitate the consideration of known sites and as-yet-unidentified archaeological resources both onshore and offshore. Where there is reason to believe that an archaeological resource might exist in a lease area, existing regulations require archaeological surveys to be conducted prior to permitting any activity that might disturb a significant archaeological site. When required, these archaeological surveys have been found to be effective in locating most archaeological resources prior to any onshore construction project or offshore bottom-disturbing activity; however, even with surveys there is the potential that a shipwreck or an inundated terrestrial site could be missed due to sedimentation on the wreck or other factors, resulting in a routine activity contacting a shipwreck or site. Such an event could result in the disturbance or destruction of unique or significant historic archaeological information.

4.4.15.3.2 Impacts of Expected Accidental Events and Spills. Oil spills and their subsequent cleanup could impact the archaeological resources of the Alaska region directly and/or indirectly. The geologic history of specific shorelines generally affects the presence or absence, condition, and age of archaeological sites on or near Alaska region shorelines; however, some type of archaeological resource is present on or adjacent to nearly all Alaska region shorelines. Existing data indicate that archaeological resources are particularly abundant along Gulf of Alaska shorelines (Mobley et al. 1990).

Archaeological resource protection during an oil spill requires specific knowledge of the resource's location, condition, nature, and extent prior to impact; however, large portions of the Alaska region coastline have not been systematically surveyed for archaeological sites. While some response groups have compiled known archaeological site data in a form useful for mitigation during an emergency response (Wooley et al. 1997), these data have not been compiled for all areas of the Alaska region.

Gross crude oil contamination of shorelines is a potential direct impact that may affect archaeological site recognition. Heavy oiling conditions (Whitney 1994) could conceal intertidal sites that may not be recognized until they are inadvertently damaged during cleanup. Crude oil may also contaminate organic material used in ^{14}C dating, and, although there are methods for cleaning contaminated ^{14}C samples, greater expense is incurred (Dekin et al. 1993). Many other anthropogenic sources of hydrocarbons and other possible contaminants also exist, so caution should always be taken when analyzing radiocarbon samples from coastal Alaska (see Reger et al. 1992). A study examining the effects of the 1989 *Exxon Valdez* oil spill on archaeological deposits revealed that oil in the intertidal zone had not penetrated the subsoil, apparently due to hydrostatic pressure (Dekin et al. 1993).

Spill Response and Cleanup. The major source of potential impact from oil spills resulting from the proposed action is the harm that could result from unmonitored shoreline cleanup activities implemented by untrained volunteers and heavy equipment operators (Borrell 2010). Cleanup activities could impact beached shipwrecks, or shipwrecks in shallow waters, as well as coastal historic and prehistoric archaeological sites. Unmonitored booming, cleanup activities involving vehicle and foot traffic, mechanized cleanup involving heavy equipment, and high-pressure washing on or near archaeological sites pose risks to the resource. Inadvertent damage from anchors can greatly alter archaeological sites and shipwrecks (Church and Warren 2008). The potential amount of damage depends on several factors, including the presence and density of shipwrecks and archaeological material in the area of activity, the number of vessels being employed in the cleanup activities, and whether offshore decontamination stations were needed and where these facilities were established. These types of impacts could be avoided or minimized if wreck locations are known. Unauthorized collecting of artifacts by cleanup crew members is also a concern, albeit one that can be mitigated with effective training and supervision. As Bittner (1996) described in her summary of the 1989 *Exxon Valdez* oil spill, “Damage assessment revealed no contamination of the sites by oil, but considerable damage resulted from vandalism associated with cleanup activities, and lesser amounts were caused by the cleanup process itself.”

The National Response Team’s *Programmatic Agreement on Protection of Historic Properties during Emergency Response under the National Oil and Hazardous Substances Pollution Contingency Plan* clarifies interagency and regulatory aspects of archaeological site protection during oil spill response. The agreement also outlines the Federal On-Scene Coordinator’s role in protecting archaeological resources, the type of expertise needed for site protection, and the appropriate process for identifying and protecting archaeological sites during an emergency response. The agreement was followed during the DWH event, and it is assumed the agreement was effective; however, no reports on the utility of the agreement for that event are currently available.

4.4.15.3.3 Impacts of an Unexpected Catastrophic Discharge Event. The PEIS analyzes a CDE in the Chukchi Sea Planning Area with an assumed volume of 1.4-2.2 million bbl and a duration of 40–75 days, and a CDE in the Beaufort Sea Planning Area with an assumed volume of 1.7–3.9 million bbl and a duration of 60–300 days (Table 4.4.2-2). A CDE could result in minor to major impacts on a large number of archaeological and historic resources. Due to the large area affected by a catastrophic event some resources such as coastal historic sites that are sensitive to prolonged contact with oil could be more heavily impacted. Cleanup crews would be needed in a greater number of locations. This could allow oil to be in contact with resources for a significant amount of time before cleanup efforts could be applied, which could result in impacts to these resources. A greater threat to archaeological and historic resources during a catastrophic discharge event would result from the larger number of response crews being employed. Historically most impacts to archaeological and historic resources during a spill response were the result of vandalism or physical damage from spill response activities (Bittner 1996; Reger et. al. 2000). A catastrophic discharge event would result in large impacts to numerous archaeological and historic resources from response activities. The number of sites potentially susceptible to injury from a CDE is quite large. Given the number of resources to be considered and personnel limitations, timely monitoring of affected sites may not be possible (Reger et al. 2000).

Cleanup activities for a CDE may involve the use of chemical substances. These substances, depending on what chemicals are actually employed, may affect archaeological sites. For example, cleanup techniques for the DWH event included application of chemical agents. The full effect of the agents on archaeological sites and shipwrecks is unknown. However, some evidence exists that the use of these substances may result in the contamination of any carbon-14 samples, making the dating of sites difficult (Borrell 2010).

A CDE also may release large amounts of HAPs, such as benzene, toluene, and xylene, which are found in oil/water mixtures, emulsions called "mousse," or in fresh oil. While HAPs evaporate over time, they may result in indirect effects on historic structures. In addition, "crude oil also contains polyaromatic hydrocarbons (PAHs) that are highly toxic and, if they have penetrated building materials, can persist for long periods of time" (Chin 2010). Contamination of a structure with HAPs or PAHs could limit access to the resource until levels are reduced.

In addition, a CDE also has the potential to indirectly affect future archaeological and historic preservation efforts, due to the depletion of public funds that were redirected to cleanup activities. A CDE, such as the DWH event, typically covers a broad region and requires a short-term and intense effort to cleanup and limit the immediate effects of the spill. Significant expenditure of public funds is required to cover upfront costs of these efforts, which ultimately could inhibit future planning and budgets for cultural resource management activities. In Louisiana, for instance, the Office of Cultural Development has indicated that "the Gulf oil spill has stretched resources thin and a discouraging budget climate that has already reduced the overall reach and effectiveness of State government now threatens to carve further into public services" (Louisiana Office of Cultural Development 2011).

The Programmatic Agreement on Protection of Historic Properties during Emergency Response under the National Oil and Hazardous Substances Pollution Contingency Plan would be followed during the response to a CDE. As mentioned above, it is assumed that the process identified in the agreement would be effective; however, no assessments of the agreement's application during the DWH event are available.

Impact Conclusions.

Routine Operations. Assuming compliance with existing Federal, State, and local archaeological regulations and policies, most impacts on archaeological resources resulting from routine activities under the proposed action should be avoided. BOEM may alter its requirements for archaeological surveys because currently, BOEM does not require the submission of archaeological reports based on high-resolution geophysical survey data in all lease-sale areas. Without the data analysis included in the archaeological reports, it is impossible to assess whether a proposed activity may affect an unknown cultural resource in the area of potential effect. When required, archaeological reports based on high-resolution geophysical data are believed to provide the information needed by BOEM to develop appropriate avoidance or mitigation strategies to protect cultural resources within the area of potential effect from impacts associated with oil and gas activities on the OCS. Impacts on archeological and historic resources from routine Program activities are expected to range from negligible to major.

Expected Accidental Events and Spills. In the case of expected accidental events and spills, some impacts could occur on coastal historic and prehistoric archaeological resources. The magnitude of the impacts would depend on the number of resources affected and on the significance and uniqueness of the information lost. Impacts can result from both direct contact with oil and from cleanup operations. Some impacts from direct contact with oil are expected when resources are present, and additional impacts are expected during cleanup activities. Impacts from small spills (<50 bbl) could range from negligible to major depending on the location of the spill in relation to sensitive resources. A similar situation is encountered with small spills up to 1,000 bbl. These spills could result in impacts ranging from negligible to major depending on the location the spill in relation to sensitive resources. Large spills (≥1,000 bbl) could also result in negligible to major impacts as well. As the size of the spill increases, the likelihood that a sensitive resource could be affected increases. However, given the irreplaceable nature of the resource, even the smallest spill if occurring in close proximity to a sensitive resource could result in major impacts. The difference between the scenarios is one of magnitude. Smaller spills are more likely to affect a single resource, whereas larger spills are more likely to affect numerous resources.

An Unexpected Catastrophic Discharge Event. In the event of a CDE that is not expected, some impacts could occur on coastal historic and prehistoric archaeological resources. Although it is not possible to predict the precise numbers or types of sites that would be affected, contact with archaeological sites would probably be unavoidable, and the resulting loss of information would be irretrievable. The magnitude of the impacts would depend on the number of resources affected and on the significance and uniqueness of the information lost. Impacts can result from both direct contact with oil and from cleanup operations. Based on experience gained from the *Exxon Valdez* oil spill, some impacts from direct contact with oil from even a CDE are expected, and additional impacts are expected during cleanup activities. Response actions associated with a CDE have the greatest potential for adversely affecting archeological and historic resources. Impacts from a CDE could range from minor to major. In the event of a CDE, many resources would likely be affected. There is a greater likelihood that more of the resources would be affected at a major level during a CDE.

4.5 OTHER ALTERNATIVES

Besides the proposed action (Alternative 1), six additional "action" alternatives are considered in this PEIS. These action alternatives are essentially identical to the proposed action except that each excludes a different, particular planning area that is included in the proposed action. For example, Alternatives 1 and 2 are identical except that Alternative 2 excludes lease sales under the Program from the Eastern Planning Area. Because of the similarity in planning areas included among the action alternatives, the types of impacts that could be incurred under each of the alternatives would be similar, but would not be expected to occur in the excluded planning area. Under all of the alternatives (including no action), oil and gas development activities would remain and continue in the excluded areas of the Program, but only on acreage that is currently under active lease at the start of the 2012-2017 Program (i.e., areas leased under previous 5-year leasing programs). Alternatives 2 to 7, which each exclude one of the planning areas, may, in part, contribute to beneficial environmental effects relative to the proposed action through avoided adverse effects which may otherwise stress environmental resources and sensitive ecosystems. This is only true if the alternative actually contributes to lesser OCS exploration and development activity levels at some point in the future (see Section 4.4.1 and Figure 4.4.1-2).

Under any of the alternatives, the types of impacts that could be incurred under any new leasing and development, or under development in currently active leases, would be the largely the same as those identified under Alternative 1. However, under Alternatives 2 through 7 (with only a single planning area excluded) or combination thereof, there is a potential for incrementally greater oil and gas development in non-excluded planning areas compared to levels anticipated under the proposed action. This potential increase in oil and gas development may result if industry reallocates its oil and gas development resources from the excluded planning area to any of the other planning areas that would remain available for leasing.

For example, under Alternative 4, leasing would be excluded in the Central GOM Planning Area, while potential leasing would be available in the Western GOM. Under this alternative, industry may modify its lease acquisition strategy and re-prioritize prospects slated for Central GOM exploration, in favor of the Western GOM Planning Area. Industry may also perceive the exclusion of the Central GOM Planning Area in the 2012-2017 Program as a sign of future access restrictions in that area and may react by increasing its bidding activity on tracts in other planning areas that would be available for leasing under the Program. However, opportunities for industry to compete in global markets combined with reduced access on the OCS may offset these incremental increases as companies consider the attractiveness of international prospects.

Under the exclusion of either or both the Chukchi and Beaufort Sea Planning Areas, the active lease inventory in these areas from previous 5-year programs will likely continue to experience lead-times to exploration and development in excess of 5 years. Therefore, the adoption of short-term (2012-2017) exclusions in these "frontier" areas would likely have little to no effect on OCS activities as industry strives to make progress to actively explore and subsequently build the infrastructure necessary to develop resources underlying its currently leased acreage. The exclusion of the Cook Inlet Planning Area (Alternative 7) may have little or no noticeable effect on exploration and development activities in other planning areas in the short term and beyond, as there are no leases currently active in this planning area, and any planning for a lease sale would not begin until industry expresses an interest in holding a sale.

Regardless of the alternative being considered, it is speculative to predict how industry may respond to the exclusion of one of the planning areas and associated lease sales. While it is also speculative to suggest how impact levels may change in other planning areas with an industry response to an exclusion, the types of impacts may be expected to be similar in nature to the types of impacts identified under the proposed action for the non-excluded areas. In addition, it is reasonable to assume that the mitigation and monitoring that would be required in the non-excluded areas would also apply to any new industry actions in the non-excluded planning areas, as would any such requirements from previous 5-year leasing programs, thereby reducing the potential for any large increases in impacts from additional industry activity.

4.5.1 Alternative 2 – Exclude the Eastern Planning Area for the Duration of the 2012-2017 Program

4.5.1.1 Description of Alternative 2

Under Alternative 2, no sales would be held in the Eastern GOM Planning Area under the Program, and there would be no change from the proposed action for the other planning areas. Under Alternative 2, the following would take place:

- Five area-wide lease sales in the Central GOM Planning Area;
- Five area-wide lease sales in the Western GOM Planning Area;
- One lease sale with a whaling deferral in the Beaufort Sea Planning Area;
- One lease sale with a 40-km (25-mi) buffer in the Chukchi Sea Planning Area; and
- One lease sale in Cook Inlet.

4.5.1.2 Summary of Impacts

Excluding the Eastern GOM Planning Area from the Program would reduce the number of potential lease sales in the GOM from 12 to 10, and there would be no offshore and onshore oil and gas development activities in the Eastern GOM Planning Area. As a result, none of the localized impacts (short or long term) on water quality, air quality, marine and coastal biota and habitats, or archeological or historic resources that would be associated with development in the Eastern GOM Planning Area would be expected to occur. Even under this alternative, there is still the potential for some of the Eastern GOM Planning Area resources to be affected by OCS activities in the 2012-2017 Program window since OCS exploration and development activities could be pursued under past lease sales. However, water and air quality, as well as marine and coastal biota and habitats, in some portions of the Eastern GOM Planning Area could be affected by oil and gas leasing and development in the eastern portions of the Central GOM Planning Area.

Because of the relatively small amount of development that would occur in the Eastern GOM Planning Area under the proposed action (no more than 1 installed platform, no more than 17 wells), the population, employment, and income impacts identified for the GOM under the proposed action would be only slightly reduced, and would remain largely unchanged in the other planning areas (see the cost-benefit analysis of the alternatives presented in Section 2.12). In addition, none of the net economic benefits of the proposed action to the Eastern GOM Planning Area (see Table 2.12.4-1) would be expected to occur.

Under Alternative 2, it is possible that industry may reallocate assets planned for the Eastern GOM Planning Area (where no more than two lease sales would be held under the proposed action) to the other GOM planning areas. This would either increase bidding activity on new leases or increase exploration and development activities on currently active leases. In such an event, the other GOM planning areas may see a short-term, incremental increase in oil and gas activities and associated impacts over the impacts identified for the proposed action. However, it is speculative to predict how industry may respond to the exclusion of the Eastern GOM Planning Area, and therefore equally speculative to identify environmental impacts associated with any industry response, although the pathways and nature of any such impacts would be similar to those identified for the proposed action. Given the small amount of oil and gas development (compared to the level of ongoing and potential future development in the other GOM planning areas) that may be relocated, any small incremental increases in oil and gas activities may be expected to have a similarly small incremental increase in environmental impacts, and the magnitude of the impacts would likely not differ from impacts under the proposed action. In addition, it is reasonable to assume that the mitigation and monitoring that would be required under this alternative would also apply to any new industry actions in the Central or Western GOM Planning Areas, as would any such requirements from previous 5-year leasing programs, thereby reducing the potential for any large increases in impacts from additional industry activity.

Under Alternative 2, potential impacts on natural, physical, and socioeconomic resources in Alaska would be similar in nature and general magnitude as those identified from the proposed action.

Under Alternative 2, no oil spills from oil and gas development activities under the Program would occur directly in the Eastern GOM Planning Area. However, spills from development in the other planning areas (especially a large or very large spill in the Central

Planning Area) could be carried by currents into the Eastern GOM Planning Area and affect marine and coastal resources, tourism and recreation, commercial fisheries, and local economies. Oil spills from oil and gas exploration and development activities associated with past lease sales in the Eastern GOM Planning Area could also occur. The nature and magnitude of any such impacts on those resources (as described in earlier sections of this chapter) will depend on the location, size, and duration of a spill in the other GOM planning areas.

4.5.2 Alternative 3 – Exclude the Western Planning Area for the Duration of the 2012-2017 Program

4.5.2.1 Description of Alternative 3

Under Alternative 3, no lease sales would be held in the Western Planning Area under the Program, and there would be no change from the proposed action for the other planning areas. Under Alternative 3, the following would take place:

- Five area-wide lease sales in the Central GOM Planning Area;
- One or two lease sales in the extreme western portion of the Eastern GOM Planning Area;
- One lease sale with a whaling deferral in the Beaufort Sea Planning Area;
- One lease sale with a 40-km (25-mi) buffer in the Chukchi Sea Planning Area; and
- One lease sale in Cook Inlet.

4.5.2.2 Summary of Impacts

Excluding the Western GOM Planning Area from the Program would reduce the number of potential lease sales in the GOM from 12 to 7. Under the proposed action, there could be as many as 96 platforms and 534 wells (and associated pipelines, landfalls, and onshore processing facilities) developed in the Western GOM Planning Area. Under Alternative 3, this development would not occur, and as a result none of the short- or long-term localized impacts identified for the proposed action on water quality, air quality, marine and coastal biota and habitats, archeological or historic resources, or land use and infrastructure that would be associated with development and operation of this infrastructure and support activities (such as support vessel and helicopter traffic) in the Western GOM Planning Area would be expected to occur. Even under this alternative, there is still the potential for some of the Western GOM Planning Area resources to be affected by OCS activities during the 2012-2017 Program window from OCS exploration and development activities that could be pursued under past lease sales. Under Alternative 3, a marginal decrease in new activity, relative to the proposed action, may contribute to improved ecosystem condition as a result of avoided adverse effects from potentially fewer routine activities or accidental spills. However, water and air quality, as well as marine and coastal biota and habitats, in some portions of the Western GOM Planning Area could still be affected by oil and gas leasing and development in the western portions of the Central GOM Planning Area, especially if that development uses existing commercial infrastructure (such as shipyards, support centers, processing facilities) and shipping lanes in coastal areas of the Western GOM Planning Area.

Even though a relatively large amount of development would occur in the Western GOM Planning Area under the proposed action, the increases in population, employment, and income identified to occur under the proposed action would be only slightly reduced under Alternative 3, and economic activity could increase in the other planning areas (see cost-benefit analysis of the alternatives presented in Section 2.12). In addition, none of the net economic benefits of the proposed action to the Western GOM Planning Area (see Table 2.12.4-1) would be expected to occur.

Under Alternative 3, it is possible that industry may reallocate assets planned for the Western GOM Planning Area to the other GOM planning areas and either increase bidding activity on new leases or increase exploration and development activities on currently active leases (i.e., Central GOM Planning Area is highest likelihood). If so, the other GOM planning areas may see a short-term incremental increase in oil and gas activities and associated impacts over those identified for the proposed action. However, it is somewhat speculative to predict how industry would respond to the exclusion of the Western GOM Planning Area for 5 years. Therefore, it is difficult to identify the exact environmental impacts that may occur elsewhere given any industry response, but the nature of any such impacts would be similar to those identified for the proposed action. In addition, it is reasonable to assume that the mitigation and monitoring that would be required under this alternative would also apply to any relocated industry actions in the Central or Eastern GOM Planning Areas, as would any requirements from previous 5-year leasing programs, thereby reducing the potential for any large increases in impacts from additional industry activity.

Under Alternative 3, potential impacts on natural, physical, and socioeconomic resources in Alaska would be similar in nature and general magnitude as those identified for the Alaska planning areas from the proposed action.

Under Alternative 3, no oil spills from oil and gas development activities would occur directly in the Western GOM Planning Area under the Program. However, spills that may occur under Alternative 3 from development in the other planning areas (especially large or very large spills in the Central GOM Planning Area or Eastern GOM Planning Area) could be carried by currents into the Western GOM Planning Area and affect marine and coastal resources, tourism and recreation, commercial fisheries, and local economies. Oil spills from oil and gas exploration and development activities associated with past lease sales could also occur. The nature and magnitude of any such impacts on those resources (as described in earlier sections of this chapter) will depend on the location, size, and duration of any spills in the other GOM Planning Areas.

4.5.3 Alternative 4 – Exclude the Central Planning Area for the Duration of the 2012-2017 Program

4.5.3.1 Description of Alternative 4

Under Alternative 4, no lease sales would be held in the Central Planning Area under the Program, and there would be no change from the proposed action for the other planning areas. Under Alternative 4, the following would take place:

- Five area-wide lease sales in the Western GOM Planning Area;
- One or two lease sales in the extreme western portion of the Eastern GOM Planning Area;
- One lease sale with a whaling deferral in the Beaufort Sea Planning Area;
- One lease sale with a 40-km (25-mi) buffer in the Chukchi Sea Planning Area; and
- One lease sale in Cook Inlet.

4.5.3.2 Summary of Impacts

Excluding the Central GOM Planning Area from the Program would reduce the number of potential lease sales in the GOM from 12 to 7. Under the proposed action, the greatest amount of oil and gas development in the GOM would occur in the Central GOM Planning Area, with as many as 316 platforms and 749 wells (and associated pipelines, landfalls, and onshore processing facilities). Under Alternative 4, this development would not occur, and as a result none of the localized impacts (short or long term) on water quality, air quality, marine and coastal biota and habitats, archeological or historic resources, or land use and infrastructure that would be associated with development and operation of this infrastructure and support activities (such as support vessel and helicopter traffic) in the Central GOM Planning Area would be expected to occur. Even under this alternative, there is still the potential for the same Central GOM Planning Area resources to be affected by OCS activities in the 2012-2017 Program window since OCS exploration and development activities could be pursued under past lease sales. Under this alternative, a marginal decrease in new activity, relative to the proposed action, may contribute to improved ecosystem condition as a result of avoided adverse effects from potentially fewer routine activities or accidental spills. However, water and air quality, as well as marine and coastal biota and habitats could still be affected in some portions of the Central Planning Area by oil and gas activities in portions of the Western and Eastern GOM Planning Areas that abut the Central GOM Planning Area, especially if those activities use existing commercial infrastructure (such as shipyards, support centers, processing facilities) that are located in the Central GOM Planning Area. Under this alternative, a marginal decrease in new activity, relative to the proposed action, could contribute to improved ecosystem condition as a result of avoided adverse effects from potentially fewer routine operations and accidental spills. While this alternative does not eliminate the risk of an oil spill occurring in the Central GOM during the time frame under consideration, the risk may be reduced because it effectively limits industry exploration and development to existing leases and, potentially at some point in the future, reduces overall activity levels. This could be an important consideration as environmental resources in the Central GOM recover from any persistent effects or stress caused by the DWH event. However, the potential decline in OCS activity levels would not occur immediately and may not even occur until much later in the Program window.

Under Alternative 4, potential impacts on natural, physical, and socioeconomic resources in Alaska would be similar in nature and general magnitude as identified from the proposed action.

Even with the large amount of development that could occur in the Central GOM Planning Area under the proposed action, under Alternative 4 the increases in population, employment, and income likely to occur under the proposed action would be only slightly reduced, and economic activity could increase in the other planning areas (see cost-benefit analysis of the alternatives presented in Section 2.12). In addition, none of the net economic benefits of the proposed action to the Central GOM Planning Area (see Table 2.12.4-1) would be expected to occur.

Under Alternative 4, it is possible that industry may reallocate assets planned for the Central GOM Planning Area to the other GOM planning areas where it may either increase bidding activity on new leases or increase exploration and development activities on currently active leases (Western GOM Planning Area only). In such an event, there may be a short-term incremental increase in oil and gas activities and associated impacts in the other planning areas. However, it is somewhat speculative to predict how industry would respond to the exclusion of the Central GOM Planning Area for 5 years. Therefore, it is difficult to identify the exact environmental impacts that may occur elsewhere given industry's response, but the pathways and nature of any such impacts would be similar to those identified for the proposed action. In addition, it is reasonable to assume that the mitigation and monitoring that would be required under this alternative would also apply to any new industry actions in the Western or Eastern GOM Planning Areas, as would any such requirements from previous 5-year leasing programs, thereby reducing the potential for any large increases in impacts from additional industry activity.

Under Alternative 4, no oil spills from oil and gas development activities associated with this Program would occur directly in the Central GOM Planning Area. However, spills from development in the Western or Eastern GOM Planning Areas could be carried by currents into the Central GOM Planning Area and affect marine and coastal resources, tourism and recreation, commercial fisheries, and local economies. Oil spills from oil and gas exploration and development activities associated with past lease sales could also occur. The nature and magnitude of any such impacts on those resources (as described in earlier sections of this chapter) will depend on the location, size, and duration of any spills in the other GOM planning areas.

4.5.4 Alternative 5 – Exclude the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program

4.5.4.1 Description of Alternative 5

Under Alternative 5, no lease sales would be held in the Beaufort Sea Planning Area under the Program, and there would be no change from the proposed action for the other planning areas. Under Alternative 5, there would be:

- Five area-wide lease sales in the Western GOM Planning Area;
- Five area-wide lease sales in the Central GOM Planning Area;
- One or two lease sales in the extreme western portion of the Eastern GOM Planning Area;
- One lease sale with a 40-km (25-mi) buffer in the Chukchi Sea Planning Area; and
- One lease sale in Cook Inlet.

4.5.4.2 Summary of Impacts

Excluding the Beaufort Sea Planning Area from the Program would reduce the number of potential lease sales in the Arctic from 2 to 1. Under the proposed action, there could be as many as 4 platforms, 136 wells, 249 km (155 mi) of offshore pipeline, and 129 km (80 mi) of onshore pipeline developed in the Beaufort Sea Planning Area and adjacent coastal areas. Under Alternative 5 this development would not occur, and as a result none of the localized impacts (short or long term) on water quality, air quality, marine and coastal biota and habitats, archeological or historic resources, or land use and infrastructure that would be associated with development and operation of this infrastructure and any supporting activities (such as support vessel and helicopter traffic) in the Beaufort Sea Planning Area would be expected to occur. Even under this alternative, there is still the potential for the same Beaufort Sea Planning Area resources to be affected by OCS activities during the 2012-2017 Program window since OCS exploration and development activities could be pursued under past lease sales. Under this alternative, a marginal decrease in new activity, relative to the proposed action, may contribute to improved ecosystem condition as a result of avoided adverse effects from potentially fewer routine activities or accidental spills. Water quality, as well as marine and coastal biota and habitats in some portions of the Beaufort Sea Planning Area and adjacent coastal areas, could still be affected by oil and gas leasing and development in the eastern portions of the Chukchi Sea Planning Area. Any adverse impact on migrating marine mammals occurring in the Chukchi Sea Planning Area could affect not only these resources but also the success of subsistence hunters in the Beaufort Sea that rely on these resources. Under this alternative, a marginal decrease in activity, relative to the proposed action, could contribute to improved ecosystem condition as a result of avoided adverse effects to sensitive or keystone biological resources from potentially fewer routine operations or accidental spills. While this alternative does not eliminate the risk of an oil spill occurring in the Beaufort Sea during the time frame under consideration, the risk may be reduced because it effectively limits industry exploration and development to existing leases and, potentially at some point in the future, reduces overall activity levels. Similarly, this alternative may reduce the space- and time-use conflicts anticipated with subsistence activities. These are important considerations as environmental resources and human cultures in the Arctic adapt to changing climate and environmental conditions.

Under Alternative 5, the increases in population, employment, and income likely to occur under the proposed action would be only slightly reduced, and economic activity could increase in the other planning areas (see cost-benefit analysis of the alternatives presented in Section 2.12). In addition, none of the net economic benefits of the proposed action to the Beaufort Sea Planning Area (see Table 2.12.4-1) would be expected to occur.

Under Alternative 5, potential impacts on natural, physical, and socioeconomic resources in the GOM planning areas would be similar in nature and general magnitude as those identified from the proposed action.

Under Alternative 5, it is possible that industry may reallocate assets planned for the Beaufort Sea Planning Area (where a single lease sale would be held under the proposed action) to the other planning areas (and especially the Chukchi Sea Planning Area) and possibly increase bidding activity on new leases or increase exploration and development activities on currently active leases. However, it is somewhat speculative to predict how industry may respond to the exclusion of the Beaufort Sea Planning Area, making it difficult to identify environmental impacts that may occur with a given industry response. However, the pathways and nature of any such impacts would be similar to those identified for the proposed action. In addition, it is reasonable to assume that the mitigation and monitoring that would be required under this alternative for the non-deferred planning areas would also apply to any new industry actions associated with response to the exclusion of the Beaufort Sea Planning Area, as would any such requirements from previous 5-year leasing programs, thereby reducing the potential for any large increases in impacts from additional industry activity.

Under Alternative 5, no oil spills from oil and gas development activities associated with the Program would occur directly in the Beaufort Sea Planning Area. However, a spill that may occur under this alternative in the Chukchi Sea Planning Area could be carried by coastal currents into the Beaufort Sea Planning Area and affect marine and coastal resources, subsistence whaling, tourism and recreation, and local economies and communities. Oil spills from oil and gas exploration and development activities associated with past lease sales could also occur. The nature and magnitude of any such impacts on those resources (as described in earlier sections of this chapter) will depend on the location, size, and duration of a spill in the Chukchi Sea Planning Area.

4.5.5 Alternative 6 – Exclude the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program

4.5.5.1 Description of Alternative 6

Under Alternative 6, no lease sales would be held in the Chukchi Sea Planning Area under the Program, and there would be no change from the proposed action for the other planning areas. Under Alternative 6, the following would take place:

- Five area-wide lease sales in the Western GOM Planning Area;
- Five area-wide lease sales in the Central GOM Planning Area;
- One or two lease sales in the extreme western portion of the Eastern GOM Planning Area;
- One lease sale with a whaling deferral in the Beaufort Sea Planning Area; and
- One lease sale in Cook Inlet.

4.5.5.2 Summary of Impacts

Excluding the Chukchi Sea Planning Area from the Program would reduce the number of potential lease sales in the Arctic from 2 to 1. Under the proposed action, there could be as many as 5 platforms, 300 wells, and 402 km (250 mi) of offshore pipeline developed in the Chukchi Sea Planning Area. Under Alternative 6, this development would not occur, and as a result none of the localized impacts (short or long term) on water quality, air quality, marine and coastal biota and habitats, archeological or historic resources, or land use and infrastructure that would be associated with development and operation of this infrastructure and any supporting activities (such as support vessel and helicopter traffic) in the Chukchi Sea Planning Area would be expected to occur. Even under this alternative, there is still the potential for the same Chukchi Sea Planning Area resources to be affected by OCS activities during the 2012-2017 Program window since OCS exploration and development activities could be pursued under past lease sales. Under this alternative, a marginal decrease in new activity, relative to the proposed action, may contribute to improved ecosystem condition as a result of avoided adverse effects from potentially fewer routine activities or accidental spills. Water quality, as well as marine and coastal biota and habitats, and land use and infrastructure in some portions of the Chukchi Sea Planning Area and adjacent coastal areas, could still be affected by oil and gas leasing and development in the western portions of the Beaufort Sea Planning Area. Any adverse impact on migrating marine mammals occurring in the Beaufort Sea Planning Area could affect not only these resources but also the success of subsistence hunters in the Chukchi Sea that rely on these resources. Under this alternative, a marginal decrease in activity, relative to the proposed action, could contribute to improved ecosystem condition as a result of avoided adverse effects to sensitive or keystone biological resources from potentially fewer routine operations or accidental spills. While this alternative does not eliminate the risk of an oil spill occurring in the Chukchi Sea during the time frame under consideration, the risk may be reduced because it effectively limits industry exploration and development to existing leases and, potentially at some point in the future, reduces overall activity levels. Similarly, this alternative may reduce the space- and time-use conflicts anticipated with subsistence activities. These are important considerations as environmental resources and human cultures in the Arctic adapt to changing climate and environmental conditions.

Under Alternative 6, the increases in population, employment, and income likely to occur under the proposed action would be only slightly reduced, and economic activity could increase in the other planning areas (see cost-benefit analysis of the alternatives presented in Section 2.12). In addition, none of the net economic benefits of the proposed action to the Chukchi Sea Planning Area (see Table 2.12.4-1) would be expected to occur.

Under Alternative 6, potential impacts on natural, physical, and socioeconomic resources in the other planning areas would be similar in nature and general magnitude as those identified from the proposed action.

Under Alternative 6, it is possible that industry may reallocate assets planned for the Chukchi Sea Planning Area (where a single lease sale would be held under the proposed action) to the other planning areas (and especially the Beaufort Sea Planning Area) and possibly increase bidding activity on new leases or increase exploration and development activities on currently active leases. However, it is speculative to predict how industry may respond to the deferral of the Chukchi Sea Planning Area, and equally speculative to identify environmental impacts associated with any industry response, although the nature of any such impacts would be similar to those identified for the proposed action. In addition, it is reasonable to assume that the mitigation and monitoring that would be required under this alternative for the non-deferred planning areas would also apply to any new industry actions associated with response to the exclusion of the Chukchi Sea Planning Area, as would any such requirements from previous 5-year leasing programs, thereby reducing the potential for any large increases in impacts from additional industry activity.

Under Alternative 6, no oil spills from oil and gas development activities under the Program would occur directly in the Chukchi Sea Planning Area. However, spills from development in the Beaufort Sea Planning Area could be carried by coastal currents into the Chukchi Sea Planning Area and affect marine and coastal resources, subsistence whaling, tourism and recreation, and local economies and communities. Oil spills from oil and gas exploration and development activities associated with past lease sales could also occur. The nature and magnitude of any such impacts on those resources (as described in earlier sections of this chapter) will depend on the location, size, and duration of a spill in the Beaufort Sea Planning Area.

4.5.6 Alternative 7 – Exclude the Cook Inlet Planning Area for the Duration of the 2012-2017 Program

4.5.6.1 Description of Alternative 7

Under Alternative 7, no lease sales would be held in the Cook Inlet Planning Area during the Program, and there would be no change from the proposed action for the other planning areas. Under Alternative 7, the following leasing activities could take place:

- Five area-wide lease sales in the Western GOM Planning Area;
- Five area-wide lease sales in the Central GOM Planning Area;
- One or two lease sales in the extreme western portion of the Eastern GOM Planning Area;
- One lease sale with a whaling deferral in the Beaufort Sea Planning Area; and
- One lease sale with a coastal deferral in the Chukchi Sea Planning Area.

4.5.6.2 Summary of Impacts

Excluding the Cook Inlet Planning Area could result in one less potential lease sale in the Alaska Region. All offshore and onshore oil and gas activities and production associated with this sale would not occur. The small amount of oil assumed to be developed under Alternative 1 in Cook Inlet would be compensated for by imported oil. It is unlikely that the additional amount of imported oil that could occur under Alternative 7 will measurably affect the number of tanker oil spills that occur in other offshore areas in the United States.

The analyses of impacts of Alternative 1, the Proposed Action, in Cook Inlet showed in almost all cases temporary and localized impacts. Any disturbance to existing environmental conditions associated with routine operations or an oil spill would be expected to be ameliorated on a time scale of days to a year or two. Under Alternative 7, these short-term localized impacts would not occur. Under the Proposed Action, no population-level impacts were predicted for biological resources, although several endangered and/or threatened bird species would be vulnerable to mortality from oil spills. A moderate to large oil spill could affect a relatively large number of Steller's eiders, which overwinter in Cook Inlet. However, because the eider does not breed in Cook Inlet, the breeding populations would not be directly affected, although the number of eiders that arrive in the Arctic for breeding could be reduced. The endangered short-tailed albatross occurs uncommonly in Cook Inlet, so large numbers of this species would not be affected by a spill. Furthermore, the albatross breeds outside Cook Inlet, so the breeding population would not be affected during the breeding season. Kittlitz's murrelets, a candidate for listing under the Endangered Species Act, also occur in Cook Inlet and could come in contact with spilled oil while foraging, depending on the timing and location of any spill that occurred.

Impacts on these species under Alternative 1 would be contained within the Cook Inlet area and would not extend to other planning areas in Alaska where these species also occur during different life stages or seasons. Under Alternative 7, none of these localized impacts on protected species would occur from OCS activity.

While no long-term population-level impacts on terrestrial mammals in the Cook Inlet area are expected under Alternative 1, increased mortality of brown and black bears could occur if previously remote areas were converted to industrial use, resulting in increased conflict between bears and humans. A large oil spill that affected intertidal areas could lead to significant mortality of eggs and juvenile fish of pelagic species, such as the salmon, leading to reduced adult survival. The overall fish populations in south central Alaska, however, would not be affected. A large spill could temporarily affect fisheries in the area that were contacted by the spill. While no long-term impacts on the fish populations are expected, economic impacts on commercial and recreational fisheries could result as a result of loss of gear, closings of affected areas, and unavailability of fishing areas during cleanup operations. These temporary and localized impacts in Cook Inlet, which are unlikely given the small amount of activity expected under Alternative 1, would be precluded under Alternative 7.

Impacts on air and water quality under Alternative 1 in Cook Inlet are expected to be short-term and localized because of the small amount of activity anticipated and the largely pristine quality of the air and water environments there. Therefore, Alternative 7 will not result in a major difference from Alternative 1 for these resources.

The analysis of archaeological resources indicated that existing BOEM requirements for archaeological surveys would be expected to eliminate most of the possible impacts on historic and prehistoric resources. Impacts were possible from cleanup operations after an oil spill. Given the small amount of liquid hydrocarbons expected to be produced under Alternative 1 in Cook Inlet, compounded with the requirement that the spill would have to contact areas with historic or prehistoric resources for impacts to occur, Alternative 7 is not expected to result in a significant difference from Alternative 1 with regard to the potential for archaeological resource impacts.

The population, employment, and income impacts anticipated under Alternative 1 in the Cook Inlet area would not occur under Alternative 7. Table 4.4.9-2 shows estimates of 4,520 jobs and $152 million in income resulting from Alternative 1 in the Cook Inlet area during the life of the Program. See Section 2.12 for a discussion of a cost-benefit analysis of the alternatives. In addition, none of the net economic benefits of the proposed action to the Cook Inlet Planning Area (see Table 2.12.4-1) would be expected to occur.

Under Alternative 7, it is possible that industry may reallocate assets planned for the Cook Inlet Planning Area (where a single lease sale would be held under the proposed action but only at industry request) to the other planning areas and possibly increase bidding activity on new leases or increase exploration and development activities on currently active leases. However, it is speculative to predict how industry may respond to the exclusion of the Cook Inlet Planning Area, making it difficult to identify environmental impacts associated with any industry response. However, the pathways and nature of any such impacts would be similar to those identified for the proposed action. In addition, it is reasonable to assume that the mitigation and monitoring that would be required under this alternative for the non-deferred planning areas would also apply to any new industry actions associated with response to the exclusion of the Cook Inlet Planning Area, as would any such requirements from previous 5-year leasing programs, thereby reducing the potential for any large increases in impacts from additional industry activity.

4.5.7 Alternative 8 – No Action

The National Environmental Policy Act requires consideration of a No Action Alternative to every major Federal action that could result in significant impacts on the environment. In the context of the Program, the No Action Alternative is defined as the scenario in which BOEM holds no OCS oil and gas lease sales during the Program. Under this scenario, none of the potential environmental impacts associated with oil and gas related activities under the proposed action that have been evaluated in Section 4.4 would occur. These precluded impacts would include both the anticipated effects under the proposed action of routine operations and accidental discharges on ecological conditions and the effects of leasing on regional employment, regional income, and sociocultural stability. In addition, the oil and natural gas that would have been produced as a consequence of sales over the 5-yr program period would not be available to consumers, who would therefore need to obtain energy from other sources. The energy substitutes needed to replace the lost OCS production would be associated with their own potential environmental effects that could occur throughout the United States or the world depending on the mix of specific energy substitutes that would be used. The analysis that follows considers these factors to evaluate the overall effects of implementing the No Action Alternative. Information is first presented on the various uses of energy in the economy and on the current and projected uses of oil and gas compared to other fuel or alternate energy sources in each economic sector. Substantial discussions of the current status and projected developments in alternate energy sources for each sector of the economy are provided. A scenario of energy substitutes is then developed that projects the mix of energy substitutes that would be used to replace lost OCS production during the life of the program. This scenario is used to evaluate the anticipated broad effects of implementing the No Action Alternative in each program area as well as in other areas that could be affected by the energy substitutes used to replace lost OCS production.

4.5.7.1 Oil and Gas Uses and Alternatives

The information in this section has been taken from BOEM's Energy Alternatives and Environment report. The Energy Alternatives and Environment report was updated since the publication of the Draft PEIS and includes discussions of near and long-term outlooks for various potential energy substitutes. Part of the report has been inserted into this section as the basis for the discussion of outlooks for energy in the Final PEIS. The full report is available for download from the BOEM Web site.

4.5.7.1.1 Transportation Sector. Total energy use in the transportation sector has grown by an average of just over 1 percent per year over the last 20 years. As of 2010, the transportation sector accounted for an estimated 28 percent of all energy consumption in the United States, a proportion that has been slowly rising since the 1960s. The vast majority of this energy has come from oil. Nearly three fourths of all petroleum consumed in the United States in 2010, was used for transportation, with natural gas, electricity, and other alternatives playing much smaller roles (EIA 2010d). In this section, we discuss recent trends in the use of oil and gas in the transportation sector and the near- and long-term potential for substitutes to these energy sources. These discussions provide a current snapshot of the various Federal policies and technological advancements that are likely to affect future fuel consumption trends in the United States. BOEM welcomes comments and feedback from the other Federal agencies on our discussions of their programs and policies.

Current Use of Oil and Gas.

Ground Travel. Oil is the dominant energy source for ground travel, which consumed approximately 136 billion gallons of motor gasoline and 42 billion gallons of diesel fuel in 2010. Growth in consumption was slow but steady during the mid-2000s economic expansion, averaging about one percent per year from 2003 to 2007 (EIA 2007a). However, motor gasoline use fell by about three percent from 2007 to 2008, the first time that total annual consumption has fallen since the 1988 to 1991 period. Consumption remained flat from 2008 to 2010 (EIA 2010e).

This mid-2000s growth trend was attributable to several factors. Growth in the U.S. population, averaging just under one percent per year, resulted in approximately three million potential new vehicle drivers annually (USCB 2009). Meanwhile, the number of highway vehicles grew even faster, at a rate of nearly four million vehicles per year from 2003 to 2007. At the end of 2007, 254 million registered highway vehicles were in use in the United States, one for every 1.19 people. The growth in the number of vehicles has been realized entirely in the light truck segment, as the number of passenger cars has remained more or less constant (USDOT 2009b). The subsequent flat growth in fuel consumption follows the general trend of fuel consumption declining during periods of economic recession and/or high gasoline prices.

After 20 years of steady increase, the average number of miles driven per vehicle peaked at 12,211 per year in 1998 and stayed more or less at that level until 2007 when it began to decline (EIA 2010f). The average fuel efficiency of all vehicles on the road improved only minimally over that time period. The trend towards increased efficiency will accelerate in the future, as the fuel efficiency of *new* vehicles has been increasing in recent years. New fuel efficiency and greenhouse gas pollution standards, announced in July 2011, will increase the minimum fleetwide average for manufacturers of cars and light trucks to 54.5 miles per gallon (MPG) for model years 2017 through 2025, which is expected to reduce oil consumption by almost 34 billion gallons per year by 2025 (USEPA 2011t). In addition, the new Heavy-Duty National Program, recently announced by the U.S. Environmental Protection Agency (USEPA) and Department of Transportation (USDOT) will reduce fuel consumption by large trucks and buses, further reducing overall ground transportation fuel use (USEPA 2011u).

The use of natural gas as a vehicle fuel in both compressed and liquid forms has increased in recent years, with an average annual growth rate of 8.3 percent from 2006 to 2010 (EIA 2010g). However, natural gas still represents a small fraction of total vehicle fuel consumption, at just over 225 million gallons of gasoline-equivalent in 2009, or slightly more than one percent of total vehicle fuel use (EIA 2011d). In 2009, approximately 117,000 natural gas-fueled vehicles were in use, many of which were buses and other fleet vehicles (EIA 2011d).

Ethanol, as a gasoline additive, makes up the majority of alternative fuel currently in use; consumption increased from 2.8 billion gallons gasoline-equivalent in 2005 to 7.3 billion gallons in 2009. As a primary fuel (i.e., in a blend that is at least 85 percent ethanol), ethanol consumption increased from 38 million gallons of gasoline-equivalent in 2005 to just over 71 million gallons in 2009. Biodiesel use rose even more quickly over that period, but remains relatively modest overall at 325 million gasoline-equivalent gallons. Electricity, hydrogen, and other fuels contributed very little; electricity use for vehicle transportation actually declined slightly over this period (EIA 2011d).

Table 4.5.7-1 summarizes the trends in the consumption of vehicle fuels and in the number of alternative fuel vehicles in recent years.

Air Travel. Certificated U.S. air carriers used 17.3 billion gallons of fuel in 2010, 6.4 percent of the total energy consumed by the U.S. transportation sector (USDOT 2011d). Until 2007, fuel use for air travel was rising faster than use for ground travel. Total consumption rose by 4.6 percent per year from 2003 to 2007 before falling in 2008 through 2010 (USDOT 2011d), indicating a strong linkage to larger economic factors. Petroleum-derived, kerosene-style jet fuel accounts for nearly all of the fuel used for air travel.

TABLE 4.5.7-1 Estimated Consumption of Vehicle Fuels and Number of Alternative Fueled Vehicles in the United States, 2009

	Consumption (1,000 gasoline-equivalent gallons)			
Fuel	2005	2009	Percent Annual Growth	Alternative-Fuel Vehicles, 2009
Ethanol in gasohol	2,765,663	7,343,133	27.65	
Biodiesel	93,281	325,102	36.63	
Natural gas (CNG and LNG)	189,287	225,175	4.44	117,446
Ethanol, 85% (E85)	38,074	71,213	16.95	504,297
Electricity	5,219	4,956	–1.28	57,185
Hydrogen	25	140	53.83	
Total Alternative Fuels	3,091,549	7,969,719	26.71	

Source: EIA 2011d.

Marine Travel. Marine travel accounts for a relatively small proportion of total oil consumption in the transportation sector and, as with air travel, does not consume any natural gas. Total fuel consumption for marine travel was about 997 trillion Btu in 2009, roughly three-fifths the amount used by air travel and four percent of the total for the sector. Marine travel employs a mix of fuels. Residual fuel oil makes up about 70 percent of oil use, while distillate/diesel fuel oil and gasoline each account for about 15 percent. This mix has remained generally consistent over time (USDOT 2011e).

As summarized in Table 4.5.7-2, total oil consumption for marine travel has shown no clear trend over time, with periods of sharp declines following years of growth, and vice versa. After dropping by nearly 30 percent from 2000 to 2003, fuel use increased nearly as dramatically to reach comparable levels by 2007. Consumption decreased from 2007 to 2009. Like other fuels, general consumption trends follow the general economic trend.

***Rail Travel*.** Similar to marine travel, rail travel comprises a small proportion of total oil consumption and virtually no natural gas consumption. Total oil use was 454 trillion Btu in 2009. The overwhelming majority of this was for freight, rather than passenger, transport. Distillate and diesel are the primary fuels used with electricity accounting for only two trillion Btu out of the total (USDOT 2011e). Following a low of 414 trillion Btu in 1990, oil consumption for rail transportation grew steadily to 594 trillion Btu in 2006, before falling to 454 trillion Btu in 2009 (USDOT 2011e).

Near-Term Market Analysis of Substitutes. This section analyzes the near-term potential for substitution away from oil and gas in the transportation sector, either through efficiency measures or through the use of alternative fuel sources. Due to the nature of the equipment involved, the focus is solely on ground transportation. Options for oil and gas substitutes in air travel will be discussed in the longer-term analysis in Section 3.3. Due to their relatively small contributions to oil and gas consumption, we do not consider substitution in the marine or rail travel sectors, except insofar as rail-based mass transit could provide a substitute for automobiles in the long run.

With the exception of flex-fuel vehicles, which operate using either gasoline or ethanol without any modifications, and the capacity of diesel vehicles to use biodiesel with relatively modest engine adjustments, most automobiles are locked into using the single fuel type for which they were originally designed. This means that, barring a major shift in driving patterns, the potential for changes in oil and gas consumption for transportation will be determined by changes in the composition of the vehicle fleet. Based on sales and registration data, the average lifespan of a passenger vehicle is approximately 14 years. Recent data suggest this may be on an upward trend, but since new vehicle sales are generally tied to the health of the overall economy, these data are not sufficient to indicate a long-term trend (USDOT 2009b,c). With a 14-year average lifespan, we can expect roughly 82 million vehicles, mostly from the late 1990s and early 2000s, to be retired in the next five years, with around 83.7 million new vehicles replacing them, assuming population growth and vehicle ownership per capita trends continue. We will use these rough estimates to establish the magnitude of the impact of various oil and gas substituting technologies below. It is important to note that in the following section and throughout this analysis, efficiency is considered a ‘substitute’ energy source; thus, much of the

TABLE 4.5.7-2 Energy Consumption for Marine Travel, 1980-2009 (trillion Btu)

	1980	1985	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Residual fuel oil	1,340	687	947	881	960	810	726	580	702	775	861	947	758	680
Distillate/diesel fuel oil	205	236	286	324	314	284	288	307	297	278	264	267	165	176
Gasoline	132	132	163	133	141	124	135	138	126	158	155	153	142	141
Total	1,677	1,054	1,396	1,338	1,415	1,218	1,149	1,025	1,125	1,211	1,280	1,367	1,065	997
Percent annual change	14.52	–8.86	5.77	–0.84	5.05	–13.92	–5.67	–10.79	9.76	7.64	5.70	6.80	–22.09	–6.38

Source: USDOT 2011e.

potential for a shift away from oil and gas use relies on technologies that continue to use these fuels, albeit in smaller quantities per vehicle mile traveled.

More Efficient Vehicles. Based on recent trends, it is possible to develop a rough estimate of the number of new vehicles expected to come into use over the next five years. Since 2000, the U.S. population has grown by an average of just under one percent per year. Over that timeframe, passenger cars and light trucks per capita has fallen by 0.7 percent annually. Considering these forces together, one can expect a net addition of 1.7 million new cars and trucks from 2011 to 2015. However, this does not tell the whole story. After accounting for 82 million vehicle retirements over that time, assuming an average lifespan of 14 years, we can assume that 83.7 million new cars and trucks will be purchased over that time, of which about half will be trucks and half passenger cars.

In the near term, the efficiency of the U.S. vehicle fleet is likely to be determined more by stricter regulatory requirements than by a demand pull from consumers for yet-more efficient vehicles. The corporate average fuel economy (CAFE) standards through model year 2010 stood at 27.5 MPG for passenger cars and 23.1 MPG for light trucks. Building on requirements in the 2007 Energy Policy Act, USEPA and USDOT have jointly established stricter targets, setting a schedule that steadily raises the requirements to an end point equivalent to of 35.7 MPG for cars and 28.6 MPG for light trucks for model year 2012-2016 vehicles. The new vehicles subject to these limits will replace older, retired vehicles manufactured in the late 1990s and early 2000s, whose fuel efficiency was about eight MPG lower on average. This is equivalent to a 23 percent savings in fuel use for passenger cars, or a 28 percent savings for light trucks. If we hold the number of miles driven per vehicle steady at the relatively high 2007 levels, we can expect to be close to an upper bound of expected total savings of 12.3 billion gallons of gasoline per year by 2015, as a result of the stricter vehicle standards. Recently announced stricter fuel efficiency and greenhouse gas pollution standards for model years 2017-2025 require 54.5 MPG fleetwide average and have been estimated to reduce oil consumption by 2.2 million barrels per day or approximately 33 billion gallons per year by 2025 (USEPA 2011t).

Hybrid Vehicles. Hybrid-electric vehicles are by now a familiar presence on U.S. roads. Powered by gasoline, hybrid vehicles can produce significant efficiency gains by using "regenerative braking" (recapturing the energy given off when a car brakes by charging a supplemental electric battery). However, by 2010, following the economic downturn that began in 2008, the sale of hybrids into the U.S. market had dropped by more than 20 percent from its 2007 peak (USDOT 2011f). Plug-in hybrids, whose batteries can be charged through electrical grid connections, entered the U.S. passenger vehicle market in 2010.

Hybrids attract attention because of their high fuel efficiency. However, it is important to note, that these gains are not necessarily additional to the savings noted above under fuel efficiency and greenhouse gas pollution standards, since hybrids would constitute a portion of the efficiency gains required under those regulations. Hybrids may be a promising technology for manufacturers to achieve fuel efficiency and greenhouse gas pollution standards. For instance, the Toyota Prius, by far the most popular hybrid in the United States, gets an estimated average 50 MPG. This compares favorably to a number of important benchmarks, including the 2008 average passenger car efficiency of 22.6 MPG, the average new car efficiency of 32.6, and the 2010 CAFE standard of 27.5 MPG (USDOT 2011g). Of course, not all hybrids match the Prius for fuel efficiency, particularly some of the hybrid sport utility vehicles on the market. Perhaps a more useful point of comparison would be the Toyota Camry hybrid, which, at 41 MPG, represents a 46 percent improvement over the conventional Camry (USDOE 2012a). Projecting this 46 percent improvement to all hybrid vehicles implies an upper bound for total oil savings of about 240 gallons per vehicle per year, based on 2008 average consumption of 522 gallons per passenger vehicle (EIA 2011e).

Electric and Plug-in Hybrid Vehicles. All-electric vehicles, rather than using gasoline, typically run on batteries, which need to be charged on a regular basis. Most users charge electric cars every night through a connection to the electric grid or an off-grid power source. Instead of an internal combustion engine, such vehicles make use of an electric motor. Many of the mechanical parts of a conventional engine are thus eliminated or replaced with electronic components. On a daily basis, the operating cost of an electric vehicle is generally lower than a typical vehicle, due to reduced fuel and maintenance costs. At present, however, the adoption of such vehicles is hindered by their limited range and by the current state of battery technology, among other factors. Many electric vehicles can travel only 50 to 100 miles on a single charge and the batteries used are heavy, expensive, and need to be replaced every few years. Plug-in hybrids, which do not face the same range limitations, are more likely to be widely adopted by consumers over the near term, especially as battery technology improves and costs decrease.

President Obama has proposed aggressive policies to promote electric cars in the U.S. with the goal of one million electric vehicles by 2015 (USDOE 2011a). Certain automakers are investing heavily in electric cars. In particular, Nissan began selling its first all-electric car, the Leaf, in late 2010 in the United States, Japan and Europe. Chevrolet also released the Volt in late 2010, which is an all-electric car with a range-extending gasoline generator. Ford will begin selling an electric version of the Focus starting in 2012, with initial production goals of 5,000 to 10,000 vehicles per year (Motavalli 2010a). The electric sports car manufacturer, Tesla, is planning greater production capacity for its new Model S, projecting 20,000 vehicles per year in 2012 (Nauman 2008). Other manufacturers have all-electric vehicles in the development phase, or for sale in other countries but not in the United States.

President Obama’s objective of at least one million electric vehicles by 2015 would represent approximately 0.7 percent of the total U.S. vehicle fleet. If this goal is met, then electric cars will comprise about 0.7 percent of the total fleet. Consequently, the near-term impact of all-electric vehicles on oil consumption may be modest, especially since the early adopters of these vehicles are likely to be drivers who travel relatively short distances (USDOT 2011h). As in the case of pure hybrid gains, the efficiency gains may not necessarily be greater than the fuel efficiency and greenhouse gas pollution standards, but electric cars may be the technology chosen to achieve the fuel efficiency and greenhouse gas pollution standards.

It is important to note the environmental consequences of shifting from gasoline to electricity as a fuel source for vehicles. In simple terms of energy used, due to efficiency gains allowed by design differences, electric vehicles represent a significant improvement over gasoline vehicles. The Nissan Leaf, with a 24-kWh battery, can travel 73 mi on a single charge, with a fuel economy equivalent to 99 MPG of gasoline (USDOE 2012b). Electric vehicles, therefore, produce environmental benefits by eliminating fossil fuel combustion and the associated tailpipe emissions of SO_2, NO_x, particulate matter, and greenhouse gases. However, these benefits are offset by increased emissions from electricity generation at power plants. The extent of these offsetting impacts will be determined by the electricity fuel sources used, which varies in different regions across the country. In the Pacific Northwest, which has a high proportion of hydropower, the net impact of electric vehicles may be positive. However, in areas where coal (which is more greenhouse gas-intensive than oil and can emit high levels of SO_2, NO_x, and particulate matter) is the dominant fuel source, the overall effect may be modestly beneficial or harmful. Areas in the immediate vicinity of coal-fired power plants may incur substantially worse air and water quality. Similarly, replacing oil fuel in cars with electricity from nuclear power plants could lead to increased production of radioactive waste, which if improperly transported or disposed could pose serious health hazards. The substitution of renewable energy as a source of baseload power (e.g., through the development of utility-scale wind, solar, biomass, and geothermal resources), would mitigate the negative impact of increased reliance on electric vehicles.

Ethanol Vehicles. Ethanol is a form of alcohol, of the type found in alcoholic beverages. As a hydrocarbon, it can also be used as an energy carrier and it has been used as a fuel source or additive for vehicles for several years. Most ethanol used for fuel in the United States is derived from corn, although in other countries, such as Brazil, sugar cane is a more popular and more efficient feedstock.

In the United States, ethanol is used primarily as an additive to gasoline. Several States mandate or subsidize ethanol blends in the range of 5 to 15 percent. Less frequently, ethanol is used as the primary fuel, either as an 85/15 blend with gasoline or in pure (neat) form. While all gasoline-powered vehicles can use ethanol in small amounts, higher concentrations require modifications. Flex-fuel vehicles can use any mixture of gasoline and ethanol or, in some cases, natural gas. Nearly eight million flex-fuel vehicles are currently in use in the United States; however, many owners may be unaware that their vehicle has this capability (USDOE 2010).

In the near term, ethanol use is likely to be determined largely by policy requirements. Most notably, the Renewable Fuel Standard, as revised through the Energy Independence and Security Act of 2007, requires an increase from nine billion gallons of ethanol and other renewable fuels in 2008 to 36 billion in 2022. USEPA has established interim targets of 12.95 billion gallons in 2010 and 20.5 billion gallons in 2015 (USEPA 2010a), more than 10% of 2008 levels of total oil consumption for transportation. Assuming this goal remains in force, the 7.5 billion gallon increase in biofuels over this time period should offset about five billion gallons of gasoline per year by 2015, taking into account ethanol's considerably lower energy density compared to gasoline (USDOE undated).

The impacts on land use and food prices from such a large increase in corn production for ethanol may be significant. These will be considered below, when we evaluate the longer-term potential for oil and gas substitutes in the transportation sector.

Public Transportation. For people living in urban areas, public transportation can provide a substitute for automobiles, especially for purposes of commuting to work or school.

While many people live in areas that are not well served by public transportation, or do not have public transportation options that meet their particular needs, for others it is a viable option even within the existing transportation infrastructure. Upwards of 65 million people live in the 10 urban areas with the highest transit usage and many more live in other transit-serviced areas. As of December 31, 2009, 7,200 separate public transportation service systems were operating in the United States. Of this total, approximately 5,200 were classified as paratransit, or transportation for elderly and disabled persons that does not follow fixed routes or schedules (APTA 2011).

Due in part to high oil prices, transit usage reached an all-time high in 2008, with ridership declining slightly in 2009 (APTA 2011). Seventy percent of trips taken on public transportation were for travel to work or school. A similar proportion of riders used public transportation five or more days per week. However, only about five percent of workers nationwide used public transportation to commute to work on a regular basis (APTA 2011). We can conclude, then, that the greatest potential for increased use of public transportation exists among commuters who currently drive to work.

The extent of oil and gas savings from using public transportation instead of automobiles is dependent on a number of factors, including but not limited to the mode of public transportation used and its fuel source, the distances involved, and the fuel use characteristics of users' automobiles. In general, it is safe to conclude that due to the inherent efficiencies in transporting large numbers of people at once, public transportation usage reduces oil and gas consumption, even for those modes of travel such as most buses that rely on fossil fuels. The American Public Transportation Association (APTA) cites data from two major reports on the topic, showing that for a typical year, using public transportation produced direct energy savings equivalent to 420 million gallons of gasoline, plus an additional 340 million gallons from avoided congestion. An even larger amount, 3.4 billion gallons, was saved due to reduced travel distances caused by public transportation-related location decisions.[22]

It is difficult to estimate the extent to which increased reliance on public transportation in place of automobiles could reduce consumption of oil and gas in the near term. Aggregated data on the utilization rate of the Nation's public transportation infrastructure (that is, the proportion of the capacity in place that is already being used, the complement to which is the proportion that could be used to accommodate increased ridership without requiring additional investment) are not readily available. Nor is it clear how many Americans who do not currently use public transportation on a regular basis could choose to do so without moving or changing their place of work.

One method to estimate the benefits of increased public transportation on energy use is to assume a continuation of the growth trend in transit use from 2004-2008. In 2009 growth did not

[22] Note that this is energy savings, not oil savings. Public transportation vehicles powered by electricity would be using some electricity generated from oil and gas, but would also presumably be relying on large amounts of coal, hydropower, and nuclear power as their underlying primary energy sources. Thus, the oil and gas savings of public transportation are likely to be even larger than these numbers would suggest.

continue, but it is not clear if this is a change in trend or a short term dip (APTA 2011). The APTA cites the U.S. Census Bureau's American Community Survey, which reports that 4.57% of workers used public transportation as their primary means of travel to work in 2004, rising to 5.01% by 2008 (APTA 2011). This translates into an increase of about 0.11% of the overall working population per year. Data from the intervening years show that the increase was essentially linear. If this trend were to continue, 5.78% of all workers would be relying primarily on public transportation by 2015. Accounting for population growth of about one percent per year, this rate of increase would imply an additional 1.7 million regular public transportation users by 2015 over 2008 levels, an increase equivalent to 23.5 percent of 2008 transit-using commuters. If we assume that non-school and work trips remain constant, that would translate into a 16.5% increase in total transit trips. Based on the nationwide totals highlighted above, such an increase would produce an incremental energy savings of 125 million gallons of gasoline equivalent (assuming there are no new indirect savings from location decisions in this timeframe).

Long-Term Market Analysis of Substitutes. This section analyzes the long-term potential for substitution away from fossil fuels. The focus is primarily on ground transportation, which could demonstrate lower fuel consumption through efficiency improvements, a shift toward greater use of public transportation, or use of alternative fuels. This section also includes a discussion on the potential for oil substitution in air travel through both efficiency improvements and fuel switching.

More Efficient Vehicles. As noted above, automobiles in the United States currently have a lifespan of about 14 years. While some individual vehicles will remain in use for a longer period of time, we assume that the Nation's fleet will have turned over nearly in its entirety within 20 years. As of 2009, more than 254 million highway vehicles were registered in the United States, of which 194 million were light duty vehicles and 7.9 million were motorcycles. The remainder comprise other vehicle types, primarily trucks, vans, and larger SUVs). Population growth may add more vehicles, outpacing any decrease in vehicles per capita (USDOT 2012a). As recognized in the new fuel efficiency and greenhouse gas pollution standards, there is huge potential for oil reductions through efficiency improvements in the Nation's automobiles. As mentioned previously, the fuel efficiency and greenhouse gas pollution standards may create incentives for the deployment of the following technologies. Since natural gas currently accounts for such a small proportion of fuel used for transportation, we do not consider it further.

Hybrid Vehicles. Hybrid vehicles are already fairly well-established, with all of the major automakers now mass-producing hybrid models. While hybrids will remain somewhat more expensive than conventional cars in terms of the upfront cost, the premium will likely fall as technology improves and manufacturers continue to scale up production. With sufficiently strong tax incentives or other forms of policy support, hybrids could theoretically replace conventional automobiles entirely.

The calculations performed earlier can be repeated to illustrate the potential scale of the impacts such a shift would entail. If population growth continues at its current pace, there will be about 393 million people in the United States in 2035, likely translating into roughly

300 million vehicles. Projecting a 40 percent savings per vehicle, based on the hybrid and traditional Toyota Camry models, would imply a total savings of 65 billion gallons of gasoline, more than one-fourth of total current consumption for ground transportation. While this is a very rough, illustrative figure, it nonetheless shows that hybrid vehicles have the potential to offset a significant fraction of oil use. Other types of fuel efficiency improvements, such as switching from trucks to cars or using more lightweight materials, would offer additional gains.

Electric and Plug-in Hybrid Vehicles. The key to future rates of adoption of electric vehicles and plug-in hybrids are the batteries used to replace, in whole or in part, the gasoline-powered combustion engine. Both plug-in hybrids and electric vehicles currently use lithium-ion batteries. Most conventional hybrids use nickel-metal hydride technology, but are expected to switch over to lithium-ion batteries as well (Pike Research 2009). Within the broad characterization of lithium ion batteries are several different subtypes, each of which can be evaluated on six basic criteria: energy storage capacity, power, safety, performance, life span, and cost. Significantly, none of the battery types currently in use performs well across all six criteria. As a result, the Boston Consulting Group concluded that absent a major breakthrough, fully electric vehicles that are as convenient as conventional cars will likely not be available before 2020 (Boston Consulting Group 2010).

Similarly, a report from the National Research Council (NRC) explored the prospects for plug-in hybrid vehicles by 2030. The NRC estimates that under optimistic assumptions the maximum number of plug-in electric vehicles on the road at that time would be 40 million. Cost and convenience factors suggest that 13 million may be more likely. The NRC did not anticipate significant cost improvements in lithium-ion batteries in the foreseeable future (NRC 2010).

Given this outlook, the impact of plug-in hybrid and electric vehicles is likely to be comparatively modest, even over a fairly long 25-year horizon. Plug-in hybrids use 20 to 55 percent less gasoline than traditional hybrids, depending on the mix of electricity and gasoline used (NRC 2010). Electric vehicles, of course, use no oil at all. The existence of 40 million plug-in hybrids, matching the high estimate from the NRC, would imply a savings of about 12 billion gallons of gasoline per year. While the NRC report did not consider all-electric vehicles, a similar number of electric vehicles (a very aggressive assumption) would save about 22 billion gallons of gasoline per year. The more likely figure of 13 million vehicles would produce savings of four to seven billion gallons.

Ethanol Vehicles. Perhaps the single most important factor influencing the long-term adoption of ethanol is the cost of producing cellulosic ethanol. Unlike traditional corn- or sugar-based ethanol, which is derived from starch, cellulosic ethanol uses cellulose as its basis, a structural component of plant cell walls and the most common organic compound on earth. A cost-effective method to produce cellulosic ethanol would allow for the use of a wide variety of feedstocks, including inedible crop residues and plants that grow on marginal agricultural land with little or no active cultivation. This would in turn enable far greater use of ethanol as a substitute for petroleum-based fuel.

At this time, cellulosic ethanol production is too expensive to justify large-scale use, due largely to the cost of producing enzymes to convert cellulose into a useable form. However, many observers expect significant cost reductions in the coming years. An early bellwether may be Novozymes, the world's largest manufacturer of industrial enzymes, which announced in February 2010, that it was launching a line of enzymes that it expects will lower overall production costs to under $2 a gallon, a cost that is in line with those for corn-based ethanol and gasoline (Leber 2010; Motavalli 2010b). In April 2011, construction started on a plant expected to produce 13 million gallons of cellulosic ethanol annually (Novozymes Bioenergy 2012).

If ethanol production costs fall below those of petroleum, further policy support may be unnecessary, as ethanol may become the preferred transportation fuel. Failing this, however, energy policy could play a major role in determining future levels of ethanol use. As noted above, the Energy Independence and Security Act mandates the use of 36 billion gallons of ethanol in 2022, of which 16 billion is intended to be cellulosic ethanol (USEPA 2010a).

Another important consideration is the availability of sufficient agricultural capacity to support substantially greater reliance on biofuels without causing an unacceptable rise in the price of basic foods (due to upward pressure on demand for agricultural land). A 2005 joint report by the U.S. Departments of Energy and Agriculture examined the feasibility of displacing 30 percent of the country's petroleum consumption with biomass-based energy, which the authors estimated would require dry biomass potential of about one billion tons per year. That report identified the potential for 368 million dry tons biomass potential per year from forestlands and 998 million dry tons biomass potential from agricultural lands, with "relatively modest changes in land use and agricultural and forestry practices." Agricultural biomass would comprise a mix of crop residues, grains for biofuels, process residues, and dedicated perennial crops. Not all of this would be suitable for conversion to liquid fuels for transportation. Nonetheless, the report makes clear that the country has the productive capacity to meet a portion, but not all, of its transportation fuel demand from biofuels (USDOE and USDA 2005). In addition to estimating the potential capacity of biofuels, a follow up report has estimated capacity at different price ranges, which broadens the potential capacity range from well below to well above the 2005 estimate (USDOE and USDA 2011).

The USDOE/USDA 2005 study cited above noted several potential environmental impacts from increased use of forest and agricultural land for biofuel production.

- Increase logging could result in greater soil erosion and elevated levels of sediment in surface waters.
- Removing crop residues could reduce soil quality, increase erosion, and release carbon from the soil into the atmosphere.
- In addition, removing the nutrients embodied in crop residues could lead to increased fertilizer use, leading to increased nutrients in water runoff and greater use of fossil fuels for fertilizer manufacture (USDOE and USDA 2011).

Furthermore, agriculture is relatively fuel-intensive. Reliance on petroleum to power machinery and equipment and to manufacture fertilizers and other inputs could offset much of the potential for biofuels to reduce overall petroleum consumption. Cellulosic ethanol is expected to have a more favorable life-cycle profile than corn ethanol, but it will nonetheless be unable to reduce petroleum consumption on a one-to-one basis.

Overall, if cellulosic ethanol becomes cost-competitive with other liquid fuel sources and/or it is given sufficiently strong policy support, it may displace a significant amount of petroleum in the long term, possibly approaching 30 percent of total consumption.

Public Transportation. In the short term, cities that have established public transportation systems could see increased ridership on their existing routes. To expand the impact of public transportation over the longer term, cities could build new mass transit systems or expand existing systems, thereby allowing residents to reduce their use of gasoline-fueled automobiles. While no firm rules exist regarding the time needed to develop new systems, anecdotal information from cities that have recently created or expanded their transit networks is instructive.

- Houston voters approved a transit referendum involving light rail in 1988, but due to opposition by key lawmakers, it was not until March 2001 that construction started on the city's METRORail system. It opened in January 2004.

- The Metro Light Rail system in Phoenix was created in the city's 2000 Regional Transit Plan. Construction began in March 2005, and the system started operations in December 2008.

- Denver has had light rail since 1994, but recently completed a major expansion. A 1995 congestion study ultimately led to a major highway and light rail expansion project known as T-REX. Construction began in October 2001 and was completed in November 2006.

These experiences suggest that a 10- to 15-year time horizon should generally be sufficient for large cities to create or expand light rail systems. Bus-based systems could presumably be implemented in much shorter timeframes.

It is difficult to predict which cities that currently lack light rail or tram service would be most likely to add such systems, but the most populous metropolitan areas that do not currently have light rail or tram service would seem to be likely targets. These include:

- Austin, TX

- San Antonio, TX

- Cincinnati, OH

- Columbus, OH

- Kansas City, MO
- Las Vegas, NV
- Orlando, FL.

These metropolitan areas had an estimated combined population of 13.8 million as of July 2009, approximately 4.5 percent of the U.S. population (USCB 2010). The extent to which new public transit networks in these or other cities could reduce automobile use would depend on the extent of the systems, the frequency of service, and residents' driving habits. To illustrate the potential magnitude of the effect, however, if 10 percent of the residents of those cities switched from automobiles to public transit for commuting purposes, it would mean an 18.7 percent increase in total nationwide transit use. This would save the energy equivalent of approximately 142 million gallons of gasoline, about one percent of current consumption for ground-based travel.[23] It is important to note, however, that by influencing patterns of urban development, the development of light rail systems could have a substantially greater impact over the span of decades. The APTA study cited above estimates that the indirect oil savings from public transportation due to location effects were more than four times greater than the direct savings from substituting for individual automobile trips (APTA 2011).

Hydrogen and Fuel Cell Vehicles. The advantages of hydrogen gas as a transportation fuel include its abundance as an element, its density as an energy carrier, and its lack of harmful emissions. However, since its gas form is too rare to be collected, it must be created from water, making hydrogen more like a battery than a traditional fuel. In vehicles, hydrogen gas can be used in two different ways: for burning in an internal combustion engine or in a chemical reaction in a fuel cell. The focus of this section is on the latter, which has the potential for greater efficiency. Fuel cells work by separating a chemical fuel, such as hydrogen, into negatively charged electrons and positively charged ions. The electrons are forced through a wire to create an electrical current that powers the vehicle. The electrons are then reunited with the ions and oxygen to form pure water. Since there are no moving parts, fuel cells are reliable and can remain operational for a long time.

Although hydrogen is one of the most abundant elements on earth, it occurs only rarely in pure elemental form. Hydrogen for fuel must be gathered from another source. Currently, 95 percent of the hydrogen used in the United States is produced through steam reforming of natural gas, in which high-pressure steam reacts with methane to produce hydrogen, carbon monoxide, and a small amount of carbon dioxide (EERE 2008). A potentially more environmentally friendly, more expensive, alternative is to split water molecules into hydrogen and oxygen through the process of hydrolysis. Since hydrolysis is powered by electricity, renewable power sources, such as wind or solar, could theoretically be used to produce the hydrogen needed to fuel vehicles.

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[23] This estimate relies on the same assumptions used in section 3.2.3 to estimate the impact of a nationwide increase in public transit use from 2010 to 2015.

All of the technology needed for hydrogen-powered, fuel cell-operated cars is already in existence, but not at a stage that would permit cost-effective, widespread commercial deployment. Key areas of ongoing research include the materials and manufacturing process for fuel cells and, in particular, reducing the amount of platinum used. Sufficient progress appears to be occurring for Toyota to expect to market a mid-size hydrogen sedan in 2015 (Mukai and Hagiwara 2011). However, some analysts argue that automakers will need to realize further cost reductions to make hydrogen vehicles cost-competitive with current offerings (Ohnsman 2010). Another area of ongoing research concerns development of more efficient means of producing hydrogen through hydrolysis or from other non-fossil fuel sources, which would ultimately be more environmentally beneficial than production from natural gas.

Another critical issue is the "chicken-and-egg" problem inherent in deploying hydrogen fuel on a wide scale. Widespread adoption of hydrogen vehicles will necessitate significant investments in infrastructure to make the fuel as widely available as gasoline is at present. However, it will be difficult to justify investment on the scale required until there are enough hydrogen-fueled cars on the road to create sufficient demand to support the industry. So long as there is a sufficient supply of petroleum or biofuels that can use existing infrastructure to meet the needs of the Nation's vehicle fleet, this will likely be more cost effective than the full cost of the transition to a hydrogen system. Well-timed policy support would likely be necessary to establish an adequate hydrogen fueling infrastructure and a smooth transition.

The California Fuel Cell Partnership estimates that if fuel cell vehicles are introduced into the market on a limited scale over the next decade as expected, they could be widely available by 2030. Due to the significant lag in vehicle turnover, it would likely be another 10 to 20 years before hydrogen could replace oil as the dominant transportation fuel. Some analysts argue that hydrogen has the potential to replace almost all of the petroleum used by the transportation sector, but over a long time horizon (NREL 2007).

More Efficient Planes. As noted above, air travel has grown significantly more fuel-efficient over time. This trend is expected to continue into the future, due in part to engineering changes and in part to operational improvements. A recent NASA and Boeing report forecasts that efficiency gains of 15 to 20 percent are possible in the medium term (Daggett et al. 2006). Meanwhile, member airlines of the International Air Transport Association, including American, Continental, Delta, United, and US Airways, have set a voluntary goal of a 25 percent improvement in fuel consumption (per revenue-ton-mile) by 2020 compared to 2005 levels (IATA undated).

If successful, a 25 percent fuel savings would reduce 4.7 billion gallons of fuel annually by 2020, based on 2008 levels of consumption. However, if passenger-miles traveled continue to grow at the three percent annual rate seen over the last five years, and if revenues rise accordingly, the reduction would be 6.4 billion gallons, equivalent to about 2.5 percent of total U.S. transportation fuel use in 2010.

Alternative-Fuel Planes. In a 2006 NASA Technical Memorandum, Daggett et al. explore the potential for alternative fuels in the aviation sector. The authors found that biofuel could be blended into jet fuel in small quantities (5 to 20 percent) without requiring any engine modifications, although an additional fuel processing step may be required to make the fuel compatible with the sector's exacting specifications. They go on to note that "[f]or biofuels to be viable in the commercial aviation industry, significant technical and logistical hurdles need to be overcome. However, the task is not insurmountable and no single issue makes biofuel unfit for aviation use." In fact, on November 7, 2011, in an effort to demonstrate technical viability, United became the first U.S. airline to fly commercial passengers on a plane fueled with a blend of biofuel and traditional jet fuel (United Airlines 2011). Other potential fuel sources, such as hydrogen or ethanol, are less suited to aviation, because the added weight of storage tanks (for hydrogen) or the weight and volume of fuel (ethanol) create significant energy efficiency penalties (Daggett et al. 2006).

As with biofuel use for ground vehicles, supply is likely to pose a bigger constraint than demand in the aviation sector. At 20 percent of current levels of fuel use, the upper limit suggested for blending with jet fuel as currently formulated, jet travel could consume as much as 2.2 billion gallons of biofuel. Soybeans, the major domestic biofuel crop, yields about 60 gallons of fuel per acre, meaning about 37 million acres would be required, an area the size of Illinois.

In light of the limits on available supply for biofuels, Daggett et al. conclude that it may be more efficient to concentrate use of this fuel source in the much larger ground transportation sector. They suggest that in the long term, the most attractive option for alternative jet fuel may be synthetic fuel produced from coal or natural gas (Daggett et al. 2006). However, to make this path environmentally preferable, at least with regard to greenhouse gas emissions, the processing plants involved would need to utilize carbon sequestration, a technology that has not yet been widely adopted.

In summary, our review of potential sources of oil and gas savings from the transportation sector highlights the following.

- The ground transportation sector accounted for about 168 billion gallons of gasoline and diesel fuel use in 2009. Air travel consumed roughly 13 billion gallons of fuel, while marine travel used approximately seven billion gallons. Natural gas did not play a significant role as a transportation fuel.

- In the near term, major sources of potential fuel savings include more efficient gasoline-powered automobiles and substitution of biofuels for gasoline in automobiles. Depending on assumptions, these two sources could save approximately 17 billion gallons of gasoline per year by 2015, or about 10 percent of the total for ground transportation.

- The potential for oil savings is greater in the long term. Most notably, cellulosic ethanol could displace as much as 30 percent of total oil consumption. Hybrid and electric vehicles, increased use of public transportation, and more efficient planes could generate oil savings as well, albeit in more modest amounts (likely on the order of nine to 14 billion gallons of gasoline equivalent). Finally, if adopted on a wide scale, hydrogen fuel could replace substantially all of the petroleum used by the transportation sector, but only over a very long time horizon.

4.5.7.1.2 Electricity Generation Sector. Petroleum plays a very modest role in electricity generation and the proportion of U.S. electricity generation from oil-fired power plants has been on a steep decline since the late 1970s. For natural gas, the converse is true. Gas-fueled electricity generation has increased steadily from 1996 to 2010, nearly doubling from 1996 to 2010 (EIA 2011f). The electricity generation sector is second only to industrial use in terms of overall consumption of natural gas. This section analyzes the use of oil and gas for electricity generation, beginning with an examination of recent trends and current use of oil and gas in the sector, and continuing with a discussion of the near- and long-term potential for substitutes. A particular focus is on the circumstances under which these fuels are used for electricity generation and how this affects the ability of renewable energy sources to serve as substitutes.

Current Use of Oil and Gas. Electricity generation consumed 65 million barrels of petroleum in 2010, or about 2.7 billion gallons. This translates into total primary energy use of about 376 trillion Btu (EIA 2011g). This represents a steep decline from 2005, when electricity production consumed more than three times as much. Prior to that, oil consumption had remained at approximately the same level since the mid-1980s. Oil consumption in the electricity generation sector peaked in 1977 at 3,900 trillion Btu, more than ten times the current level (EIA 2009c).

Within the electricity generation sector, petroleum is used primarily to fuel "peaker" plants — facilities that stand idle most of the time and are used only at times of very high demand. Generally, such plants are relatively cheap to build but expensive to operate, as the per-unit fuel costs are more expensive than other plants; thus, they are only used when all other options have been exhausted. As a result, oil provides the fuel for only a small fraction of electricity generated in the United States (Table 4.5.7-3). Petroleum was used to produce 37 million megawatt (MW) hours of electricity in 2010, less than one percent of the 4,127 million megawatt-hour (MWh) total. This was far less than the generation provided by coal, natural gas, nuclear, hydroelectric, or even biomass and wind resources (EIA 2011g).

Since most petroleum-fired plants are used relatively infrequently, these plants contribute a larger proportion of generating *capacity* to the total than they do actual generation. In 2010, oil-fired plants accounted for 57,647 MW of net summer generating capacity, or 5.3 percent of total U.S. capacity. This figure has remained fairly steady since 2002, despite the significant drop in petroleum-fueled electricity generation over that time period (during which overall peak electricity demand increased) (EIA 2010c, 2008b). For peaker plants in particular, this indicates that there may not be a strong correlation over the short run between available capacity and actual use. Thus, oil price changes may be reflected to some degree in electricity generation, but it will take a longer time (and a more sustained price change) before total capacity of oil-fired plants is similarly affected.

TABLE 4.5.7-3 Electric Utilities Generating Capacity and Net Generation

Energy Source	Generators	Generating Capacity (megawatts)	Net Generation (thousand megawatt-hours)	Percent of Net Generation
Coal	1,396	342,296	1,847,290	45
Gas	5,529	467,214	987,697	24
Nuclear	104	106,731	806,968	20
Hydroelectric	4,020	78,204	260,203	6
Other renewable	3,015	56,993	169,761	4
Petroleum	3,779	62,504	37,061	1
Total	17,843	1,113,942	4,127,648[a]	100

[a] Total includes sources not represented in table.

Source: EIA 2011h.

The use of oil predominantly as a peak fuel means that most oil-fired plants are relatively small and that there are a relatively high number of them in use. In 2010, 3,779 petroleum-fired generating stations were available, with an average capacity of 16.5 MW. By comparison, 1,396 coal-fired plants were in operation, with an average generating capacity of almost 250 MW.

Compared to petroleum, much larger quantities of natural gas are used for electricity generation. In 2010, 7,680 billion cubic feet of natural gas or 7,893 trillion Btu, were consumed in electricity generation (an energy content more than 20 times greater than that supplied by petroleum). Natural gas use rose sharply during the economic expansion years, growing by an average of 6.3 percent annually from 2003 to 2008. While that rate may seem modest, it was five times greater than the overall increase in electricity generation. More interestingly, after dipping in 2008, it grew substantially through 2010. Only coal supplied a larger share of the Nation’s electricity in 2010 (EIA 2011g).

In terms of nameplate generating capacity, natural gas ranks as the largest component of the electricity generation sector, with 467,214 MW in 2010, or about 40 percent of the total. Growth in gas-fired capacity has outpaced overall capacity expansion in recent years (2.2 percent vs. 1.3 percent per year). Notably, gas generation expanded much more rapidly in the early years of the last decade than in later years, growing more than 16 percent per year from 1999 to 2003. This was largely in response to the relative flexibility of natural gas power plants, which can be used for baseload, intermediate, or peak generation and the comparatively favorable environmental profile of such plants compared to coal or nuclear power. As of 2010, 5,529 gas-fired generators were in operation in the U.S., with an average capacity of approximately 85 MW (EIA 2011g).

Electricity generation is somewhat more efficient using gas than oil. This is partially due to the nature of the combustion engines used for each fuel. Since natural gas engines are more expensive and run more frequently, there is a greater incentive for efficient combustion. However, efficiency has also been rising in recent years as the result of greater use of natural gas combined-cycle plants. In a combined-cycle plant, the exhaust gases from the gas turbine are used to heat steam which is used to turn a second turbine, thereby capturing the waste heat from the first cycle. As these secondary steam turbines are installed in new gas power plants or placed into existing ones, the efficiency of gas-fired electricity generation should continue to improve.

Near-Term Market Analysis of Substitutes. A significant proportion of oil- and gas-fired generation does have the capability to switch between the two fossil fuels. As of 2010, 26 percent (124,412 MW) of capacity with natural gas listed as the primary fuel was capable of switching to petroleum liquids and 41 percent (22,296 MW) of capacity with oil listed as the primary fuel was capable of switching to natural gas (EIA 2011i). However, this report is not concerned with substitutions between oil and gas but rather switches from oil and gas to other energy sources. Although no comprehensive data exist, it seems logical to assume that a similar proportion of oil and gas plants would be capable of using biofuels, which can be refined to meet specifications similar to those of many petroleum products. In the near term, however, the increasing demand for biofuels in the transportation sector put in place by the Renewable Fuels Standard suggests that there will be relatively little additional biofuel supply available for use by power plants. It seems likely then that there is little if any near-term potential for cost-effective substitution away from oil and gas among existing power plants.

With existing generating plants excluded, we must then consider how the composition of the electricity generation sector as a whole could change in the near term. Power plants are long-lived assets, meaning that reactions to market or policy signals will necessarily be somewhat delayed. Using data from 2004 to 2008, approximately four to six percent of all petroleum-fired generators were retired each year, implying an expected lifespan of about 20 years; for natural gas-fired generators, the retirement rate was somewhat lower, implying an expected lifespan of 23 years (EIA 2010h). (This is consistent with a general rule of thumb that fossil fuel plants can run for about 25 years before needing to replace generators and other key equipment.) Therefore, we can assume that only those gas plants that were built in the late 1980s to early 1990s will likely be retired over the next few years. If recent trends continue, approximately 500 MW of oil-fired capacity and 2,100 MW of gas-fired capacity will be retired every year, or 2,500 MW and 10,500 MW respectively over a five-year period (EIA 2010h). These retirements will most likely be balanced at least in part by new capacity additions of the same type, but these figures nonetheless give an idea of the scope of potential near-term substitution away from oil and gas. If market conditions changed such that oil or gas became more expensive, this is the maximum amount of generation we could expect to be displaced by alternatives.[24]

[24] This considers only replacement of retiring units, and not additions of new capacity. Based on trends from 2004 to 2008, retirements of petroleum generation are likely to outpace new additions in the near future, while new natural gas generation will outpace retirements by more than 10,000 MW per year, U.S. Department of Energy, Energy Information Administration, *Electric Power Annual with Data for 2008*, January 21, 2010, "Table 1.5: Capacity Additions, Retirements and Changes by Energy Source, 2008." See http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html. It is highly doubtful that new renewables could displace this generation on top of the replacement of retiring units discussed here.

However, as noted above, different fuel sources are useful for electricity generation in varying contexts. This means that certain renewable electricity sources may not be direct substitutes for oil- and/or gas-fired generation. Biomass, geothermal and nuclear power are generally used as baseload power, making them poor substitutes for oil and of limited usefulness in replacing natural gas (which, while sometimes employed for baseload generation, is more commonly used as intermediate or peak power). Hydroelectric power is mostly used for baseload generation as well, although it is more flexible and can be ramped up and down more easily; however, with most potential large hydroelectric sites already developed, there is relatively limited potential for additional domestic capacity. A Navigant Consulting study, based on an earlier USDOE report, estimated a maximum technical capacity of about 84,000 MW of additional hydroelectric power, of which 22,000 MW could realistically be developed by 2025. This would constitute an increase of approximately 30 percent over 2010 levels, but would still leave hydropower at less than 10 percent of total electricity generation (Frantzis 2010).

Wind and solar power are more likely alternatives for both of these fossil fuels.[25] Due to their intermittent nature, however, there are limits to the maximum amount of near-term penetration that these energy sources will likely achieve in a cost-effective manner. Nonetheless, a report from National Renewable Energy Laboratory (NREL) projected that wind power could achieve a 20 to 30 percent penetration in the eastern United States by 2024, given sufficient investment in transmission upgrades. In the absence of such investment, this level of wind penetration would require significant curtailment or shutting down of wind plants, with a high associated cost (EnerNex Corp. 2010). Sufficiently robust infrastructure is important in that it can more effectively use widely-dispersed wind plants to ‘cancel out’ each other’s variability. While wind generation in particular has been growing at an impressive rate with nearly 10,000 MW installed in 2009 (AWEA 2010), on par with capacity additions of oil and gas in recent years (EIA 2011j),[26] it is not likely to approach this 20 percent constraint in the next five years. Indeed, uncertainty regarding Federal support for wind energy resulted in a decrease in new installed capacity in 2010 (a total of just over 5,100 MW); through the third quarter of 2011, new installed capacity for the year stood at 3,360 MW (AWEA 2011a, b). Solar power currently makes up a much smaller proportion of electricity generation and is not likely to displace a significant amount of fossil fuel generation over that time frame.

Finally, note that the electricity generation industry is shifting from simple-cycle steam turbines to combined-cycle generators for natural gas. Combined-cycle generators are about 25 to 30 percent more efficient than simple-cycle generators in terms of electricity produced per unit fuel (EIA 2011k). We can expect a trend towards greater efficiency to continue as newer

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[25] This is true in terms of electricity produced and thus fuel used on an ongoing basis; with regard to *capacity*, it is a more dubious proposition. Since wind and solar are not firm resources, a certain level of natural gas or oil capacity will generally be required as a ‘backstop’ resources to protect against grid problems in times when the supply of these renewables cannot meet the instantaneous demand for electricity.

[26] Again, it is important to distinguish between capacity and electricity generation. Due to its intermittency, wind has a much lower capacity factor than oil or gas generation; thus, a megawatt of wind capacity will produce far less electricity over time than a megawatt of natural gas capacity (or petroleum, if it is being used for non-peak power). Capacity additions of wind and solar cannot be considered one-for-one substitutes for fossil fuels.

natural gas generators and power plants come online, meaning that less gas will be needed to meet the same level of electricity demand.

Overall, in the near term, the maximum potential for a shift away from oil and gas in the electricity generation sector is limited by the level of oil and gas generator retirements (expected to be about 2,500 MW and 10,500 MW over five years, respectively) and the extent to which these generators can be replaced by renewables (predominantly wind power) and more efficient natural gas combined cycle plants. Based on 2008 capacity factors and fuel efficiency, we estimate that this maximum replacement potential translates into about 182 billion cubic feet of gas and 3.5 million gallons of oil avoided each year. While wind power may place some strains on the grid at high levels of penetration, this is not a near-term concern. Biofuels and other renewables are not likely to play a significant role in replacing fossil fuels over this time period.

Long-Term Market Analysis of Substitutes. As noted above, fossil fuel generators, both oil and gas, have an expected lifespan of about 20 to 25 years. In this timeframe, there will be a more or less complete turnover of the Nation’s oil and gas generators, as well as the new additions necessitated by growth in demand. There is significant potential for substitution away from these fuels over that period, dependent on the availability and suitability of other power sources.

Biofuels represent the most obvious potential substitute for petroleum and gas in terms of fuel characteristics, although, as noted above, they are more likely to be used in the transportation sector, which represents a much larger source of demand. Even assuming significant scale-up of new biofuel production capabilities, the maximum amount available from domestic sources would not likely be enough to meet current levels of both transportation and electricity fossil fuel demand. Therefore, biofuels are excluded from further consideration here.

As of 2010, natural gas accounted for 24 percent of electricity generation and petroleum provided an additional one percent. As noted above, NREL has concluded that wind power alone could achieve 20 to 30 percent penetration in the eastern U.S. by 2024, with adequate investments in transmission infrastructure (EnerNex Corp. 2010). Furthermore, a similar study found that 30 percent wind penetration is technically feasible in the western States as well, with some modifications to current practice by grid managers (GE Energy 2010). In simple terms of magnitude, wind could theoretically displace oil and gas for electricity generation entirely. Wind is already reasonably cost-competitive with oil and gas and will become more so if fuel prices rise and/or if climate policy results in a carbon tax or cap-and-trade mechanism. The manufacturing process and technology for wind turbines is fairly mature and well-established. For wind, therefore, the most important constraint will be the ability of the electric grid to accommodate significant amounts of an intermittent resource. Much of the wind potential evaluated by NREL would come from the Great Plains. While the report emphasizes the benefits of regional integration and coordination, this geographic dynamic suggests that a portion of the wind power is likely to be replacing coal, rather than oil or gas.[27] In addition, some amount of oil or gas will be needed to balance the intermittency of wind resources. Nonetheless, wind power could potentially replace a major portion of oil- and gas-fired electricity generation.

A substantial portion of the long-term wind potential identified by NREL, 54 gigawatts, is to come from offshore wind. The United States has areas appropriate for offshore wind power development near large coastal urban areas. With growing electricity demand and space constraints on land-based electricity generation and transmission, offshore wind is favorably positioned to play a role in meeting future energy demand (NREL 2010). Constructing sufficient transmission infrastructure is a significant barrier, but with Google and the renewable energy investment firm Good Energies committing to significant investments in an undersea transmission 'backbone' that would serve projects along the Atlantic coast, there could be sufficient infrastructure to spur additional offshore development (Wald 2010). Since coastal U.S. areas rely more heavily on natural gas (and small amounts of oil) for electricity generation than the Midwest, any offshore wind development that does result would help further reduce dependence on these fossil fuels.

Solar power, although not expected to play a significant role in centralized electricity generation over the next few years, could become more important given the right mix of technological improvements and market or policy influences. A study by the research firm Clean Edge, Inc. and the non-profit Co-op America found that photovoltaic and concentrated solar power could reach 10 percent of electricity generation by 2025, although this would require a capital investment of hundreds of billions of dollars. As a resource that is generally available during times of peak demand (i.e., warm-weather periods), widespread use of solar power would imply significant displacement of both oil and gas. Such a scenario is dependent on significant cost decreases in the manufacturing process, to be driven both by the realization of economies of scale and by other technological improvements (Clean Edge, Inc. and Co-op America 2008).

Overall, given favorable conditions, solar and wind power could be used to replace a significant portion of oil and gas used for electricity generation. The technical constraints posed by their status as intermittent resources mean that these energy sources cannot be used to completely replace fossil fuels, even with investments in the transmission grid and/or in battery storage. While it is not the aim of this report to develop a detailed forecast, some simple math can illustrate the potential scope of substitution. The EIA's 2010 Annual Energy Outlook forecasts electricity generation to grow at one percent annually over the next 25 years (EIA 2011b). At that rate, total electricity generation would be approximately 5,389 billion MW-hours in 2035, up from 4,119 billion MW-hours in 2008. If wind is in fact able to reach 20 percent and solar to reach 10 percent penetration, this would imply a total of about 1,078 and 539 billion MW-hours respectively produced from these sources. By way of comparison, wind

27 Although coal is a baseload power source, and thus not directly replaceable by a given wind plant, a widely dispersed network of wind plants could provide sufficiently firm power in the aggregate to eliminate the need for a portion of the region's coal-fired capacity. The NREL report frames its results in terms of smaller increases in capacity of fossil plants, rather than absolute reductions, but it appears that they forecast wind to displace a mix of coal and gas plants.

accounted for 1.34 percent of all generation in 2008, while solar was virtually zero. If the assumption is made that half of the growth in these renewables replaces oil and gas, and half coal, then this suggests that they could displace 772 billion MW-hours of oil- and gas-fired electricity annually, more than 80 percent of the current total produced from these sources, or roughly two-thirds of what would come from these fossil fuels in 2035 if they were to continue to hold their current proportions of total generation. If expanded renewables displaced a higher proportion of oil and gas relative to coal, then even more electricity from these sources could be avoided.

Note that nuclear power represents another potential substitute for natural gas. The Nuclear Regulatory Commission is actively reviewing applications for operating licenses for 22 new nuclear power plants and power companies are considering additional plants as well (Nuclear Energy Institute 2011). However, since natural gas is used primarily as an intermediate or peak power source, whereas nuclear power is a baseload resource, the potential for substitution is limited. Furthermore, the extent to which nuclear power will be able to successfully compete with other baseload resources such as coal or biomass will depend on climate policy, the relative ease or difficulty of gaining regulatory approval, and fuel cost and availability. Nonetheless, expanded use of nuclear power could result in avoided natural gas use to a greater degree than outlined above.

Finally, we note that climate change and energy policy could have a significant effect on shaping the electricity sector. It is not the intention of this paper to discuss potential policy initiatives and their potential impacts in detail. It is difficult to predict the political appetite for climate and energy policy or the specific tools potentially employed. However, concepts discussed in the last five years include the following:

- *USEPA regulation of greenhouse gases as criteria pollutants under the Clean Air Act.* In April 2009, USEPA declared carbon dioxide and five other greenhouse gases to be endangering public health and welfare, a precursor for the agency to regulate them under the Clean Air Act. If regulations were promulgated, they would likely reduce coal use and increase oil and gas use.

- *A nationwide renewable energy standard or clean energy standard.* A renewable energy standard would require electric utilities to meet a minimum amount of electricity demand (e.g., 20 percent) through renewable sources. A clean energy standard, as proposed by the Administration, would credit a broader range of clean electricity sources – including nuclear power, with partial credit for generation from efficient combined-cycle natural gas plants and fossil fuel plants that capture and store carbon dioxide.

- *Subsidies for renewable energy production.* Policymakers could extend existing incentives for generation from renewable sources, such as the production tax credit of 2.1 cents per kilowatt-hour for wind or the investment tax credit of 30 percent of the cost of solar installations, or create new incentives, such as feed-in tariffs similar to those that enabled significant renewable energy capacity expansion in Europe in recent years.

These or other policy measures will influence the mix of renewables, oil, gas, and other resources in the electricity sector, but they will be unlikely to change the maximum potential levels of substitution described above. Even over a 25-year time horizon, natural gas is likely to contribute a significant portion of electricity generation in the United States.

4.5.7.1.3 Industrial Sector.

Current Use of Oil and Gas. The industrial sector used 1.57 billion barrels of petroleum in 2010, with primary energy use of 8,029 trillion Btu. It consumed a similar 7,930 trillion Btu in natural gas, slightly more than was used for electricity generation (7,380 trillion Btu). The industrial sector was therefore the second-largest petroleum-consuming sector of the economy after transportation and the highest gas-consuming sector (EIA 2011l, m).

Industrial oil use peaked domestically in 1979 at just less than two billion barrels. More recently, levels of consumption have remained relatively steady from year to year. From 1998 to 2007, annual industrial petroleum use held between 1.77 and 1.91 billion barrels, a difference of less than 10 percent. Oil use has remained lower since 2008, due to the economic recession. What has changed over the past decades is the composition of the sector's petroleum inputs. Liquid petroleum gases (LPG) have steadily increased as a proportion of total petroleum, from five percent in 1950 to 24.2 percent in 1980 to 33.3 percent in 2008. As LPG use has grown, residual fuel oil has virtually disappeared, dropping from 33.4 percent of industrial oil in 1950 to just 1.4 percent in 2010 (EIA 2011n). Since LPGs are comparatively cleaner than residual fuel oil, this indicates that the net environmental impact of industrial oil use has moderated over time.

Natural gas has a similar story. After peaking in 1973 at 10,388 trillion Btu, industrial natural gas consumption fell sharply in the late 1970s and early 1980s, before climbing back during the 1990s. Natural gas use has been falling again in recent years, from 9,933 trillion Btu in 1997 to 7.380 trillion Btu in 2010 (EIA 2011m). This could reflect a response to a long-term trend of rising natural gas prices over that time period.

Oil and gas are used for three broad purposes within the industrial sector: to generate heat and steam for industrial processes, either in boilers or in direct process heating; for heating and air conditioning of ambient air; and as nonfuel feedstocks for a variety of products, including solvents, lubricants, plastics, asphalt, and various chemicals. Oil and natural gas are also used by many industrial facilities for cogeneration, which produces electricity, as well as usable heat and steam to be consumed either on-site or by neighboring facilities.

The EIA's Annual Energy Review (AER), the source for the summary figures listed above, does not provide more fine-grained information on particular end uses of petroleum and natural gas. For that, we rely on EIA's quadrennial Manufacturing Energy Consumption Survey (MECS), which last reported data for 2006. There are discrepancies between the industrial sector as defined in the AER and manufacturing facilities as defined in the MECS, with the MECS appearing to cover a smaller amount of total industrial activity. Nonetheless, the two are sufficiently similar for our purposes to use manufacturing facilities as a proxy for the entire industrial sector. Doing so allows us to examine the particular end uses of oil and gas within the industrial sector in greater detail.

Table 4.5.7-4 shows total energy use in manufacturing facilities for both fuel and non-fuel applications. Specific end uses are discussed in greater detail below.

Process Heating. Process heating is the practice of heating particular materials used in manufacturing, such as metals, plastics, and ceramics. Process heating softens, melts, or evaporates materials, and may be used to catalyze chemical reactions. This can be accomplished through a variety of equipment types, including furnaces, ovens, dryers, and specially designed heaters for the process in question. Process heating systems may use fuel directly or may be electricity- or steam-based. Only direct fuel-burning equipment is considered here.

Process heating is the largest industrial fuel use of natural gas. Excluding onsite transportation within industrial facilities, electricity generation, and unspecified uses, process heating accounted for 47 percent of industrial natural gas use in 2006. In 2002, the date of EIA's previous MECS survey, this number stood at 49 percent. Total gas use for process heating dropped by nine percent over that time period.

Process heating is also a major industrial use of petroleum, if nonfuel applications are excluded. Process heating represented 32 percent of industrial petroleum fuel use in 2006, once again excluding transportation, electricity generation, and unspecified uses. Petroleum use for process heating dropped 23 percent from 2002, at which point it had accounted for 42 percent of industrial petroleum fuel use. If nonfuel applications are included, process heating accounted for less than five percent of total petroleum use in both 2002 and 2006 (EIA 2009i, h).

Boilers and Cogeneration. Boilers use a fuel source such as oil or gas to produce steam, which is in turn used to heat other materials and/or the ambient environment, or to drive turbines. The EIA's MECS distinguishes boilers from direct process heating, which does not use steam as an intermediary. The equipment used is different between these two processes, although the end application may often be the same (i.e., heating a manufacturing input).

Conventional boilers accounted for 28 percent of industrial petroleum use for fuel in 2006, with cogeneration responsible for another 20 percent, for a total of 48 percent. The numbers were somewhat lower for natural gas, at 24 percent and 16 percent respectively. Again, these figures exclude onsite transportation, non-cogeneration electricity production, nonfuel applications, and unspecified uses. There was relatively little change in these proportions from 2002. Including nonfuel use has only a modest impact on natural gas, but drops the proportion of petroleum use for boilers and cogeneration dramatically, to four percent for boilers and three percent for cogeneration. Both natural gas and petroleum use for boilers and cogeneration were virtually unchanged in absolute terms from 2002 to 2006 (EIA 2009i, h).

TABLE 4.5.7-4 Manufacturing Facilities Energy Use (trillion Btu)

	Net Electricity		Natural Gas		Petroleum		Coal		Other		Total	
End Use	2002	2006	2002	2006	2002	2006	2002	2006	2002	2006	2002	2006
Boiler Fuel												
Conventional boiler use	9	41	1,306	1,281	99	96	255	129	–[a]	–	1,679	1,547
CHP and/or cogeneration process	4	–	857	838	61	69	521	417	–	–	1,443	1,324
Direct uses – process												
Process heating	343	346	2,742	2,487	142	110	368	345	–	–	3,595	3,288
Process cooling and refrigeration	194	206	45	32	2	1	[b]	[b]	–	–	241	239
Other process use	1,681	1,692	169	269	23	41	12	66	–	–	1,885	2,068
Direct Uses – non-process												
Facility HVAC	262	265	417	378	13	13	5	2	–	–	699	658
Facility lighting	196	198	–	–	0	0	–	–	–	–	196	198
Other facility support	48	60	30	30	1	1	[b]	[b]	–	–	79	91
Other non-process use	3	8	10	8	1	7	0	[b]	–	–	14	23
Boiler fuel and direct uses subtotal	**2,740**	**2,817**	**5,576**	**5,322**	**342**	**342**	**1,162**	**961**	–	–	**9,831**	**9,442**
Nonfuel uses (Btu equivalent)	**0**	**0**	**674**	**398**	**3,022**	**2,380**	**799**	**473**	**3,693**	**3,711**	**8,189**	**6,962**
Boiler fuel, direct uses and nonfuel uses total	**2,740**	**2,817**	**6,251**	**5,719**	**3,364**	**2,722**	**1,961**	**1,434**	**3,693**	**3,711**	**18,020**	**16,404**
Other uses												
Onsite transportation	4	7	2	3	53	55	–	–	–	–	59	65
Conventional electricity generation	–	–	55	19	1	4	14	3	–	–	70	26
End use not reported	96	26	162	168	56	58	6	52	6,006	5,820	6,306	6,125
Total[c]	**2,840**	**2,850**	**6,470**	**5,909**	**3,474**	**2,839**	**1,981**	**1,489**	**9,699**	**9,531**	**24,455**	**22,620**

[a] – = Not applicable.

[b] Estimate less than 0.5.

[c] Numbers do not add due to rounding.

Sources: EIA 2006, 2009i.

Heating, Ventilation, and Air Conditioning (HVAC). After process heating and boilers and cogeneration, HVAC is the only significant industrial end use of petroleum and natural gas except use as chemical feedstocks. The HVAC sector accounted for four percent of petroleum and seven percent of natural gas fuel use in both 2002 and 2006. The proportion of petroleum use drops to less than one percent when nonfuel applications are factored in. Natural gas use for HVAC saw a modest decline in absolute terms from 2002, matching the overall pattern in industrial gas use, while petroleum remained constant (EIA 2009i, h).

Non-energy Uses. While nonfuel applications make up a relatively small proportion of industrial gas use, just seven percent in 2006, down from 11 percent in 2002, they account for nearly 90 percent of petroleum consumption (see Table 4.5.7-5). Thus, the use of petroleum products as chemical feedstocks deserves particular attention.

Over half of the nonfuel consumption of petroleum takes place at petroleum refineries. In addition to various forms of petroleum fuels, refineries also produce a range of petrochemicals, including lubricating oils, paraffin wax, and asphalt and tar. However, the information available is not sufficiently detailed to indicate petroleum use for each of these products (EIA 2009i).[28]

The next most significant source of demand is plastics materials and resins, which accounts for nearly 20 percent of nonfuel petroleum consumption (EIA 2009i). Plastics come in a wide variety of forms and are used for an equally wide variety of applications, but almost all plastics are composed of chains of carbon and hydrogen (sometimes with other elements included). This structure makes petroleum an ideal feedstock for plastics. Most plastic manufacturing processes have very little material waste and incorporate virtually all of the petroleum input into the final product (Graedel and Howard-Grenville 2005).

The other major consuming sectors of nonfuel petroleum are classified as "petrochemicals" and "other basic organic chemicals." Again, the information available does not provide any further detail. "Other basic organic chemicals" is also a major nonfuel user of natural gas. However, the most significant nonfuel consumer of natural gas is nitrogenous fertilizers, which are widely used throughout the agricultural sector (EIA 2009i).

Notably, nonfuel use of both petroleum and natural gas was significantly lower in 2006 than in 2002. The most significant decline for each came in chemicals. Detailed information was not available for petroleum. For natural gas, the decline was especially significant in nitrogenous fertilizers (which fell by 40 percent), basic organic chemicals (which dropped by 54 percent), and plastics (which fell by 83 percent). Although there is less detail, data from earlier years suggests this may be a sustained decrease rather than an isolated phenomenon.

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28 The input source for this sector is classified as 'other' in the MECS table regardless of the actual material type (petroleum, natural gas, coal). However, given the function of oil refineries, this energy is almost certainly taken from petroleum products. This discrepancy accounts for much of the 'other' nonfuel consumption in the table above.

TABLE 4.5.7-5 Manufacturing Facilities Select Nonfuel Uses of Natural Gas and Petroleum for Nonfuel (trillion Btu equivalent)

	Natural Gas		Petroleum	
End Use	2002	2006	2002	2006
Petroleum refineries	0	0	3,307[a]	3,399[a]
Chemicals				
Petrochemicals	37	0	899	[b]
Other basic organic chemicals	162	74	717	[b]
Plastic materials and resins	66	11	1,283	1,180
Nitrogenous fertilizers	295	176	0	0
All other chemicals	69	91	108	[b]
Total chemicals	629	352	3,007	2,297
All other applications	45	46	15	83
Total (all nonfuel)	674	398	6,329[a]	5,779[a]

[a] Numbers shown here include 3,307 trillion Btu in 2002 and 3,399 trillion Btu in 2006 in “other” fuel used at petroleum refineries, which we assume comes from petroleum.

[b] Data withheld in source material to prevent disclosing data on individual establishments.

Source: EIA 2009i.

There was relatively little change in nonfuel consumption of petroleum at petroleum refineries or for plastics, the only major categories for which data are available for both years (EIA 2009i).

Near-Term Analysis of Substitutes. Industrial equipment is typically long-lived. The Chartered Institute of Building Services Engineers (CIBSE) lists the “indicative life expectancy” for boilers at 15 to 25 years, and gas or oil fired furnaces at 15 years (CIBSE undated). In addition, such equipment often represents a significant expenditure. As a result, turnover rates are relatively low. Only in extreme circumstances would a change in fuel prices prompt a facility manager to replace petroleum- or gas-fired equipment significantly in advance of its planned retirement date. For that reason, any form of fuel switching that would require replacing major equipment as a long-term but not a near-term possibility is included.

Near-term substitution will require alternative fuel sources that are compatible with existing equipment. For petroleum, this implies liquid biofuels such as ethanol or biodiesel. As discussed in the transportation chapter, near-term biofuel use will most likely be driven largely by policy requirements. The Renewable Fuel Standard currently in place sets a target of 20.5 billion gallons of renewable fuel use *for transportation* by 2015. This is more than the total domestic production forecast for that year by EIA’s Annual Energy Outlook (USEPA 2010a; EIA 2011b). Even if this dynamic of demand outstripping supply corrects itself somewhat, there is unlikely to be any significant quantity of liquid biofuels left over for use in industrial, fuel-based applications.

For non-fuel uses such as plastics, there may be greater potential for substitution away from petroleum. The manufacture of biobased plastics, mostly produced from starch, sugar, and cellulose, increased by 600 percent between 2000 and 2008, although they still represent a small proportion of total plastics (Ceresana Research 2009). Globally, demand for bioplastics is forecast to grow at approximately 25 percent annually from 2010 to 2015 (Pira International 2010). This suggests potential for biobased plastics to replace a portion of conventional plastics.

Plastics manufacturing accounted for the equivalent of 1,198 trillion Btu of petroleum consumption in 2006. While it is not clear what proportion of total plastic produced domestically currently derives from non-petroleum sources, five to 10 percent appears to be reasonable based on global estimates (U.K. National Nonfood Crop Centre 2010; Nova Institute 2009). From this base, the projected growth rates in bioplastic manufacture just reported would suggest that an additional 130 to 260 trillion Btu of petroleum for plastics manufacturing could be replaced by biological feedstocks over the next five years. This amounts to approximately 1.5 to three percent of total industrial petroleum use (EIA 2011n).

The other readily available petroleum substitute for plastics manufacturing is recycled plastic, which can replace virgin materials. A large amount of potentially recoverable plastic is discarded in the United States each year. For example, only 7.1 percent of all plastic discarded in municipal solid waste in 2009 was recovered. However, even this represents a modest improvement from earlier years when the recovery rate was approximately six percent from 1990 through 2005 (USEPA 2010b). In the near-term, dramatically increased recovery of plastic seems unlikely. However, if the trend of modest increases from 2005 to 2009 continues, recycling rates could reach 8.75 percent by 2015, amounting to about 2.6 million tons of plastic. The incremental increase of 0.5 million tons recycled would save about 11 trillion Btu of oil.

Long-Term Analysis of Substitutes. There is greater potential for substitution in the longer term as industrial facilities replace their existing oil- and gas-fired equipment, affording them the opportunity to switch to systems using alternate fuel sources. Many facilities may switch from oil to gas, but we do not evaluate this possibility here, focusing instead on moves away from oil and gas to other fuel sources. Other substitutes include biofuels, electricity, and expanded use of the substitutes noted above for plastics manufacturing (i.e., recycled plastic or biobased chemicals). While there is significant variation between different types of equipment, an appropriate rule of thumb is that industrial equipment is replaced every 25 years. This represents the appropriate timeframe for our long-term analysis.

The potential for biofuel production has already been discussed in the transportation chapter and is not repeated in detail here. As described there, biofuels could displace a significant portion of petroleum use over the next 25 years, perhaps up to 30 percent of total nationwide consumption. Biofuels are unlikely to have much impact on natural gas. However, with three-fourths of U.S. petroleum use taking place in the transportation sector, most of the substitution is likely to take place there. Thus, there is likely comparatively little room for expanded biofuel use in the industrial realm. Furthermore, due to the limits on potential biofuel supply (based on available land to dedicate to growing fuel crops), if overall biofuel use does approach the upper boundary of 30 percent, any substitution of biofuels for petroleum that did happen in the industrial sector would come at the expense of similar substitution elsewhere. This would be true for biobased inputs for plastics manufacturing, as well as for fuel use.

Industrial facilities could also use equipment powered by electricity instead of oil- and gas-fired equipment. Given that most industrial oil- and gas-using equipment is used simply to provide heat (e.g., for process heating or in boilers), such a move would generally be thermodynamically inefficient. While electricity generation and consumption produces considerable energy losses, combustion for heat is far more efficient at utilizing embodied energy from a fuel source. Even so, electricity is a viable option, and if generated from renewable sources, it may result in lower environmental impacts.

As with biofuels, the potential for expanded use of renewable energy has been discussed previously in this report and is not repeated again here. We do note, however, that substitution of electrical equipment for oil- and gas-fired combustion equipment would result in an increase in overall electricity demand. As with biofuels, if renewable power generation approaches the upper boundaries outlined previously, any renewable electricity use by industrial sources would simply displace renewable energy use that would have occurred elsewhere.

Significantly increased plastic recycling represents the final mode of substitution away from industrial petroleum use. A recent report on the European plastics industry notes that Germany recycled the highest proportion of its post-consumer plastic waste of any European country, at 33.9 percent. An additional 60 percent of Germany's plastic waste was sent to waste-to-energy plants (PlasticsEurope, EuPC, EuPR, and EPRO 2010). Compared to the contemporaneous 7.1 percent U.S. recycling rate, this would constitute an ambitious goal. We therefore use it as an upper boundary on the potential for long-term recycling in the United States.

Thirty million tons of plastic waste was generated in this country in 2009 and this figure has held relatively constant in recent years (USEPA 2010b). If this level of waste production continues into the future, 33.9 percent recycling would represent an increase of 26.8 percent above recent levels, or an additional eight million tons of plastic. This level of recycling would save 192 trillion Btu of petroleum, or about 2.4 percent of 2010 total industrial petroleum use (EIA 2011l).

4.5.7.1.4 Residential and Commercial Sector. This chapter discusses oil and gas consumption in the commercial and residential sectors. Similar to the industrial sector, oil and gas use in residences and commercial establishments is dominated by a small number of specific end uses. There has been a long-term shift away from oil use toward electricity in these applications, while natural gas use has not changed as dramatically. The potential substitutes for commercial and residential use of oil and gas are similar to those for the commercial sector, consisting mainly of electricity and biogas, although efficiency could also be considered a feasible substitute in certain applications. The current trend of increased building efficiency and weatherization, supported in part by investments through the American Recovery and Reinvestment Act, favors decreasing use of oil and gas in the residential and commercial sector.

Current Use of Oil and Gas. The commercial and residential sectors consume negligible amounts of petroleum compared to the transportation and industrial sectors, but contribute more substantially to natural gas consumption. Residences used 1,220 trillion Btu of petroleum in 2010; commercial buildings used 717 trillion Btu, for a total of 1,937 trillion Btu (395 million barrels) (EIA 2011o). This amounts to 5.2 percent of nationwide petroleum consumption. For natural gas, the residential sector consumed 5,061 trillion Btu in 2010 and the commercial sector consumed 3,276 trillion Btu, for a total of 8,337 trillion Btu (EIA 2011p). Combined, these sectors accounted for 34 percent of gas consumption, greater than industrial levels and electricity generation (EIA 2011p).

Petroleum consumption has been falling steadily in both the residential and commercial sectors since the early 1970s. Residential petroleum consumption reached its highest point in 1972, at 2,856 trillion Btu, while commercial use peaked one year later at 1,604 trillion Btu. Overall oil use has fallen by nearly 60 percent for both sectors since that time (EIA 2011p).

As with the industrial sector, the composition of the residential and commercial sectors' petroleum inputs has evolved over time. In the residential sector, kerosene use has dropped precipitously, from 25.8 percent of the total in 1949 to 2.5 percent in 2010, while LPGs have more than made up the difference. Even more dramatically, in the commercial sector, residual fuel oil, which accounted for nearly half of all petroleum consumed in 1949, was down to just 11.7 percent of consumption in 2010. It was replaced mainly by distillate fuel oil, which almost doubled from 30.4 percent to 56.1 percent over the same time period (EIA 2011o). The replacement of residual fuel oil with distillate fuel oil, in particular, points to lower overall emissions from oil combustion over time.

After growing steadily from approximately 1,000 trillion Btu in 1950 to nearly 5,000 trillion Btu in 1970, annual residential natural gas consumption has remained between 4,000 and 5,250 trillion Btu over the past 40 years. Commercial gas use, meanwhile, remained largely steady throughout the 1970s and 1980s, increased by about 20 percent during the early 1990s, and has leveled off since. Growth in commercial gas use has been essentially flat since 1996 (EIA 2009j).

Most residential petroleum and natural gas use is for space heating and water heating. To a lesser extent, these fuels are also used for appliances such as ranges, ovens and refrigerators. Similarly, commercial gas and oil use is dominated by space heating and water heating, with additional small amounts for cooking and miscellaneous other applications. Electricity was another major energy source for these applications. The split between these fuel sources by end use is shown in the table below. Due to discrepancies between different data sources, the totals in the table do not match those reported above. Note that for residential buildings, the most recent year for which end-use data were available was 2005 and to balance comparability with currency throughout this section we use 2008 data for commercial buildings (EIA 2009l; EERE 2011c). Table 4.5.7-6 also shows electricity consumption by these sectors, which was discussed in the electricity generation chapter.

TABLE 4.5.7-6 Residential and Commercial Sector Energy Use (trillion Btu)

	Residential Sector, 2005				Commercial Sector, 2008			
End Use	Oil	Natural Gas	Electricity	Total	Oil	Natural Gas	Electricity and Other	Total
Space heating	1,070	2,950	280	4,300	240	1,560	1,000	2,800
Water heating	290	1,410	420	2,120	20	440	320	780
Cooking and appliances	50	430	2,770	3,250	–[a]	170	2,800	2,970
Air conditioning	–	–	880	880	–	30	4,110	4,140
Other	–	–	–	–	210	290	5,870	6,370
Total[b]	**1,410**	**4,790**	**4,350**	**10,550**	**470**	**2,490**	**14,100**	**17,060**

[a] – = Not applicable.

[b] Totals do not match those reported in text due to discrepancies between data sources.

Source: EIA 2011q; EERE 2011c.

Space Heating. Space heating is the most significant use of petroleum and natural gas in both the residential and commercial sectors, accounting for three-fourths of residential oil use and 62 percent of residential gas use in 2005. Electricity use for space heating was comparatively small. A similar proportion of natural gas use in the commercial sector was for space heating in the recent and comparable year of 2008 (63 percent), but oil use was minimal and electricity more substantial (EIA 2011r; EERE 2011c).

Perhaps surprisingly, given the low total amount of electricity used for residential space heating, 35 percent of homes used electricity as their primary heating type in 2009, a figure that has climbed steadily since 1980. The apparent mismatch between total consumption and proportional use suggests that electricity is used for heating primarily in areas with mild winters and low heating demand. The increasing percentage use of electricity has come mostly at the expense of heating oil, whose use dropped from 17 percent of homes in 1980 to six percent in 2009. The proportion of homes with natural gas as their primary heating fuel has declined only slightly over that same period, from 55 percent of homes to 50 percent. Other factors favoring electricity may include steady improvements in electric heat pump efficiency and the development of hybrid-heating systems that combine electric heating with gas heating, with each source used within its most efficient temperature band. However, historically low prices for natural gas since the most recent EIA data in 2009 could result in increasing market share for gas heating.

Water Heating. After space heating, water heating is the other most significant end use of oil and gas in the residential and commercial sectors, comprising 21 percent of residential oil use and 29 percent of residential gas use in 2005. In the commercial sector, water heating used negligible amounts of oil, but accounted for 18 percent of natural gas use in 2008 (EIA 2011r; EERE 2011c).

As might be expected, a similar proportion of homes use natural gas for water heating, as for space heating, or 51 percent in 2009. This has remained essentially unchanged since 1980. Just seven percent of homes used petroleum (fuel oil or liquefied petroleum gas) for water heating in 2005, down from 13 percent in 1980. The remaining 39 percent of homes relied on electricity for water heating in 2005, a modest increase from 33 percent in 1980. Only one percent of homes used other energy sources, such as solar water heating (EIA 2011r).

Cooking and Appliances. Cooking and appliances represent the final major end uses of residential and commercial gas. About nine percent of residential and seven percent of commercial gas use went toward cooking and appliances with residences also using a small amount of petroleum for these purposes. There is no information readily available on the proportion of homes using oil, gas, and other fuels for these end uses. In absolute terms, however, natural gas use for appliance applications grew by about 20 percent from 1980 to 2005, less than the rate of population growth. Meanwhile, oil use remained essentially unchanged and electricity use increased by 80 percent (EIA 2011r; EERE 2011c). The rise in total electricity use could be due in part to increased per-capita consumption, but it seems more likely that, matching the trend with space heating and water heating, an increasing proportion of homes are using electricity rather than oil or gas as their primary fuel. It would stand to reason that a home that used gas (or oil) for one major end use would be more likely to use it for others as well.

Near-Term Analysis of Substitutes. Furnaces and boilers, water heaters, and cooking appliances – the equipment directly responsible for oil and gas consumption in the commercial and residential sectors – are durable, long-lived goods. Water heaters have an average life span of 13 years, while furnaces, boilers and range/ovens typically last for 20 years or more (California Energy Commission, undated a). Such items also represent significant investments for most buyers. Thus, similar to industrial consumers, residential and commercial consumers would be unlikely to replace their oil- or gas-fired equipment any earlier than necessary except under extreme conditions. For that reason, any fuel-saving strategy that would require major new equipment to be a long-term but not a near-term possibility is considered.

Given that dynamic, we identify two broad strategies for near-term reductions in oil and gas use in these sectors. The first strategy considered is fuel switching or, more likely, fuel blending by oil and gas distribution utilities. Heating oil, which is often distributed by trucks, could be replaced or supplemented by ethanol or biodiesel, both of which are discussed earlier in this report. Although with greater transition costs, wood pellets are another substitute fuel for homes with heating oil. Fossil fuel natural gas can be supplemented with equivalent gas produced from renewable sources.

Biogas, which is created through the anaerobic breakdown of organic material, is produced mainly from manure, sewage, or agricultural wastes (in digesters), or in landfills, where such anaerobic digestion occurs naturally. While such gas is used primarily in industrial facilities for heating applications or by utilities for electricity generation, with some processing to remove moisture and impurities (similar to the process for fossil fuel natural gas), biogas can be refined to nearly pure methane and injected into distribution pipelines for use in the commercial and residential sectors. The potential for increased used of biogas was discussed in the industrial sector chapter of this report; if the United States reaches the levels of biogas production discussed, any biogas used to offset fossil fuel consumption in the commercial and residential sectors would simply replace substitution at industrial facilities or in the electricity generation sector.

The second strategy considered for reducing oil and gas use in commercial and residential sectors is efficiency upgrades to decrease space heating demand. This refers to efficiency improvements for buildings in retaining heat, rather than the efficiency of the heating equipment itself. Adding insulation, sealing leaks, and installing more efficient windows reduces the thermal transmissivity of a building envelope, thereby reducing the oil or gas needed to maintain a comfortable temperature in the winter. These actions can also save electricity from lower demand for space cooling in the summer or space heating where electricity rather than oil or gas is the primary energy source.

In recent years, this approach has emerged as a major energy-saving strategy, largely because it can often deliver substantial energy use reductions at a fairly modest cost. In addition to ARRA-based investments, another prominent example is the Recovery Through Retrofits initiative, overseen by the Council on Environmental Quality's Middle Class Task Force. This initiative focused on overcoming market barriers to residential efficiency improvements, access to information, financing, and workforce training (White House Council on Environmental Quality undated). This follows on the efforts of numerous public utilities commissions and similar organizations as well as 26 States that have enacted energy savings targets, which often establish specific obligations or financial incentives for utilities to reduce energy consumption. Utilities in many jurisdictions are required to collect a separate monthly charge from customers that can only be used to fund efficiency programs. Others operate under a decoupling regulatory framework in which profits are determined not by direct revenues from energy sales, but rather from performance against a number of targets, including efficiency measures implemented. While such regulatory efforts initially focused on electric utilities, an increasing number apply to gas utilities as well (American Council for an Energy-Efficient Economy 2011).

On the household scale, the USDOE estimated that participants in its low-income weatherization program reduced their annual gas heating consumption by 32 percent (EERE 2009). Because the low-income households participating in this program have somewhat less efficient housing stock than the general population, this may overstate the potential gains somewhat, but it nonetheless indicates that there is room for substantial improvement among the entire universe of residential consumers. Forty million households are eligible for USDOE's weatherization program (Eisenberg 2010).

On a larger level, States with gas reduction goals have generally set more modest statewide targets. For example, Massachusetts has a goal of 1.15 percent gas savings by 2012 and Minnesota's goal is 1.5 percent savings in 2013. New York has the most aggressive and long-term goal, calling for a 14.7 percent reduction in gas demand by 2020 (Nowak et al. 2011).

In the near term, it is highly unlikely that all homes eligible for weatherization assistance, whether from USDOE or from State- or utility-level programs, will take advantage of them. Nonetheless, if all State-level programs weatherized as many homes as USDOE's nationwide program, this would translate into a total of 200,000 homes per year, or one million over a five-year period (EERE 2009). Based on the average efficiency improvements noted above, this level of participation could result in 8.5 trillion Btu in natural gas savings, or an equivalent amount in oil or electricity.[29]

Long-Term Analysis of Substitutes. Over a longer timeframe, commercial and residential consumers will need to their replace space and water heating equipment and appliances as these objects reach the end of their useful lifespan. This will provide consumers with an opportunity to shift away from oil- and gas-fired equipment. Construction of new building stock and renovations of existing buildings allow further prospects for substitution.

The lowest capital cost substitution would typically be to replace oil- or gas-fired space and water heating equipment and appliances with electric-powered units, which are readily available and widely used. As noted above, in 2005, 30 percent of households used electricity as the primary energy source for space heating and 39 percent used it for water heating. Both of these proportions have been growing over the past several years (EIA 2009m).

Despite the lower up-front costs of electric space and water heating equipment, the fuel costs may be much higher compared to oil and gas. The Federal Energy Management Program estimates the annual energy cost of a typical gas water heater as approximately half the cost of an electric unit (EERE 2010), while the California Energy Commission reports that electricity usually costs three times as much as gas (California Energy Commission undated b). While gas water heaters are generally more expensive up front, the difference in fuel costs outweighs this initial price premium. A cost comparison for space heating is more complicated, and depends on the type of electric heating technology chosen. Appliances that use resistance heating (such as electric furnaces, baseboard heaters and electric oven/ranges) are generally uneconomical compared to gas or oil units (EERE 2011d; California Energy Commission undated c). On the other hand, air source heat pumps (which operate on the same principle as central air conditioners) are very efficient at moderate temperatures and may be cost competitive with oil or even natural gas, depending on local fuel prices and climate.[30] Some manufacturers also offer systems that heat pumps with natural gas backup heat (instead of traditional resistance heating), allowing consumers to take advantage of the most efficient heat source for a given ambient temperature.[31] Therefore, electricity remains a viable substitute for some end uses. The associated environmental impacts would depend on the fuel mix used to produce the electricity. These issues have been discussed previously, and we do not repeat them here.

A second substitute comes in the form of renewable energy, specifically solar water heaters. Solar water heaters use collectors to gather solar energy, which is then used to heat

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[29] 32 percent reduction in space heating gas demand per participating household × 1 million participating households / 111 million total households × 2,950 trillion Btu total household space heating gas demand = 8.5 trillion Btu savings.

[30] The Energy Information Administration maintains a detailed heating cost calculator at http://tonto.eia.doe.gov/ask/generalenergy_faqs.asp#compare_heating_fuels.

[31] Heat output of an air source heat pump declines with ambient temperature. Below a certain point (generally around 30–35°F), a backup heat source is required to maintain home temperature.

water in a storage tank. Active solar water heaters contain a circulating pump, while passive systems do not. Although solar water heaters are most effective in warm, sunny areas such as Florida or California, they can be used in colder locations as well. Germany, for example, has more than 9,800 MW_{th} of solar thermal capacity installed, while Austria has more than 3,200 MW_{th}. Most, but not all, of this is for water heating (EurObserv'ER 2011). In the United States, all 50 States have some form of incentive for solar water heating systems, while the Federal Government provides a tax credit covering 30 percent of the installed cost of such systems (N.C. Solar Center and Interstate Renewable Energy Council undated).

Solar water heaters usually have a gas or electric backup, to provide supplemental heating on cloudy days, in cold seasons, or in high-demand hours. As a result, they do not eliminate gas use entirely. The Solar Rating & Certification Corporation and the Energy Star program both estimate that typical solar water heaters cut gas consumption in half (Solar Rating and Certification Corporation undated; USDOE and USEPA undated a). If applied nationwide, this would imply residential gas savings of 700 trillion Btu and an additional oil savings of 150 trillion Btu. Solar water heating in the commercial sector could contribute modest further savings. Adoption on this scale is extremely unlikely; even 10 percent adoption, with savings of 70 trillion and 15 trillion Btu, would represent a substantial increase over current levels (less than one percent of U.S. homes used solar water heaters in 2005) (EIA 2009m). This would require significant policy support, as without generous tax credits or other incentives the higher upfront cost of a solar water heating system would make it uneconomical for most consumers to purchase, especially in less favorable climates.

Another alternative heating option is the geothermal (also known as the ground source) heat pump. Geothermal heat pumps take advantage of stable year-round temperatures below ground or in groundwater to provide a heat source in the winter or heat-sink in the summer. Geothermal heat pumps use 25–50% less energy than conventional heating and cooling systems, and provide excellent humidity control (USDOE 2011b). High installation costs (for underground or waterborne heat exchanger piping) have limited the use of geothermal heat pumps. They are generally installed only in new construction homes.

The other options for long-term substitution involve improvements to the building stock itself. Improved building-envelope efficiency has already been discussed as a short-term option. As stated earlier, if 200,000 homes per year are renovated, the resulting savings could reach 8.5 trillion Btu annually after five years. Simply extending this trend to a 25-year period would indicate that renovations to five million homes could save 42.5 trillion Btu in oil, gas, or electricity used for space heating. Of course, a more aggressive approach covering more homes would see proportionally greater impacts.

Over the long run, the building stock will also go through a more fundamental transformation, as new buildings are built to replace aging ones and to accommodate population growth. One well-regarded analysis estimates that 89 million new or replaced homes and 190 billion square feet of nonresidential building will be constructed by 2050, and that two-thirds of buildings that will exist at that time did not exist in 2007 (Ewing et al. 2008). For context, in 2009, there were an estimated 114 million households nationwide (EIA 2011r).

Given the massive scale of building expected, more efficient construction could produce substantial savings in oil and gas use for space heating (as well as electricity, for both heating and cooling). This could take the form of a greater number of high-efficiency buildings, such as those constructed to standards such as Energy Star or LEED, or improvements to building codes that raise minimum performance requirements for all buildings.

Minimum building energy efficiency standards have been tightening in recent years. The International Energy Conservation Code (IECC), a model code, is expected to require 30 percent energy savings in its 2012 form as compared to the 2006 code, which itself represented a significant improvement over prior years. Such a move would have far-reaching impacts. Thirty nine States have adopted residential codes based on some version of the IECC and most of these have adopted either the 2006 or 2009 versions. A similar number of States have adopted commercial energy codes based on ASHRAE 90.1, another model code (Online Code Environment & Advocacy Network undated). Presumably, these States will continue to adopt more recent versions of these codes as they are released.

On the upper end of the spectrum, voluntary standards have pushed ‘green’ buildings to outperform industry averages. The two most important such standards are Energy Star, managed by USEPA and USDOE, and the U.S. Green Building Council’s LEED family of standards. The Energy Star program reports that 16,084 buildings and plants are currently Energy Star-certified (USDOE and USEPA undated b). To earn this designation, buildings must be more efficient than 75 percent of comparable buildings nationwide, which is roughly equivalent to 25 percent less energy use. LEED has been more widely adopted. As of March 2011, there were just over 30,000 registered commercial LEED building projects (U.S. Green Building Council 2011a). A 2008 study found that, while there was considerable variation between projects, the average LEED-certified commercial building had energy use 25 percent below that of conventional buildings (Turner and Frankel 2008). While this is similar to the results of the Energy Star program, LEED measures against presumed results from conventional new buildings, whereas Energy Star compares its buildings to existing buildings. This discrepancy notwithstanding, for our purposes we can assume that new commercial buildings meeting either the LEED or the Energy Star standard will result in at least a 25 percent reduction in energy use below current levels.

Both Energy Star and LEED also have programs addressing homes. Energy Star homes must be at least 15 percent more efficient than the 2004 International Residential Code, but with the additional energy-saving features included, they are typically 25 to 30 percent more efficient than standard homes. More than one million U.S. homes currently meet the Energy Star standard (USDOE and USEPA undated c). The LEED for Homes program has not achieved similar penetration, with just under 50,000 registered homes as of March 2011. As with commercial buildings, LEED measures energy gains versus standard new buildings. They estimate an average of 30 percent energy savings for LEED-certified homes (U.S. Green Building Council 2011b).

It can safely be assumed that most if not all new residential and commercial buildings will meet the stricter minimum standards envisioned by the latest IECC and ASHRAE energy codes. Meanwhile, the overall impact of LEED, Energy Star and other voluntary green building standards will depend on market penetration. While not attempting a definitive analysis, we can make some rough, order-of magnitude approximations to demonstrate the scale of potential savings. Replacing half of all currently existing residences and commercial buildings over the next 25 years, through new construction or retrofits, with buildings that are 25 percent more efficient in space heating (a conservative estimate, since space heating will likely account for a disproportionate level of total energy savings), would translate into an aggregate 12.5 percent reduction in space heating energy demand, or about 564 trillion Btu of natural gas and 164 trillion Btu of oil. If 10 percent of these buildings met Energy Star and/or LEED standards and realized a further 25 percent improvement from the new baseline, they would save an additional 42 trillion Btu of natural gas and 12 trillion Btu of oil from space heating. In total, under these assumptions more efficient new buildings could save approximately 782 trillion Btu of oil and natural gas per year within 25 years.

4.5.7.2 Analysis of the Environmental Effects of the No Action Alternative

The selection of the No Action Alternative would eliminate all oil and gas activities that were projected to occur under the Program. OCS-related activities could still occur, however, in these areas as a result of leasing activity during previous and future programs. At the same time, the No Action Alternative would require energy substitutes to replace the oil and gas production that would not occur as a result of the Program. The energy substitutions would be associated with their own potential environmental impacts that could occur within or outside program areas that were considered in the proposed action.

4.5.7.2.1 Energy Substitutions for OCS Oil and Gas. With less oil and gas available from the OCS under the No Action Alternative, consumers could obtain oil and gas from other sources, substitute to other types of energy, or consume less energy overall. Similarly, energy production may shift from OCS oil and gas to onshore oil and gas, overseas oil and gas production, or domestic production of oil and gas alternatives (e.g., coal). Each of these shifts in consumption and production relative to the proposed action yield environmental impacts that this section evaluates.

The process for calculating these impacts begins with the application of MarketSim, a multi-market equilibrium model that simulates the energy supply, demand, and price effects of OCS oil and gas production compared with baseline projections from the EIA’s Annual Energy Outlook. In addition to simulating oil and natural gas markets, MarketSim includes separate modules for coal and electricity, enabling the model to capture the broad effects of the No Action Alternative across individual segments of the energy market. Modeling each of these sectors, MarketSim produces an estimate of the energy market’s response to the absence of production that would occur as a result of the No Action Alternative.

Table 4.5.7-7 presents the changes in energy markets projected by MarketSim for the No Action Alternative. The table presents the quantities of the energy sources that would be used to replace the lost production of OCS hydrocarbons under the No Action Alternative. The quantities of domestic onshore production of both oil and natural gas is projected to increase but

TABLE 4.5.7-7 Cumulative Energy Substitutions for Oil and Gas Under the No Action Alternative

Energy Sector	Quantity[a]	Replacement Percent (%)
Domestic onshore oil	53–402	1–3
Domestic onshore gas	759–2,326	13–17
Oil imports	3,540–7,870	56–62
Gas imports	458–1,224	8–9
Other	108–274	2
Coal	335–925	5–6
Electricity[b]	146–388	3
Reduced demand[c]	330–814	6

[a] Quantities expressed as energy equivalents of a million bbl (Mbbl) of oil. Values derived from MarketSim output rounded to the nearest Mbbl. Range of values based on price assumptions of $60 and $160/bbl for oil and $4.27 and $11.39 per million cubic feet of gas. Quantities were calculated for a 40 year time period, which is slightly different than the 40-50 year assumed life of the program.

[b] Electricity generated from sources other than oil, gas or coal such as nuclear, hydro, solar and wind.

[c] Demand reductions resulting from energy conservation.

will make up for only a fraction of foregone OCS production. To ensure that demands for oil and gas are met, MarketSim projects a sharp increase in oil and gas imports under the No Action Alternative, via both tanker and pipeline. The model also projects that the reduction in OCS oil and gas production under the No Action Alternative will be replaced by an increase in domestic coal and electricity production and by energy conservation.

MarketSim projects that natural gas consumption will decline, while domestic consumption of oil, coal, and electricity will increase. Given that domestic oil production declines under the No Action Alternative, the increase in oil consumption may be somewhat unexpected. This increase in consumption reflects the fact that oil and gas are substitutes within the industrial sector and, to a lesser extent, the residential and commercial sectors. Therefore, as natural gas prices increase under the No Action Alternative, consumption of substitutes, including oil, increases. The increase in oil prices under the No Action Alternative may cause substitution in the opposite direction (i.e., from gas to oil), but the impact of increased gas prices is the more dominant of the two effects.

4.5.7.2.2 Impact Analysis.

Oil Spills. Table 4.5.7-8 shows the amount of oil projected to be developed in the planning areas considered in the Program and the amount of additional oil imported into planning areas that would be at risk from tanker spills because of their location relative to ports and terminals that would receive oil imports under the No Action Alternative. The table presents volumes of oil as a single quantity, rather than as a range of values, to simplify the comparison of quantities. The number of oil spills greater than 1,000 bbl that could result from import tanker accidents under the No Action Alternative and from accidents at OCS facilities and pipelines under the Proposed Action are presented. The number of spills was calculated by applying oil spill rates to the volume of OCS production and to the volume of import tankering projected under the two alternatives. Notably, the GOM is projected to experience four fewer large spills under the No Action Alternative. Part of this reduction is explained by the fact that the volume of oil imports under the No Action Alternative is smaller than the precluded volume of OCS oil that would have been produced under the No Action Alternative. Another factor is that tankering has a lower spill risk than OCS production in part because OCS production includes the risk of spills during both the production and the transportation phases, while tankering involves only risk during transportation. The production risk associated with oil import substitutes would occur in oil-exporting nations. It is interesting to note that while the Central GOM Planning Area accounts for most of the OCS oil production, and therefore would experience the greatest amount of reduction in oil spill risk under the No Action Alternative, the Western GOM Planning Area would experience the greatest amount of risk from the increased import tankering that is projected to occur.

Cook Inlet is projected to produce a small amount of oil under the proposed action and to import a small amount of oil as an energy substitute under the No Action Alternative. As a result, there would be no appreciable difference in oil spill risk between the two alternatives. Since there are no oil import ports or terminals in the Alaskan Arctic program area, the No Action Alternative would eliminate the risk from OCS sources without introducing any risk from oil tankers. It is important to keep in mind, however, that a reduction in the risk of oil spills from OCS production redistributes, rather than totally eliminates, the spill risk. As Table 4.5.7-8 shows, the Atlantic and Pacific coasts could each be exposed to an additional import tanker spill occurrence along these coasts under the No Action Alternative, whereas these areas would have no exposure to oil spill risk from OCS activities under the proposed action.

Routine Operations. Routine OCS operations, such as installing offshore facilities and pipelines, transporting materials and personnel from the coast to offshore, and conducting seismic surveys, are associated with impact factors that could have potential environmental effects. The effects of noise, collisions with service vessels, air emissions, drilling and production discharges, and other impact factors associated with OCS activities were analyzed in Section 4.4 of this draft PEIS. With no new OCS activity occurring under the No Action Alternative, the potential for impacts from these factors would be eliminated within the program areas considered in the proposed action. The elimination of potential impacts in these program areas could redistribute a range of other environmental impacts that would result from the development and transportation of energy substitutions. These impacts could occur on or near the OCS, or elsewhere. While insufficient data are available for quantification of these

TABLE 4.5.7-8 Projected Large Spill Occurrences under the No Action Alternative

Planning Area	Volume of Oil at Risk for Spill[a] (Bbbl) Proposed Action	Oil Imports	Change in Spill Occurrence under the No Action Alternative[a]
Atlantic Coast	0	1.3	
North Atlantic	0	0.6	+1
Mid-Atlantic	0	0.5	
South Atlantic	0	0.1	
Straits of Florida	0	0.1	
Total Atlantic Coast	0	1.3	+1
Gulf of Mexico	4.1	2.7	
Central GOM	3.2	0.7	–2
Western GOM	0.8	1.9	1
Eastern GOM	<0.1	<0.1	0
Total GOM	4.1	2.7	–1
Pacific/South Alaska Coasts	0	1.6	
Southern California	0	0.4	+1
Central California	0	0.5	
Washington/Oregon	0	0.4	
Gulf of Alaska	0	0.2	
Shumagin	0	0.1	
Total Pacific/South Alaska Coasts	0	1.6	+1
Alaska Program Areas			
Cook Inlet	0.2	0.1	0
Arctic	1.6	0	–2
Alaska Program Area	1.8	0,01	–2

[a] OCS spill rate calculated as platform spill rate (0.25 spills/Bbbl) plus the pipeline spill rate (0.88 spills/Bbbl) since spills could occur at the platform or during transport. The tanker spill rate was calculated as 0.34 spills/Bbbl in lower 48 and 0.46 spills/Bbbl in Alaska.

substituted impacts, some issues of particular environmental concern from energy substitutions are listed below.

Acid Mine Drainage from Coal Mining. Runoff from coal mining sites may increase the acidity of surface waters near and downstream from coal mining sites, adversely affecting habitat for aquatic organisms and limiting human recreational uses.

Contamination of Groundwater from Oil and Gas Extraction. The extraction of oil and gas from onshore sources can, in some cases, lead to the contamination of local groundwater supplies. For example, focusing on shale gas extracted from wells in Pennsylvania and New York, Osborn et al. (2011) found that average methane concentrations in drinking water wells increased with proximity to the nearest gas well and were 17 times greater than wells not located near extraction sites (Osborn et al. 2011). In addition, oil and gas wells may lead to groundwater contamination from accidental spills, losses of well control, and/or pipeline leaks.

Water Discharges from Oil and Gas Operations.[32] To facilitate resource extraction from subsurface formations, oil and gas producers use water to develop pressure, causing oil and gas to rise to the surface (e.g., enhanced oil recovery and hydraulic fracturing). Producers must manage these waters as well as waters extracted from geologic formations during oil/gas extraction. The environmental impacts associated with this "produced water" vary based on the geologic characteristics of the reservoir that produced the water and the separation and treatment technologies employed by producers.

Coal Combustion Impacts. Coal consumed in place of gas under the No Action Alternative will result in environmental costs associated with diminished air quality and the disposal of coal combustion residuals. The combustion of coal in power plants or industrial boilers produces higher emissions of NO_X, SO_X, and PM than the combustion of natural gas and results in greater CO_2 emissions.[33] In addition, coal combustion residuals generated by power plants or coal-fired industrial boilers may pose a risk to local groundwater supplies when disposed in surface impoundments or landfills when such units are not properly maintained.

Socioeconomic and Sociocultural Effects. Sections 4.4.9.1 and 4.4.13.1 describe the effects of the proposed action on socioeconomic and sociocultural conditions, respectively, in the GOM. OCS oil- and gas-related activities have been an important source of employment and income in GOM coastal areas. According to Henry et al. (2002), the nature of blue-collar jobs in the oil and gas industry has been instrumental in the formation and persistence of Cajun culture in South Louisiana. The No Action Alternative would result in reduced employment and income opportunities and potentially could affect the stability and cohesion of communities and cultures. The No Action Alternative could also be interpreted as a boom-bust event. The infrastructure and population of affected areas in the GOM have developed over decades in association with a regular occurrence of lease sales and resulting OCS activities. The No Action Alternative could result in situations in which local infrastructure and populations could not be maintained,

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32 This discussion is based on USEPA (2008a).

33 For detailed emissions data for power plants, see USEPA (2010d).

resulting in out-migration and a reduction in public services. Furthermore, the No Action Alternative's disruption of a continuous process of activity in the GOM could affect future investments which would compound the social, economic, and cultural effects associated with the No Action Alternative.

Conclusion. No potential impacts from routine operations or from accidental discharges described in Section 4.4 would occur under the No Action Alternative. Most of the oil that was projected to be developed in the Arctic under the Proposed Action would be replaced by tanker imports that would offload at U.S. ports, none of which are located within the Arctic area. Under the No Action Alternative, Arctic program areas would therefore not receive any impacts from the Program or from energy substitutions such as tankering. The spill risk associated with replacing the lost OCS Arctic oil production would be transferred to other Planning Areas along the Atlantic, GOM, and Pacific coasts where increases in oil imports and associated risks of tanker spills would occur. The Pacific and Atlantic coasts would each be exposed to the risk of one additional tanker spill under the No Action Alternative. About two-thirds of the lost OCS production in the GOM would be replaced by tanker imports into GOM terminals. The spill risk from tankering would be greater in the Western GOM Planning Area than in the Central GOM based on the location of terminals. There would be effects of the No Action Alternative on socioeconomic conditions in the GOM and potential effects on community cohesion and levels of public services available there. The potential exists for low-probability catastrophic consequences from the development of energy substitutes to OCS oil and gas. For example, a nuclear accident could occur as a result of nuclear power production or a catastrophic discharge event could occur in offshore waters of other nations during oil and gas exploration and production activities. The potential risk from impacts associated with routine OCS operations and activities removed under the No Action Alternative would be transferred to other areas within and beyond the OCS where energy substitutes such as imported and onshore oil and gas, and coal would be developed and transported.

4.6 CUMULATIVE IMPACTS

A cumulative impact, as defined by the CEQ, "results from the incremental impact of [an] action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or nonfederal) or person undertakes such other actions" (40 CFR 1508.7). The analyses presented in this section place the direct and indirect impacts of the 2012-2017 Program alternatives, presented in the preceding sections of Chapter 4, into a broader context that takes into account the full range of impacts of actions taking place within the Eastern, Western, and Central GOM and the Cook Inlet, Chukchi Sea, and Beaufort Sea Planning Areas currently and into the foreseeable future. Repeated actions, even minor ones, may produce significant impacts over time through additive or interactive (synergistic) processes. The goal of the cumulative impacts assessment, therefore, is to identify such impacts early in the planning process to improve decisions and move toward more sustainable development (CEQ 1997).

A separate analysis accounting for the full range of possible actions under the No Action Alternative (NAA) has not been included in the cumulative impacts assessment. However, the types of activities and most significant effects resulting from a no action scenario are addressed in Section 4.5.7. Moreover, many of the past, present, and reasonably foreseeable future actions and trends that would contribute to cumulative impacts under the Program "action" alternatives also contribute to cumulative impacts under the NAA. Under the NAA, there would be no OCS oil and gas lease sales conducted during the 2012-2017 Program, and as a result, energy would be obtained from other sources to replace the lost oil and gas production. Most of the lost OCS production would be replaced by tanker imports into GOM terminals, but some would also be made up by onshore production (transported via pipelines) and domestic production of oil and gas alternatives such as coal. Because the mix of non-OCS sources of energy and the locations of resource or energy development are unknown (but could occur throughout the United States or the world, on land or at sea), setting the spatial boundaries for the NAA over the 40- to 50-year time frame of the cumulative impacts analysis is tantamount to speculation. For this reason, a separate treatment of the cumulative effects under NAA is not considered herein.

4.6.1 Methodology for Assessing Cumulative Impacts

The general approach for the cumulative impacts assessment follows the principles outlined by the CEQ (1997) and the guidance developed by the EPA (1999) for independent reviewers of environmental impact statements. It also considers the findings and recommendations of the NEPA task force as they pertain to programmatic assessments and environmental management systems (NEPA Task Force 2003). The cumulative impacts analyses presented in Sections 4.6.2 (Marine and Coastal Physical Resources), 4.6.3 (Marine and Coastal Habitats), 4.6.4 (Marine and Coastal Fauna), and 4.6.5 (Social, Cultural, and Economic Resources) incorporate the following basic guidelines:

- The individual receptors and receptor groups (i.e., resources, ecosystems, and human communities) identified in the affected environment sections of Chapter 3 become the endpoints or units of analysis;

- Direct and indirect impacts of the proposed action (Alternative 1) and other action alternatives (Alternatives 2 through 7) described in the environmental consequences sections of Chapter 4 form the basis for the impact-producing factors considered;

- Impact-producing factors are derived from a set of past, present, and reasonably foreseeable future actions (including the Program) and trends; and

- The spatial and temporal boundaries are defined around the individual receptors and receptor groups and the set of past, present, and reasonably foreseeable future actions and trends that could impact them.

The cumulative impacts assessment focuses on the resources, ecosystems, and human communities that may be affected by the incremental impacts associated with the Program (under any of the seven action alternatives) in combination with other past, present, and reasonably foreseeable future actions. The CEQ discusses the assessment of cumulative impacts in detail in its report, *Considering Cumulative Effects under the National Environmental Policy Act* (CEQ 1997). On the basis of the guidance provided in this report, the following methodology was developed for assessing cumulative impacts:

1. Potential cumulative impacts issues associated with the Program (under any of the seven action alternatives) were identified during the scoping and consultation phases of the assessment. Other actions and issues were added later as they were identified.

2. The spatial boundaries of cumulative impacts (i.e., regions of interest) were defined. The regions of interest encompass the geographic areas of affected resources, ecosystems, and human communities, and the distances at which impacts associated with the Program and other past, present, and reasonably foreseeable future actions may occur. The spatial boundaries for the cumulative impacts assessment are discussed in Section 4.6.1.1.1.

3. The temporal boundaries (i.e., the time frame) of cumulative impacts were defined. The time frame of the cumulative impacts analysis extends from the past history of impacts on each receptor or receptor group through the anticipated life of the Program and beyond. The temporal boundaries for the cumulative impacts assessment are discussed in Section 4.6.1.1.2.

4. Past, present, and reasonably foreseeable future actions were identified. These include projects and activities that could impact resources, ecosystems, or human communities within the defined regions of interest and within the defined time frame. Other processes and general trends (e.g., those associated with climate change) were also identified. Past and present actions are generally accounted for in the analysis of direct and indirect impacts under each resource area as part of the current baseline (described in Chapter 3) and are carried forward to the cumulative impacts analysis. The exploration and development scenarios for the Program cumulative cases in the GOM, Cook Inlet, and Arctic regions are presented in Section 4.6.1.2.1. The types of other past, present, and reasonably foreseeable future actions and general trends in the GOM, Cook Inlet, and Arctic OCS regions are identified and described in Sections 4.6.1.2.2, 4.6.1.2.3, and 4.6.1.2.4.

5. The potential impact-producing factors of past, present, and reasonably foreseeable future actions and general trends were determined. Impact-producing factors are the mechanisms by which an action or trend affects a given resource, ecosystem, or human community. The contributions of impact-producing factors from various actions and general trends were aggregated to form the contextual framework of the cumulative impact assessment to follow.

6. Cumulative impacts were evaluated by considering the incremental impacts of the Program (under any of the seven action alternatives) in combination with

other past, present, and reasonably foreseeable future actions and general trends. The cumulative impacts analyses for resources, ecosystems, and human communities are presented in Sections 4.6.2, 4.6.3, 4.6.4, and 4.6.5, and are summarized at the end of each section. Conclusions for resource and systems analyses in these sections use the same four-level classification scheme that was used for the direct/indirect impacts analyses, as defined in Section 4.1.4. A comprehensive summary of cumulative impacts for each of the OCS regions is provided in Section 4.6.6.

Cumulative impacts on a given resource, ecosystem, or human community may result from single actions or a combination of multiple actions over time. They may be additive, less than additive (countervailing), or more than additive (synergistic). The analyses presented in the following sections identify these effects and their importance where they are thought to occur.

Because this is a programmatic-level assessment, lease sale-specific issues, such as the determination of appropriate mitigation measures and environmental monitoring, are not addressed here. However, BOEM imposes environmental controls on operators through rules and regulations included in its lease sale proposals (see Appendix B). These rules and regulations include lease stipulations, OCS regulations, notice to lessees (NTLs), and other measures to protect the environment from the effects of lease-related activities. Environmental protection on the OCS is an ongoing priority. The BSEE has broad permitting and monitoring authority to ensure safe operations and environmental protection as OCS projects within a lease block are implemented.

The cumulative impacts assessment presented in this PEIS is the first of many such analyses that will be conducted for activities under the Program. NEPA reviews are required for various phases of projects taking place within a lease block or portion of a lease block; these reviews will focus on the application and enforcement of mitigation measures, as well as environmental monitoring to demonstrate the effectiveness of such measures (see Table 1-1).

Appendix C provides a listing of Federal laws and Executive Orders that would apply to leasing under the Program.

4.6.1.1 Spatial and Temporal Boundaries for the Cumulative Impacts Assessment

4.6.1.1.1 Spatial Boundaries. The spatial boundaries, i.e., regions of interest, for the cumulative impacts assessment encompass the geographic areas of affected resources and the distances at which impacts associated with past, present, and reasonably foreseeable future actions may occur. For the cumulative impacts analysis, marine and coastal ecoregions are used as the spatial framework for most resources because they encompass the areas potentially affected by the Program and other (non-Program) actions, both within and beyond the administrative (planning area) boundaries in which such activities are taking place. Marine ecoregions are ecosystem-based regions defined according to the boundaries of LMEs developed by NOAA (see Section 3.2). The analysis also uses the marine and coastal ecoregions developed by the CEC for North America to subdivide the LMEs into more localized regions, as appropriate. Coastal and nearshore areas are delineated by coastal ecoregions. The geographic scope of the cumulative analysis varies depending on the resources being evaluated. Table 4.6.1-1 provides a summary of the regions of interest for the cumulative assessment by resource for the GOM, Cook Inlet, and Arctic OCS regions.

The regions of interest presented in Table 4.6.1-1 are relevant for the proposed action (Alternative 1) and other action alternatives (Alternatives 2 through 7) because they span the broadest possible geographic areas of affected resources and the extent of their potential impacts. It is acknowledged, however, that the spatial boundaries of each of the action alternatives are different in that each alternative omits one of the planning areas included in the proposed action for the duration of the Program (see Chapter 2).

4.6.1.1.2 Temporal Boundaries. The cumulative impacts analysis incorporates the sum of the effects of the Program in combination with other past, present, and future actions, since impacts may accumulate or develop over time. The future actions described in this analysis are those that are "reasonably foreseeable"; that is, they are ongoing (and will continue into the future), are funded for future implementation, or are included in firm near-term plans. The reasonably foreseeable time frame for future actions evaluated in this analysis is 40 to 50 years from the time the Program takes effect (in 2012). This time frame represents the temporal boundaries for all the alternatives.

4.6.1.2 Past, Present, and Reasonably Foreseeable Future Actions

The cumulative impact analyses that follow evaluate OCS oil and gas related activities associated with the Program, as well as activities associated with past and future 5-year programs that could occur over the next 40 to 50 years. These are presented in Section 4.6.1.2.1 under the cumulative case for the GOM, Cook Inlet, and Arctic OCS regions. The analyses also take into consideration impacts from other types of actions and general trends not related to the Program. These actions and trends and their impact-producing factors are described in Sections 4.6.1.2.2 (GOM), 4.6.1.2.3 (Cook Inlet), and 4.6.1.2.4 (Arctic Region).

4.6.1.2.1 Cumulative Case Scenario for the OCS Program. Tables 4.6.1-2 and 4.6.1-3 present the exploration and development scenarios for the cumulative case for the GOM and Alaska (Cook Inlet and Arctic) regions, respectively, over the next 40 to 50 years. The cumulative case scenarios take into account activities that will be part of the Program, as well as those from past and future 5-year OCS programs. The estimates for each case represent the broadest possible analysis of potential elements affecting the OCS over the next 40 to 50 years, consistent with the proposed action (Alternative 1), and are, therefore, also applicable to the other action alternatives (Alternatives 2 through 7) considered in this PEIS since each alternative is the same as the proposed action (less one planning area) for the duration of the Program (see Chapter 2). Certain effects, however, were not considered under the cumulative cases presented here. For example, Alternative 4 includes all but one of the six planning areas

TABLE 4.6.1-1 Regions of Interest for the Cumulative Impacts Analysis by Resource

	Regions of Interest		
Resource	Gulf of Mexico	Cook Inlet	Arctic Region
Water Quality	Coastal waters (bays and estuaries), marine waters (State offshore and Federal OCS), and deep water (depths greater than 305 m [1,001 ft])	All waters of Cook Inlet	Coastal waters (bays); and marine (State offshore and Federal OCS) and deep waters in the Chukchi and Beaufort Seas
Air Quality	Coastal counties in Texas, Louisiana, Mississippi, Alabama, and Florida	Kenai Peninsula, Alaska Peninsula, and Kodiak Island Boroughs	North Slope Borough
Acoustic Environment (Noise)	GOM LME	Gulf of Alaska LME	Chukchi Sea and Beaufort Sea LMEs
Coastal and Estuarine Habitats	Estuarine drainage areas (NOAA); coastal and nearshore habitats, including barrier islands, beaches, wetlands, and seagrasses	Coastal and nearshore habitats within estuarine watersheds of the coastline and around bays, lagoons, and river mouths; includes beaches, marshes, tidal flats, scarps, riverine mouths/deltas, and marine algae	Coastal and nearshore habitats within estuarine watersheds along the coastline and around bays, lagoons, and river mouths; includes barrier islands, beaches, low tundra, marshes, tidal flats, scarps, peat shorelines, and marine algae
Marine Benthic Habitats	Seafloor of the OCS and slope/deep sea; includes soft sediments, hard bottom areas, chemosynthetic communities, warm water coral reefs, and deepwater coral reefs	Seafloor of the Alaska Fjordland Shelf Ecoregion; includes Kachemak Bay, Shelikof Strait, and lower Cook Inlet; and Gulf of Alaska (oil spills)	Seafloor of the Beaufort/ Chukchi Shelf Marine Ecoregion and the Arctic Slope and Arctic Plains Marine Ecoregions
Marine Pelagic Habitats	Water column and water surface of the Mississippi and Texas Estuarine Areas	Water column and water surface of the Cook Inlet and Shelikof Strait	Water column and water surface of the Beaufort/ Chukchi Shelf Marine Ecoregion

TABLE 4.6.1-1 (Cont.)

	Regions of Interest		
Resource	Gulf of Mexico	Cook Inlet	Arctic Region
Essential Fish Habitat	Water and substrate of coastal, estuarine, and marine environments; includes submerged aquatic vegetation, emergent intertidal wetlands (marshes and mangroves), soft-bottom (mud, sand, or clay), live/hard-bottom, oyster reefs, coral reefs, marine sediment, continental slope, chemosynthetic cold seeps, *Sargassum*, and manmade structures identified by the GOM Fishery Management Council	Water and substrate from the lower Cook Inlet to the Gulf of Alaska shelf; includes estuaries, bays, kelp forests, and reefs identified by the Gulf of Alaska Fisheries Management Area of the North Pacific Fisheries Management Council	Water and substrate of the Arctic Management Area
Marine Mammals (ESA- and non-ESA species)	Northern GOM waters	Cook Inlet Level III Coastal Region; Gulf of Alaska Level III Coastal Region	Beaufort/Chukchian Self Level II Ecoregion, including the Chukchian Neritic and Beaufortian Neritic Level III Ecoregions
Terrestrial Mammals (ESA- and non-ESA species)	Coastal habitats of northern GOM waters	Coastal habitats in the Cook Inlet Planning Area and nearby coastal habitats in the Gulf of Alaska	Coastal habitats of the Arctic region
Marine and Coastal Birds (ESA- and non-ESA species)	Northern GOM coastline, including coastal habitats used by migratory species from northern latitudes; includes coastal wetlands and marshes, mud flats, and beaches	Cook Inlet Planning Area, including coastal habitats (wetlands and bays) used by migratory species; includes mudflats, beaches, lagoons, and islands	Beaufort and Chukchi Seas, including coastal habitats
Reptiles (ESA- and non-ESA species)	Coastal habitats of the Eastern, Western, and Central GOM Planning Areas	NA[a]	NA

TABLE 4.6.1-1 (Cont.)

	Regions of Interest		
Resource	Gulf of Mexico	Cook Inlet	Arctic Region
Fish	Northern GOM waters and seafloor (continental shelf to abyssal plain) and associated rivers, bays, lakes, and estuaries	Cook Inlet waters and seafloor and associated rivers and bays	Waters and seafloor of the Beaufort and Chukchi Seas and associated bays, ice, and reefs
Invertebrates	Northern GOM Shelf and Slope Marine Ecoregions	Cook Inlet and Gulf of Alaska	Beaufort and Chukchi Seas
Special Areas of Concern	Eastern, Western, and Central GOM Planning Areas, including adjacent onshore areas	Cook Inlet and Gulf of Alaska Planning Areas, including adjacent onshore areas	Beaufort and Chukchi Seas Planning Areas, including adjacent onshore areas
Population, Employment and Income	129 counties in the 23 Labor Market Areas (LMAs) in Texas, Louisiana, Mississippi, Alabama, and Florida along the GOM coast	Anchorage municipality, Kenai Peninsula, Kodiak Island, and Matanuska-Susitna Boroughs	North Slope and Northwest Arctic Boroughs
Land Use and Infrastructure	Coastal counties along the northern GOM	Lands in the vicinity of the Cook Inlet Planning Area	Land in the vicinity of the Beaufort and Chukchi Seas Planning Areas
Commercial and Recreational Fisheries	GOM coastal States	Upper and Lower Cook Inlet Management Areas; Gulf of Alaska	Arctic Management Area
Tourism and Recreation	Coasts of Florida, Alabama, Mississippi, Louisiana, and Texas	Cook Inlet area (including Anchorage), Kenai Peninsula, and Prince William Sound	North Slope Borough (mainly Barrow or Deadhorse)
Sociocultural Systems and Subsistence	Coastal counties along the northern GOM	South central Alaska (including Anchorage, Kenai, Soldotna, Nikiski, Port Lions, and Alaska Native communities)	Adjacent Native communities

TABLE 4.6.1-1 (Cont.)

	Regions of Interest		
Resource	Gulf of Mexico	Cook Inlet	Arctic Region
Environmental Justice	129 counties in the 23 LMAs in Texas, Louisiana, Mississippi, Alabama, and Florida along the GOM coast	Anchorage municipality, Kenai Peninsula, Kodiak Island, and Matanuska-Susitna Boroughs	North Slope and Northwest Arctic Boroughs
Archaeological and Historic Resources	Eastern, Western, and Central GOM Planning Areas, including adjacent onshore areas (e.g., river channels, floodplains, terraces, levees)	Cook Inlet Planning Area, including adjacent onshore areas	Beaufort and Chukchi Seas Planning Areas, including adjacent onshore areas

[a] NA=not applicable.

TABLE 4.6.1-2 Estimated Offshore Exploration and Development Activity for All of GOM OCS Cumulative Case Compared to the 2012-2017 Program

Activity Elements[a]	Estimated Activity for all GOM OCS Cumulative Case[b]	GOM OCS 2012-2017 Program Activity
Years of activity	40–50	40–50
Oil (Bbbl)[c]	18–26	2.7–5.4
Gas (Tcf)[d]	76–112	12–24
New Platforms[e]	1,400–2,000	200–450
FPSOs[f]	1–6	0–2
No. of exploration and delineation wells	6,900–9,800	1,000–2,100
No. of development and production wells	8,500–12,000	1,300–2,600
Miles of pipeline	19,000–43,000	2,400–7,500
Service vessel trips/week to new facilities	1,400–1,900	300–600
Helicopter trips/week to new facilities	12,000–24,000	2,000–5,500
New pipeline landfalls	0–40	0–12
New natural gas processing facilities	0–14	0–12
Platforms removed with explosives	870–1,200	150–275
Drill Muds/Well (tons)		
New exploration and delineation wells	1,000	1,000
New development and production wells	1,000	1,000
Drill Cuttings/Well (tons)		
New exploration and delineation wells	1,200	1,200
New development and production wells	1,200	1,200
Produced Water/yr (Mbbl) [g]		
Oil well	19,000–27,000	73–140
Natural gas well	161–247	26–52
Bottom Area Disturbed (ha)[h] *for new activity*		
Platforms	960–12,000	150–2,500
Pipeline	9,500–69,000	2,000–11,500

[a] See Figure 4.6.1-1 and Section 3.11 Land Use and Infrastructure figures depicting current levels of OCS GOM activity elements.

[b] Except where noted.

[c] Bbbl = billion barrels.

[d] Tcf = trillion cubic feet.

[e] Note that these platform numbers are only for new activity associated with past, present, or reasonably foreseeable future programs. The number of platforms currently active on the GOM OCS is approximately 3,000.

[f] FPSOs = floating, production, storage, and offloading systems.

[g] Based on 1.04 bbl produced water/bbl of oil, and 86 bbl produced water/1 Mcf gas (Clark and Veil 2009); Mbbl = million barrels. Calculations based on the total volume of oil or gas produced; actual discharges at a well are highly variable depending on geologic formation and age of well.

[h] Assumes 0.7–6 ha (1 ac) per platform and 0.5–1.6 ha (1.2–2.5 ac) per mile of pipeline.

TABLE 4.6.1-3 Offshore Exploration and Development Scenario for the OCS Program Alaska Cumulative Case and the OCS 5-Year Program under the Proposed Action[a]

	Arctic Region				South Central Alaska Region	
	Beaufort Sea		Chukchi Sea		Cook Inlet	
Scenario Elements	Cumulative Case	OCS 5-Year Program	Cumulative Case	OCS 5-Year Program	Cumulative Case	OCS 5-Year Program
Years of activity	40–0	40–50	40–50	40–50	40–50	40–50
Oil (Mbbl)[b]	500–1,100	200–400	1,500–6,225	500–2,200	100–200	100–200
Gas (Tcf)[c]	0–5.75	0–2.2	0–24.75	0–8.0	0–0.68	0–0.68
Platforms	2–10	1–4	3–16	1–5	1–3	1–3
No. of exploration and delineation wells	12–40	6–16	12–54	6–20	6–12	6–12
No. of platform production wells	90–310	40–120	180–880	60–280	42–110	42–110
No. of subsea production wells	20–25	10	54–235	18–82	0	0
Miles of new offshore pipelines	50–423	30–155	150–1,000	25–250	25–150	25–150
Miles of new onshore pipelines	40–290	10–80	250–500	0	50–105	50–105
Service vessel trips/week[d]	2–30	1–12	3–48	1–15	1–3	1–3
Helicopter trips/week	2–30	1–12	3–48	1–15	1–3	1–3
New pipeline landfalls	0	0	0	0	0–1	0–1
New shore bases	0	0	0	0	0	0
New waste facilities	2–4	0	2–4	0	0	0
New natural gas processing facilities	2–4	0	2–4	0	0	0
Docks/causeways	2–4	0	2–4	0	0	0
Exploration well muds, cuttings, produced water	425 tons dry mud with 80% recycled; 525 tons dry rock cuttings, totaling 610 tons discharged at each well site.		425 tons dry mud with 80% recycled; 525 tons dry rock cuttings, totaling 610 tons discharged at each well site.		360 tons dry mud, with 80% recycled; 450 tons dry rock cuttings; totaling 522 tons per site.	

TABLE 4.6.1-3 (Cont.)

	Arctic Region				South Central Alaska Region	
	Beaufort Sea		Chukchi Sea[a]		Cook Inlet	
Scenario Elements	Cumulative Case	Proposed Action	Cumulative Case	Proposed Action	Cumulative Case	Proposed Action
Development wells muds, cuttings, produced water	All muds, cuttings, and produced water treated and disposed of in wells.		All muds, cuttings, and produced water treated and disposed of in wells.		All muds, cuttings, and produced water discharged down hole.	
Bottom Area Disturbed (ha)[e]						
Platforms	3–15	1.5–6	4–24	1.5–7.5	1.5–4.5	1.5–4.5
Pipelines[f]	70–595	42–217	210–1,400	35–350	35–210	35–210
Surface Soil Disturbed (ha)[g]						
Pipeline	290–1,825	70–584	1,825–3,650	0	365–770	365–770

[a] Values for the cumulative case represent the proposed action (under the 2012 to 2017 OCS program) and actions associated with ongoing and future OCS program oil and gas activities. Because no OCS program oil and gas activities other than those associated with the 5-yr 2012–2017 OCS program are anticipated in the Cook Inlet Planning Area, the cumulative case scenario for the Cook Inlet Planning Area is the same as for the proposed action.

[b] Mbbl = million barrels.

[c] Tcf = trillion cubic feet.

[d] In the Arctic region, service vessel trips will only occur during open-water and broken-ice conditions (typically during August and September).

[e] Assumes 0.7–6 ha (1.7–15 ac) per platform and 0.5–1.6 ha (1.2–4.0 ac) per mile of pipeline.

[f] Value represents bottom area disturbance from offshore pipeline construction only.

[g] Onshore pipeline construction only. Assumes 7.3 ha (18 ac) per pipeline mile.

included in the proposed action (Alternative 1): the Central GOM Planning Area. The Program under Alternative 4 could have the effect of diverting oil and gas exploration and development activity to the Western GOM Planning Area (or elsewhere) or accelerating activity already planned there to compensate for lost production in the Central GOM Planning Area.

It should be noted that the cumulative case scenario for the Arctic planning areas reflects inherent uncertainty about the future of OCS oil and gas activities. To date, there have been no development and production activities on the Arctic OCS, partly because of operational issues related to the extreme environmental conditions and legal issues associated with approving activities in the region. The values presented in Table 4.6.1-3 for the cumulative case reflect a small increase in activity in the Arctic as a result of future leasing beyond the 2012-2017 Program. These values are for analytical purposes only and are not intended as forecasts of future activity. At this time, future activity is unpredictable and could span a considerable range. Transportation and other scenario assumptions that were used in the proposed action exploration and development scenario and impact analyses (Section 4.4.1) also apply to the cumulative analyses.

Estimates of the assumed numbers of large and small oil spills that could result from all Program activities over the 40- to 50-year time frame are presented in Table 4.6.1-4. The source and number of assumed spills were based on the volume of anticipated oil production in each region, the assumed mode of transportation (pipeline and/or tanker), and the spill rates for large spills. Assumptions regarding the number of large oil spills from import tankers were based on the estimated level of crude oil imports and worldwide tanker spill rates. We assume that these spills would occur with uniform frequency over the life of the Program.

There is currently a total of 29,097 lease blocks in the GOM planning areas; of these, 7,800 are active (Section 4.4.1.1). Shallow-water oil production in the GOM OCS has been in decline since 1997, and is expected to be offset by deepwater production over the life of the Program. Over the next 5 years, BOEM projects that GOM OCS oil production will exceed 1.7 Mbbl/day (620 Mbbl annually). Gas production is expected to increase, then level off to about 8 Bcf/day (2,920 Bcf annually) (Karl et al. 2007).

The Cook Inlet Planning Area has had oil and gas operations in State waters since the late 1950s and currently has a well-established oil and gas infrastructure. The most recent sale in which leases were purchased occurred in 1997 (when two leases were purchased). A lease sale was held in 2004, but no leases were purchased (Section 4.4.1.2). There are currently no existing OCS-related oil and gas activities in Cook Inlet.

There has been no oil and gas development activity in the Arctic planning areas. Since 1979, 10 lease sales have been held in the Beaufort Sea Planning Area and three in the Chukchi Sea Planning Area, but no activity has resulted to date (Section 4.4.1.3).

The impact-producing factors for the Program (under any of the action alternatives) are listed in Table 2.10-1. A summary of related impacts is provided in Table 2.10-2.

TABLE 4.6.1-4 Large and Small Oil Spill Assumptions for the Cumulative Case

		Number of Spill Events[a]		
			Arctic Region	South Alaska Region
Scenario Elements	Assumed Spill Volume	Gulf of Mexico Region	Beaufort and Chukchi Seas	Cook Inlet
Oil Production (Bbbl)[b]		18–26	2–7.3	0.1–0.2
Large (bbl)	≥1,000			
Pipeline	1,700[c]	16–23	1–6	1 spill from either
Platform	5,000[d]	4–7	1–2	
Tanker	3,100–5,800[e]	5–10		
Small (bbl)[f]	≥50 to <1,000	230–330	25–95	1–3
	≥1 bbl to <50	1,350–1,950	150–550	7–15

[a] The assumed number of spills are estimated using the 1996–2010 spill rates in Anderson et al. (2012). The assumed spill rate for pipeline is 0.88 spills/Bbbl produced. The assumed spill rate for platforms is 0.25 spills/Bbbl produced. For the Alaska OCS region, the 1996–2010 spill rates were compared to fault-tree rates in Bercha Group, Inc. (2011, 2008a, b, 2006). The greater number of spills from Anderson et al. (2012) is represented in Table 4.6.1-4. The values provided for the Arctic region are the combined totals for the Beaufort and Chukchi Seas.

[b] Bbbl = billion barrels.

[c] During the last 15 years (1996–2010), 7 oil spills ≥1,000 bbl occurred from U.S. OCS pipelines. The median spill size was 1,720 bbl. The maximum spill size between 1996 and 2010 from U.S. OCS pipelines was 8,212 bbl.

[d] During the last 15 years (1996–2010), 2 oil spills ≥1,000 bbl occurred from U.S. OCS platforms. During Hurricane Rita, one platform and two jack-up rigs were destroyed, and a combined total of 5,066 bbl were spilled. The median spill size, when not accounting for a decreasing trend in the rate of platform spills over 1964–2010, is 7,000 bbl. The low-probability very large spill occurrence, such as the DWH event, is represented as a catastrophic spill event.

[e] 3,100 bbl for tankers in the GOM; 5,800 bbl for TAPS tankers transporting Alaska OCS oil.

[f] The number of spills <1,000 bbl is estimated using a spill rate for both pipeline and platform spills.

4.6.1.2.2 Non-OCS Program Actions and Trends – Gulf of Mexico Region. Table 4.6.1-5 summarizes ongoing and reasonably foreseeable future actions and trends affecting resources and systems in the GOM. Past and present actions are generally accounted for in the baseline environment (described in Chapter 3) and the analysis of direct and indirect impacts under each resource area (Section 4.4). These impacts are carried forward to the cumulative analysis, which also takes into account the effects of ongoing and reasonably foreseeable future actions and trends. Cumulative scenarios (based on types of actions) and impact-producing factors are described for each action or trend on the basis of recent environmental reports or NEPA reviews.[34] General locations of ongoing and reasonably foreseeable future actions in the GOM relative to the OCS planning areas and LMEs are shown on maps provided throughout this section.

Ongoing Oil and Gas Exploration, Development, and Production. Oil and gas development is the main industrial activity occurring in the GOM region. In addition to activity related to past OCS programs, oil and gas development has taken place in the coastal waters of the GOM States and in Mexico's waters. These activities contribute to cumulative effects on air and water quality, the acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine and terrestrial mammals, and birds), commercial and recreational fisheries, sociocultural systems (local economies and subsistence), and cultural resources (if present). Important impact-producing factors associated with oil and gas development in the GOM include subaerial noise and subsea noise and vibrations, platform lighting, engine emissions and fuel spills (marine vessels), oil spills (storage tanks and vessel casualty), hazardous spills and releases, oil and chemical releases (from wells and produced water), disturbance or injury of fish and wildlife, habitat displacement or degradation, chronic seafloor disturbance (by anchors and mooring lines), bottom sediment disturbance (turbidity and contaminant resuspension), resource consumption, wildlife collisions with infrastructure and marine vessels, and collisions among marine vessels (e.g., 1979 collision of the Burmah Agate tanker with the freighter Mimosa about 8 km (5 mi) off Galveston, Texas, as documented by ERCO [1982]).

State Waters. All the GOM States except Florida[35] have active oil and natural gas programs in both offshore State waters and on coastal lands. In 2009, oil and natural gas produced in GOM State waters totaled 503 million barrels (Mbbl) and 114 Bcf, respectively (EIA 2010a, b). Offshore State oil and gas activity levels are highest in Texas and Louisiana, a long-established trend that will likely continue over the next 40 to 50 years. Figure 4.6.1-1 shows active producing wells and oil/gas pipelines in State waters of the GOM (Louisiana only; producing wells and oil/gas pipeline data for Texas were not publicly available).

Crude oil production in Texas has a long history, but has declined over the past decade (from approximately 449 Mbbl in 1999 to 404 Mbbl in 2009). During the same period, its

[34] It should be noted that the DWH event is not included in Table 4.6.1-5 since it is not an on-going or reasonably foreseeable future event. However, the effects of the DWH event are incorporated into the cumulative impacts sections for those resources it has affected.

[35] A drilling moratorium in Florida State waters has been in effect since July 1990 and there has been no leasing of tracts since the early 1980s (Lloyd 1991).

TABLE 4.6.1-5 Ongoing and Reasonably Foreseeable Future Actions and Trends – Gulf of Mexico

Type of Action or Trend	Associated Activities, Facilities, or Processes	Impact-Producing Factors	Affected Resources and Systems
Ongoing oil and gas exploration, development, and production (onshore, in State and Federal OCS waters and Mexico's waters)	Construction of infrastructure (ports, platforms, and pipelines) Onshore fuel storage tanks, refineries, and transfer stations Pipeline landfalls Onshore support facilities (e.g., pipe yards) Operations and maintenance Seismic surveys Exploratory drilling Waste generation (produced water, drilling fluids, and muds/cuttings) Oil and gas production Decommissioning (plugging production wells and removing infrastructure) Marine vessel traffic Aircraft traffic	Subaerial noise and subsea noise and vibration Platform lighting (offshore) Engine emissions (marine vessels) Fuel spills (marine vessels) Oil spills (storage tanks and vessel casualty) Hazardous spills/releases Oil and chemical releases (wells and produced water) Disturbance or injury of fish and wildlife Habitat displacement and degradation Chronic seafloor disturbance (by anchors and mooring lines) Bottom sediment disturbance (turbidity and contaminant resuspension) Resource consumption Collisions (wildlife with infrastructure and marine vessels) Collisions (among marine vessels)	Air quality, water quality, acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), commercial and recreational fisheries, sociocultural systems (local jobs and revenue, and subsistence harvesting), and cultural resources (if present)
Existing oil and gas infrastructure (onshore, and in State and Federal waters)	Ports Exploration wells Oil and gas pipelines Pipeline landfalls Platforms Tanker vessels Louisiana Offshore Oil Port Onshore fuel storage tanks and transfer stations	Noise Engine emissions (marine vessels) Fuel spills (marine vessels) Oil spills/releases (tanker accidents, transfers, and pipeline or well releases) Hazardous spills/releases Collisions (wildlife with infrastructure and marine vessels) Collisions (among marine vessels)	Air quality, water quality, acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), commercial and recreational fisheries, sociocultural systems (local jobs and revenue, and subsistence harvesting), and cultural resources (if present)

TABLE 4.6.1-5 (Cont.)

Type of Action or Trend	Associated Activities, Facilities, or Processes	Impact-Producing Factors	Affected Resources and Systems
Oil imports	Tanker traffic Lightering (transfer) operations	Noise Oil spills Engine emissions (tankers) Collisions (wildlife with tankers) Collisions (among marine vessels)	Air quality, water quality, acoustic environment, marine and coastal habitats, and marine and coastal fauna (fish, marine mammals, and birds)
Onshore industry and agriculture	Port facilities Erosion control structures (e.g., jetties and groins) Platform fabrication yards Shipyards Support and transport facilities Pipelines Pipecoating plants and yards Natural gas processing plants and storage facilities Refineries Petrochemical plants Waste management facilities Land-based vehicle traffic and equipment Agricultural crops and livestock	Noise Erosion of downdrift areas Engine emissions (marine vessels and land-based vehicles and equipment) Fuel spills (marine vessels and land-based vehicles and equipment) Permitted discharges to air and water Pollutant releases via surface runoff (non-point sources) Hazardous spills/releases Collisions (wildlife with vessels and infrastructure)	Air quality, water quality, acoustic environment, coastal habitats, benthic and marine habitats, marine and coastal fauna (fish, marine mammals, and birds), commercial and recreational fisheries, sociocultural systems (local jobs, subsistence harvesting), and cultural resources (if present)
Commercial fishing	Fishing vessel traffic Use of drifting gear (purse nets and bottom longlines) Use of pots and traps Use of hook and line Bottom trawling Surface longlining	Noise Fuel spills (fishing vessels) Disturbance or injury of marine wildlife (e.g., ingestion and/or entanglement) Bottom sediment disturbance (turbidity and contaminant resuspension) Damage to hard bottoms (e.g., reefs) Resource consumption	Water quality, acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), and sociocultural systems (local jobs and revenue)

TABLE 4.6.1-5 (Cont.)

Type of Action or Trend	Associated Activities, Facilities, or Processes	Impact-Producing Factors	Affected Resources and Systems
Alternate energy development	Wind, wave, and ocean current technologies and infrastructure (including subsea cables) Technology testing (bottom sampling, deep-tow sonar surveys, borings) Facility construction and operation Periodic maintenance (by marine vessel) Facility decommissioning (facility removal)	Subaerial noise and subsea noise and vibration Bottom sediment disturbance (turbidity and contaminant resuspension) Collisions (wildlife with infrastructure)	Acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), and cultural resources (if present)
Military operations	Surface marine vessel traffic Aircraft traffic Aerial operations (e.g., flight training) Submarine operations Offshore dumping areas (ordnance, chemical waste, vessel waste)	Subaerial noise and subsea noise and vibration Engine emissions (marine vessels) Fuel spills (marine vessels) Disturbance or injury of fish and wildlife Bottom sediment disturbance (turbidity and contaminant resuspension) Contaminant releases Collisions (wildlife with marine vessels)	Water quality, acoustic environment, marine and coastal habitats, and marine and coastal fauna (fish, marine mammals, and birds)
Marine vessel traffic	Crude oil tankers LNG tankers Commercial container vessels Tugs and barges Military vessels U.S. Coast Guard vessels (search, rescue, and homeland security) Cruise ships Commercial fishing vessels Small watercraft	Noise Engine emissions (marine vessels) Fuel spills (marine vessels) Discharges of bilge water and waste Oil spills (vessel casualty) Increased wave action (nearshore and along navigation channels) Collisions (wildlife with marine vessels) Collisions (among marine vessels)	Air quality, water quality, acoustic environment, marine and coastal habitats, and marine and coastal fauna (fish, marine mammals, and birds)

TABLE 4.6.1-5 (Cont.)

Type of Action or Trend	Associated Activities, Facilities, or Processes	Impact-Producing Factors	Affected Resources and Systems
Scientific research	Oceanographic and biological surveys Marine vessel traffic (including submersibles) Sampling, tagging, and tracking species of interest Seismic surveys Drilling Sediment and subsurface sampling Well installation and geophysical logging	Subsea noise and vibration Disturbance or injury of wildlife Bottom sediment disturbance (turbidity and contaminant resuspension)	Water quality, acoustic environment, marine and coastal habitats, and marine and coastal fauna (fish, marine mammals, and birds)
Liquefied natural gas (LNG) import terminals (offshore)	Operation of existing LNL terminal Construction and operation of new onshore and offshore LNG import terminals Tanker traffic	Accidental explosions or fires Cooled water releases Fuel spills (tankers) Collisions (wildlife with tankers)	Water quality, marine and coastal habitats, marine and coastal fauna (fish and marine mammals)
Marine mineral mining	Marine vessel traffic Bottom sampling and shallow coring Mining (coastal waters) Coastal and barrier island restoration Beach nourishment Public works projects	Noise Bottom sediment disturbance (turbidity and contaminant resuspension) Resource consumption	Water quality, acoustic environment, and marine and coastal habitats
Wastewater discharge to MARB watershed and GOM waters	Discrete conveyances such as pipes or man-made ditches from sewage treatment plants, industrial facilities, and power generating plants Drilling wastes (offshore) Marine vessel and platform discharges	Permitted releases to water Pollutant releases via surface runoff (non-point sources)	Water quality, marine and coastal habitats, marine and coastal fauna (fish, mammals, and birds), commercial and recreational fisheries, and sociocultural systems (local communities and subsistence harvesting)

TABLE 4.6.1-5 (Cont.)

Type of Action or Trend	Associated Activities, Facilities, or Processes	Impact-Producing Factors	Affected Resources and Systems
Persistent contaminants and marine debris	Accumulation of contaminants from multiple sources (discharges, spills, and releases; and atmospheric deposition) Accumulation of floating, submerged, and beached debris	Exposure to contaminants in marine waters and sediments, and in the food web via toxicity or bioaccumulation Collisions (marine vessels with debris) Entanglement in or ingestion of debris by marine wildlife Habitat displacement and/or degradation	Water (and sediment) quality, marine and coastal habitats, marine and coastal fauna (fish, mammals, and birds), commercial and recreational fisheries, and sociocultural systems (subsistence harvesting)
Hypoxic zone in northern GOM	Accumulation of nutrients mainly from MARB watershed Seasonal zone of depleted dissolved oxygen (increasing in size and during over the past 50 years)	Exposure to low dissolved oxygen levels in marine waters (with mortality and reproduction impacts also affecting food web) Habitat displacement and/or degradation	Water quality, marine and coastal habitats, marine and coastal fauna (benthic organisms and fish), commercial and recreational fisheries, and sociocultural systems (subsistence harvesting)
Dredging and marine disposal	Excavation of subaqueous sediments Transport of sediments (by dredger or pipeline) Relocation and disposal of sediments	Noise Reduction of sediment deposition on downdrift landforms Bottom sediment disturbance (turbidity and contaminant resuspension)	Water quality, acoustic environment, marine and coastal habitats, marine and coastal fauna (fish and marine mammals), and cultural resources (if present)
Recreation and tourism	Shores and beaches Resorts, marinas, parks, and gardens Recreational and sport fishing Water sports Cruise ships	Noise Disturbance or injury of fish and wildlife Habitat displacement and/or degradation Economic activity	Air quality, water quality, acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), and sociocultural systems (jobs and revenues, and subsistence harvesting)
Climate change	Increase in atmospheric and ocean temperatures Increase in precipitation rate Increase in storm frequency and intensity Sea level rise and coastal erosion Ocean acidification	Changes in water quality (temperature, salinity, and pH) Changes in water circulation Changes in storm frequency and intensity Saltwater intrusion (coastal aquifers)	Air quality, water quality, marine and coastal habitats, and marine and coastal fauna (fish, marine mammals, and birds)

TABLE 4.6.1-5 (Cont.)

Type of Action or Trend	Associated Activities, Facilities, or Processes	Impact-Producing Factors	Affected Resources and Systems
Legislative actions (existing and forthcoming)	Federal statutes and regulations Executive Orders State statutes and regulations International agreements	Management and protection of various resources throughout the marine and coastal regions of the GOM	All resources

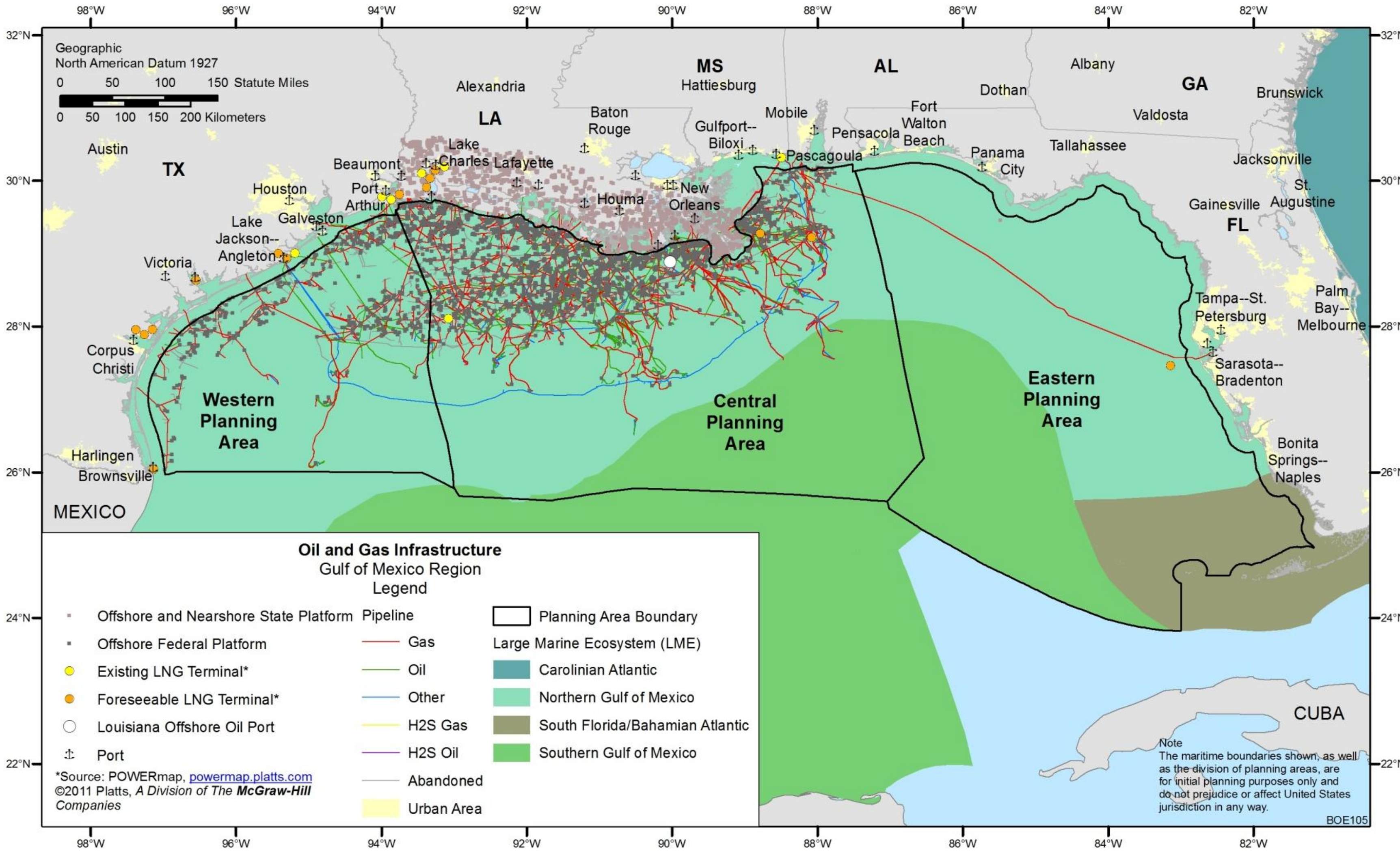

FIGURE 4.6.1-1 Oil and Natural Gas-Related Infrastructure in State Waters and GOM OCS Planning Areas

offshore production increased from 475,000 to 897,000 bbl (EIA 2000, 2010a). From 2005 to 2009, the State's offshore gas withdrawals (from gas and oil wells) totaled 38 Bcf (EIA 2010b). Louisiana's offshore program produced 5.5 Mbbl of crude oil in 2009; from 2005 to 2009, its offshore gas withdrawals totaled 76 Bcf (EIA 2010a, b).

Although Mississippi ranked eleventh in the nation in both crude oil and natural gas production in 2009 (EIA 2010a, b), the State does not currently have an offshore program. Alabama did not produce crude oil from offshore waters in 2009; however, from 2005 to 2009 its offshore gas withdrawals totaled 109 Bcf (EIA 2010b).

Mexico's Waters. Mexico is the world's seventh largest crude oil producer (producing about 2.6 Mbbl/day in 2010) and the second largest source of oil imports to the United States. Most of its current production comes from the two oil fields, Cantarell and Ku-Maloob-Zaap (KMZ), located about 80 km (50 mi) offshore in the Bay of Campeche, in the southern GOM. In 2010, oil production from the Cantarell field was 558,000 bbl/day, down 74% from its peak production level of 2.14 Mbbl/day in 2004. Production from the KMZ field has offset some of these losses, producing 839,200 bbl/day in 2010. (Natural gas production from the Cantarell field has increased since 2005, totaling 457 Bcf in 2010.) As of January 1, 2011, Mexico had 10.4 Bbbl of proven oil reserves, most of which are concentrated offshore in the Campeche Basin, more than 1,000 km (620 mi) to the south of the Louisiana coast (EIA 2011s).

Various types of oil and gas related infrastructure exist within Mexico's offshore region. These include platforms and pipelines, natural gas flares, natural gas processing and pipeline distribution networks (including a pipeline network with 10 active connections with the United States), and two LNG terminals (with another currently under construction) (EIA 2011s). A major oil spill resulting from a blowout at the Ixtoc I platform in the Cantarell oil field in 1979 resulted in a release of about 3.3 Mbbl of oil, some of which travelled as far as the Texas shoreline (ERCO 1982; Miglierini 2010).

In February 2012, the United States and Mexico signed the *Transboundary Hydrocarbons Agreement* in relation to the development of oil and gas reservoirs that cross the international maritime boundary between the two countries in the GOM. The agreement provides a legal framework and establishes guidelines for transboundary commercial developments between U.S. companies and Petroleos Mexicanos (Pemex), Mexico's State-owned oil and gas company. It provides for joint inspections teams to ensure compliance with applicable laws and regulations (U.S. Department of State 2012).

Existing Oil and Gas Infrastructure. The oil and gas industry in the GOM is one of the most developed in the world. There are currently more than 3,200 active platforms in operation at water depths less than 61 m (200 ft) and 63 active platforms at water depths greater than 61 m (200 ft) (26 of which are in waters greater than 300 m [1,000 ft] deep) (Figure 4.6.1-1). An estimated 41,843 km (26,000 mi) of oil and gas pipeline stretches across the seafloor. As of October 2011, there were more than 38,000 approved applications to drill in the GOM (BOEM 2012c; NOAA 2011c). Oil and gas infrastructure contributes to cumulative effects on air and water quality, the acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), commercial and recreational fisheries, sociocultural systems (local economies and subsistence), and cultural resources (if present). Important impact-producing factors associated with infrastructure include noise, engine emissions (marine vessels), fuel spills (marine vessels), oil spills or releases (tanker accidents, transfers, and pipeline or well releases), hazardous spills or releases, wildlife collisions with infrastructure and marine vessels, and collisions among marine vessels.

The Louisiana Offshore Oil Port (LOOP), operated by Marathon Domestic LLC, is a deepwater port petroleum terminal located in the GOM, about 26 km (16 mi) southeast of Port Fourchon (Figure 4.6.1-1). The terminal has been operational since 1981 and serves as an unloading and distribution port for supertankers entering the GOM. Petroleum is transported via pipeline from the LOOP to Lafourche Parish where it is stored and distributed to U.S. markets. Marathon Domestic LLC has announced its intention to expand the port’s storage capacity and construct a new pipeline; but no near term plans have been submitted to Maritime Administration (MARAD) or the USCG (MARAD 2012). Operations at the LOOP may contribute to cumulative effects on water quality, marine and coastal habitats, and marine and coastal fauna (fish, mammals, and birds). An important impact-producing factor associated with the LOOP is oil spills (from tanker accidents, transfers, and pipeline releases).

Oil Imports. U.S. imports of crude oil and petroleum products grew steadily every year from 1981, when the annual total was 2.2 Bbbl, to a peak in 2005, when the annual total was 5.0 Bbbl. Since 2005, imports have been in decline, dropping to an annual total of 4.3 Bbbl in 2009 (its lowest point since 2000). The Gulf Coast district was the largest importer of crude oil, with a total of 1.9 Bbbl in 2009 (EIA 2010b, 2011a). The USDOE estimates that crude oil imports will continue to decline from 2009 to 2035 as the growth in demand is met by domestic production (EIA 2011b). Canadian oil imports, representing about 21% of the total in 2009, are delivered by pipeline (EIA 2010a). The remaining oil arrives in the United States on tankers. In 2009, an estimated 3,800 tankers were received in GOM ports, about 10 tankers daily (assuming an average tanker capacity of 500,000 bbl).

Tanker traffic in the GOM contributes to cumulative effects on air and water quality, the acoustic environment, marine and coastal habitats, and marine and coastal fauna (fish, marine mammals, and birds). Important impact-producing factors associated with tanker traffic include noise, oil spills (from accidents and lightering operations), wildlife collisions with tankers, and collisions among marine vessels.

Onshore Industry and Agriculture. Oil and gas development and production play an important role in onshore industrial development in the GOM region. Onshore industry provides locations from which offshore operations are staged and where the exploration and production equipment, personnel, and supplies used for oil and gas operations on the GOM OCS originate (see Section 3.11.1). The level of use of onshore facilities and new facility development closely follow the level of activity in offshore drilling. The types of onshore facilities that support the offshore oil and gas industry include port facilities (12 of the nation’s 20 largest ports are located in the GOM), platform fabrication facilities, shipyards, shipbuilding and repair facilities, support and transport facilities, pipelines, pipe coating yards, natural gas processing and storage facilities, refineries, petrochemical plants, and waste management facilities. Figures 3.11.1-4 and 3.11.1-5 (Section 3.11) show the locations of these facilities. Onshore industry contributes to cumulative effects on air and water quality, the acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), commercial and recreational fisheries, sociocultural systems (local economies and subsistence), and cultural resources (if present). Important impact-producing factors include noise, engine emissions and fuel spills (marine vessels and land-based vehicles and equipment), permitted discharges to air and water, pollutant releases via surface water runoff, hazardous spills or releases, and wildlife collisions with marine vessels and infrastructure.

Agriculture in the Mississippi and Atchafalaya River Basins (MARB) contributes 70% of the nitrogen and phosphorus discharged to the northern GOM each year. These nutrients originate mainly from cultivated crops (predominantly corn and soybean), but also from animal grazing and manure on pasture and rangelands. Urban sources contribute another 9 to 12% (Alexander et al. 2008). Nutrient loadings in the MARB contribute to cumulative effects on water quality (hypoxia), marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), commercial and recreational fisheries, and sociocultural systems (local economies and subsistence). Important impact-producing factors include permitted discharges to water and nutrient releases via surface water runoff.

Several Federal and State initiatives are in progress to control nutrient loads in the MARB (GOM Task Force 2012). These include the following:

- *Clean Water Act (CWA) Impaired Waters (USEPA).* Under Section 303(d) of the CWA, States have identified more than 15,000 nutrient-related impairments, the majority of which are in MARB States. Over the past 20 years, Total Maximum Daily Loads (TMDLs) have been developed to address nutrient loads in impaired waters.

- *Numeric Nutrient Criteria (USEPA).* The USEPA is working with States to develop water quality criteria for nutrients (phosphorus and nitrogen) in States within the Mississippi River Basin.

- *Nutrient Application Management System (USDA).* Under the nutrient application management system, land is managed to control the amount, source, placement, form, and timing of the application of plant nutrients and soil amendments; since 2000, 113,312 km^2 (28 million acres) of land within the MARB have been managed under this system.

- *Erosion Control Practices (USDA).* Since 2005, erosion control practices associated with crop production on 137, 593 km^2 (34 million acres) of land within the MARB have helped to reduce sheet and rill erosion, thus improving soil fertility, soil health, and sustainable crop production, and reducing offsite impacts such as phosphorus loads in surface runoff.

The ultimate goal of these initiatives is to reduce or make progress toward reducing the areal extent of the hypoxic zone in the GOM to a 5-year running average of less than 5,000 km^2

(1,930 mi^2) by the year 2015, as stated in the *Gulf Hypoxia Action Plan* developed by the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force (GOM Task Force 2008).

Commercial Fishing. Commercial fishery landings in the GOM, including western Florida, Alabama, Mississippi, Louisiana, and Texas, amounted to an estimated 649,000 metric tons in 2009, worth more than $629 million (see Section 3.12.1.1). Commercially important species groups in the GOM include oceanic pelagic (epipelagic) fishes, reef (hard bottom) fishes, coastal pelagic species, and estuarine-dependent species. White and brown shrimp accounted for 25% and 23%, respectively, of the entire GOM commercial fishery in 2009. In terms of total landing weight reported in 2009, the top U.S. ports in the GOM region were Empire-Venice, Louisiana; Intracoastal City, Louisiana; and Pascogoula-Moss Point, Mississippi. The highest reported total catch values were for two ports in Louisiana: Empire-Venice ($67.2 million) and Dulac-Chauvin ($50.9 million).

In 2010, the DWH event, located about 80 km (50 mi) southeast of the Mississippi River, caused the temporary closure of both offshore and nearshore/inshore commercial fishing grounds, stressing an industry already severely damaged by Hurricanes Katrina and Rita in 2005. The effects of the DWH event are still being assessed and recovery efforts (e.g., habitat restoration and stock assessments) are regularly monitored to assess their effectiveness (GSMFC 2011). By November 15, 2010, the NOAA Fisheries Service reported that there were about 2,697 km^2 (1,041 mi^2) or 0.4% of fishing areas in the GOM still closed because of the DWH event (down from a high of about 229,270 km^2 [88,522 mi^2] or 36.6% on June 2, 2010). All fishery areas were reopened as of April 19, 2011 (NOAA 2012c).

While fishery-related activities have beneficial effects to local economies, they may also contribute to adverse cumulative effects on water quality, the acoustic environment, marine and coastal habitats, and marine and coastal fauna (fish, marine mammals, and birds). Important impact-producing factors include noise, fuel spills, disturbance or injury of marine wildlife (ingestion and/or entanglement), bottom sediment disturbance (turbidity and contaminant resuspension), damage to hard bottoms (e.g., reefs), and resource consumption.

Alternate Energy Development. The Energy Policy Act of 2005 amended Section 8 of the Outer Continental Shelf Lands Act (OCSLA) (43 USC 1337) to give the Secretary of the Interior authority to issue a lease, easement, or ROW on the OCS[36] for activities that are not otherwise authorized by the OCSLA or other applicable law, if those activities:

- Produce or support production, transportation, or transmission of energy from sources other than oil and gas; or
- Use, for energy-related purposes or other authorized marine-related purposes, facilities currently or previously used for activities authorized under the OCSLA, except that any oil and gas energy-related uses shall not be

36 This excludes areas on the OCS within the exterior boundaries of any unit of the National Park System, National Wildlife Refuge System, National Marine Sanctuary System, or any National Monument.

> authorized in areas in which oil and gas preleasing, leasing, and related activities are prohibited by a moratorium.

In response to this new authority, BOEM of the USDOI, formerly the Minerals Management Service (MMS), established an Alternative Energy and Alternate Use Program on the OCS (now referred to as its Renewable Energy Program) to approve and manage these potential activities. BOEM completed its PEIS to evaluate the potential environmental impacts of implementing the program and established initial policies and best management practices to mitigate these impacts in October 2007 (MMS 2007e). Each project developed under this new program will be subject to environmental reviews under NEPA, and each project may have additional project-specific mitigation measures. On April 22, 2009, BOEM published its final regulations to establish an environmentally responsible Renewable Energy Program on the OCS. Documents and information related to the program can be found at http://www.boem.gov/Renewable-Energy-Program/index.aspx.

While it is too early to predict the number and types of alternate uses and renewable energy projects that could be developed over the next 40 to 50 years, several OCS renewable energy projects have been proposed. Most of these are wind energy projects. The first commercial wind lease (Cape Wind off the coast of Massachusetts) was signed by the Secretary of the Interior in 2010 and its construction is expected to begin by the end of 2011 (BOEMRE 2011g). Noncompetitive leases for 14 lease areas off the coasts of New Jersey (6), Delaware (1), Georgia (3), and southeast Florida (4) have also been approved. These leases are for data collection and technology testing activities related to the development of wind and ocean current resources (BOEMRE 2011h). None of these leases are within the subject regions for this PEIS.

Alternate energy projects provide beneficial effects in terms of providing cleaner sources of energy and adding jobs to local communities. They may also contribute to adverse cumulative effects (mainly during their construction) on the acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), and cultural resources (if present). Important impact-producing factors associated with alternate energy development in the GOM include subaerial noise and subsea noise and vibration, bottom sediment disturbance (turbidity and contaminant resuspension), and wildlife collisions with infrastructure.

Military Operations. Numerous U.S. military bases are located along the GOM coast (Figure 4.6.1-2; see also Section 3.9.1.2.3). U.S. Navy air stations serve as training bases in jet aviation, sea and air rescue, and coastal mine countermeasures, as well as home ports for various ships and operations. Some support U.S. Army and USCG activities. The U.S. Air Force conducts training activities over the deepwater region of the GOM. There are more than 40 military warning areas in the northern GOM region; most of these areas are designated for testing and training operations and overlie waters that are less than 800 m (2,600 ft) deep. Several military dumping areas have also been designated within the GOM planning areas (Figure 4.6.1-2). These areas are used for the disposal of spoil, ordnance, chemical waste, and vessel waste. To avoid multiple-use conflicts in GOM OCS areas used by both the military and oil and gas lessees and operators, BOEM applies a standard military areas stipulation to all leases in the Western and Central GOM Planning Areas.

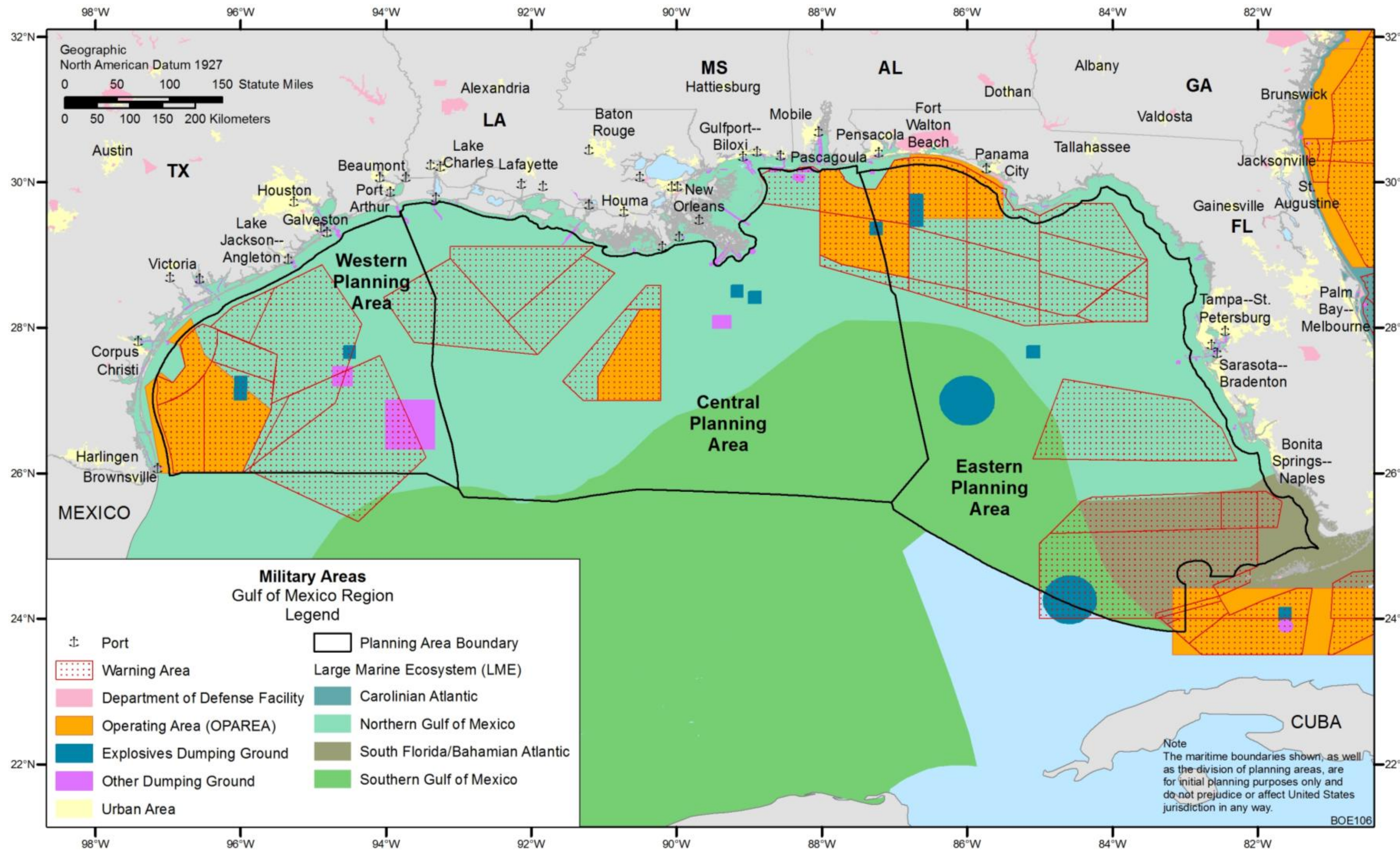

FIGURE 4.6.1-2 Military Operations and Dumping Grounds in the GOM OCS Planning Areas

Military operations in the GOM are expected to continue and military use areas are expected to remain the same (and not be released for nonmilitary use) over the next 40 to 50 years. These operations contribute to cumulative effects on water quality, marine and coastal habitats, and marine and coastal fauna (fish, marine mammals, and birds). Important impact-producing factors associated with military operations include subaerial noise and subsea noise and vibrations, engine emissions (marine vessels), fuel spills (marine vessels), disturbance or injury of fish and wildlife, bottom sediment disturbance (turbidity and contaminant resuspension), contaminant releases, and wildlife collisions with marine vessels.

Marine Vessel Traffic. Marine vessel traffic includes crude oil and LNG tankers, commercial container vessels, military, USCG vessels, cruise ships, commercial fishery vessels, and small watercraft. In 2009, a total 18,956 vessel calls were made in GOM ports, comprising about 34% of all U.S. vessel calls. U.S. vessel calls overall have been in decline in recent years (down 7% in 2009 from 2004) (USDOT 2011b). It is estimated that about 60% of all crude oil imports into the United States are delivered by tanker ships entering through the GOM (VesselTrax 2007). BOEM expects that over the next 40 to 50 years, total vessel calls in GOM ports will rise about 3% per decade beyond current rates.

Marine vessels in the GOM contribute to cumulative effects on air and water quality, marine and coastal habitats, and marine and coastal fauna (fish, marine mammals, and birds). Important impact-producing factors associated with tanker traffic include noise, engine emissions, discharges of bilge water and waste, fuel spills, oil spills (vessel casualty), wildlife collisions with marine vessels, increased wave action (nearshore and along navigation channels), and collisions among marine vessels. Figure 4.6.1-3 shows shipping channels (also known as shipping safety fairways) in the GOM.

Scientific Research. Various ongoing scientific studies are conducted by Federal and State agencies, universities, and organizations to study water quality and biological resources (and systems) in coastal and marine waters of the GOM. Research operations typically involve research cruises or the use of robotic or human-operated submersible vessels. Such research provides important information on the stock, safety, and value of GOM fisheries; the effects of various actions taking place in the region (e.g., oil spills); the status of the seasonal hypoxic zone; and the effects of global climate change. Activities related to scientific research of biological systems requires some human presence and interaction with wildlife, such as sampling, tagging, or tracking species of interest.

Other types of research relate more to the physical processes and systems within the GOM: depositional and erosional processes (along the coast and on the OCS), seafloor geology and geologic hazards (e.g., mass wasting and subsidence), and non-oil and gas energy resources (e.g., gas hydrates). Activities related to scientific research of physical systems involve the use of marine vessels, and include seismic surveys, ocean floor drilling/sampling, well installation, and geophysical logging.

Research-related activities in the GOM are likely to increase over the next 40 to 50 years (in response to concerns over the environmental effects of the DWH event and climate change). While such activities are necessary and beneficial, they may also contribute to adverse

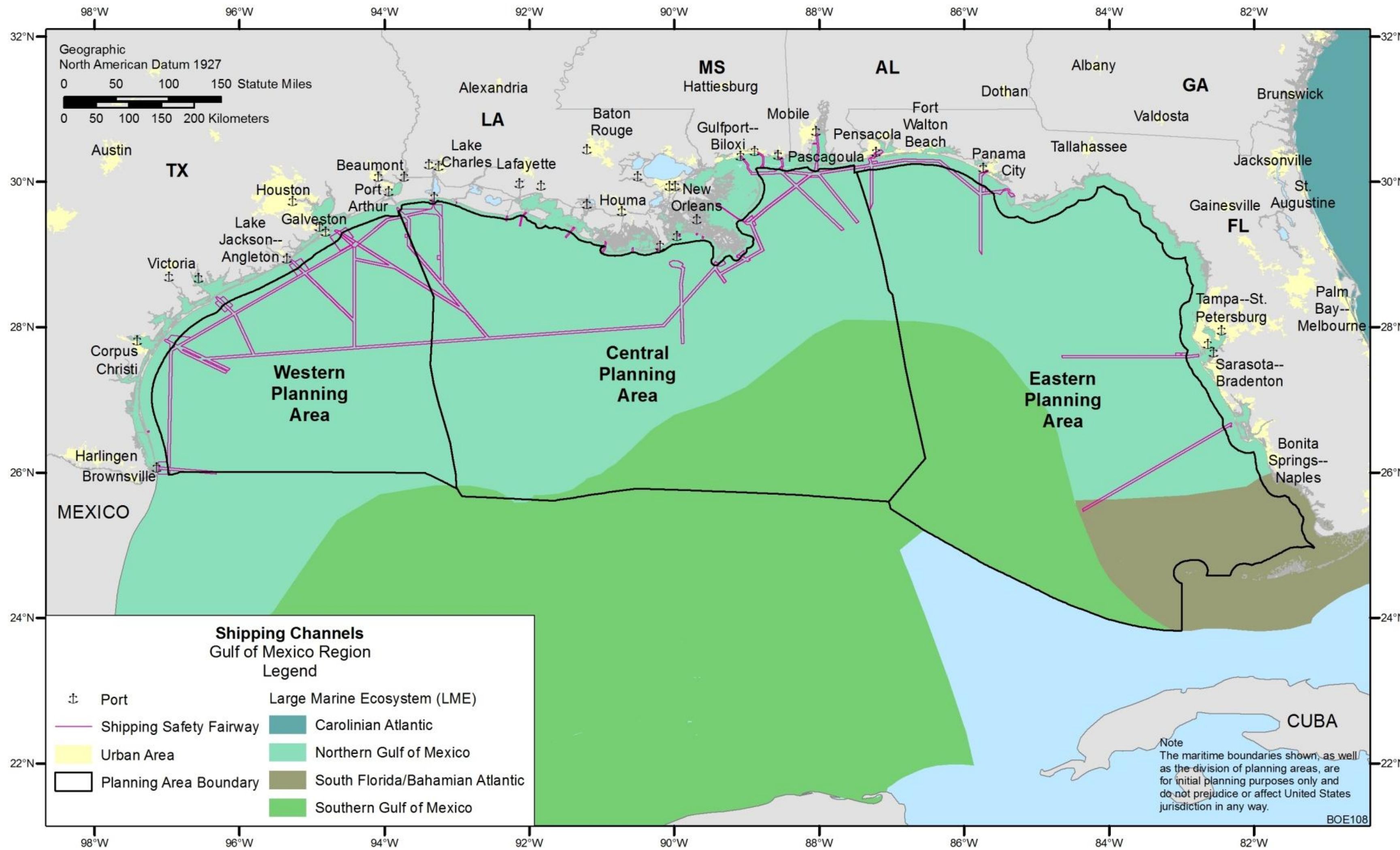

FIGURE 4.6.1-3 Shipping Channels in the GOM

cumulative effects on water quality, the acoustic environment, coastal and marine habitats, and coastal and marine fauna (fish, marine mammals, and birds). Important impact-producing factors include subsea noise and vibration, disturbance or injury of fish and wildlife, and bottom sediment disturbance (turbidity and contaminant resuspension).

Liquefied Natural Gas Terminals. The United States is an importer and exporter of natural gas (EIA 2010b). The USDOE projects a significant increase in overall natural gas consumption between 2009 and 2035; estimates of LNG imports over this period are variable, ranging from 140 to 2,140 Bcf by 2035 (EIA 2011b). The United States currently operates 12 LNG import terminals, only one of which is located offshore in the GOM — the Gulf Gateway Energy Bridge, a 0.5 Bcf/day facility operated by Excelerate Energy, located off the coast of Louisiana (Figure 4.6.1-1; FERC 2012a). It is reasonably foreseeable that additional LNG terminals will be constructed in the GOM over the next 40 to 50 years to offload LNG from tankers into the existing offshore natural gas pipeline system. As of February 2012, an additional seven applications for licenses to import LNG (or expand current LNG facilities) have been approved by FERC (Figure 4.6.1-1). These include three along the coast of Texas (Cheniere, Corpus Christi; Cheniere/Freeport LNG Expansion, Freeport; and Gulf Coast LNG Partners, Port Lavaca) and one along the Louisiana coast (Sempra-Cameron LNG Expansion, Hackberry). The U.S. Department of Transportation (MARAD) has also approved three offshore LNG import terminals: Main Pass — McMoRan Exploration Company and TORP Technology-Bienville LNG (in the GOM) and the Hoegh LNG-Port Dolphin Energy facility (offshore Florida) (FERC 2012b). An additional seven LNG import terminals have been proposed off the coast of Texas and Louisiana (FERC 2012c).

LNG import terminals in the GOM contribute to cumulative effects on water quality, marine and coastal habitats, and marine and coastal fauna (fish, marine mammals, and birds). Important impact-producing factors include accidental explosions or fires, cooled water releases, fuel spills (LNG tankers), and wildlife collisions with LNG tankers.

Marine Mineral Mining. Marine minerals, such as sulfur, sand, gravel, and shell, have been extracted in the northern part of the GOM. OCS sand and gravel resources are currently used for coastal restoration, beach nourishment, barrier island restoration, and other purposes such as public works projects (Figure 4.6.1-4). BOEM has conveyed rights to about 44 million m^3 (58 million yd^3) of OCS sand for 31 coastal restoration projects in five States, under the authority of the *Outer Continental Shelf Lands Act*. A summary of completed and ongoing noncompetitive lease agreements for OCS sand and gravel resources issued under the BOEM Marine Minerals Program can be found on BOEM's Marine Mineral Projects Web page at http://www.boem.gov/Non-Energy-Minerals/Marine-Mineral-Projects.aspx. It is expected that funding for State-led restoration projects will increase over the next 40 to 50 years and such projects will request offshore sand resources from both State and Federal jurisdictions; however, most of these resources will come from the OCS.

While mining in GOM coastal waters has beneficial effects when materials are used for restoration projects, it may also contribute to adverse to cumulative effects on water quality, the acoustic environment, and marine and coastal habitats. Important impact-producing factors associated with mining are turbidity/contaminant resuspension caused by bottom sediment

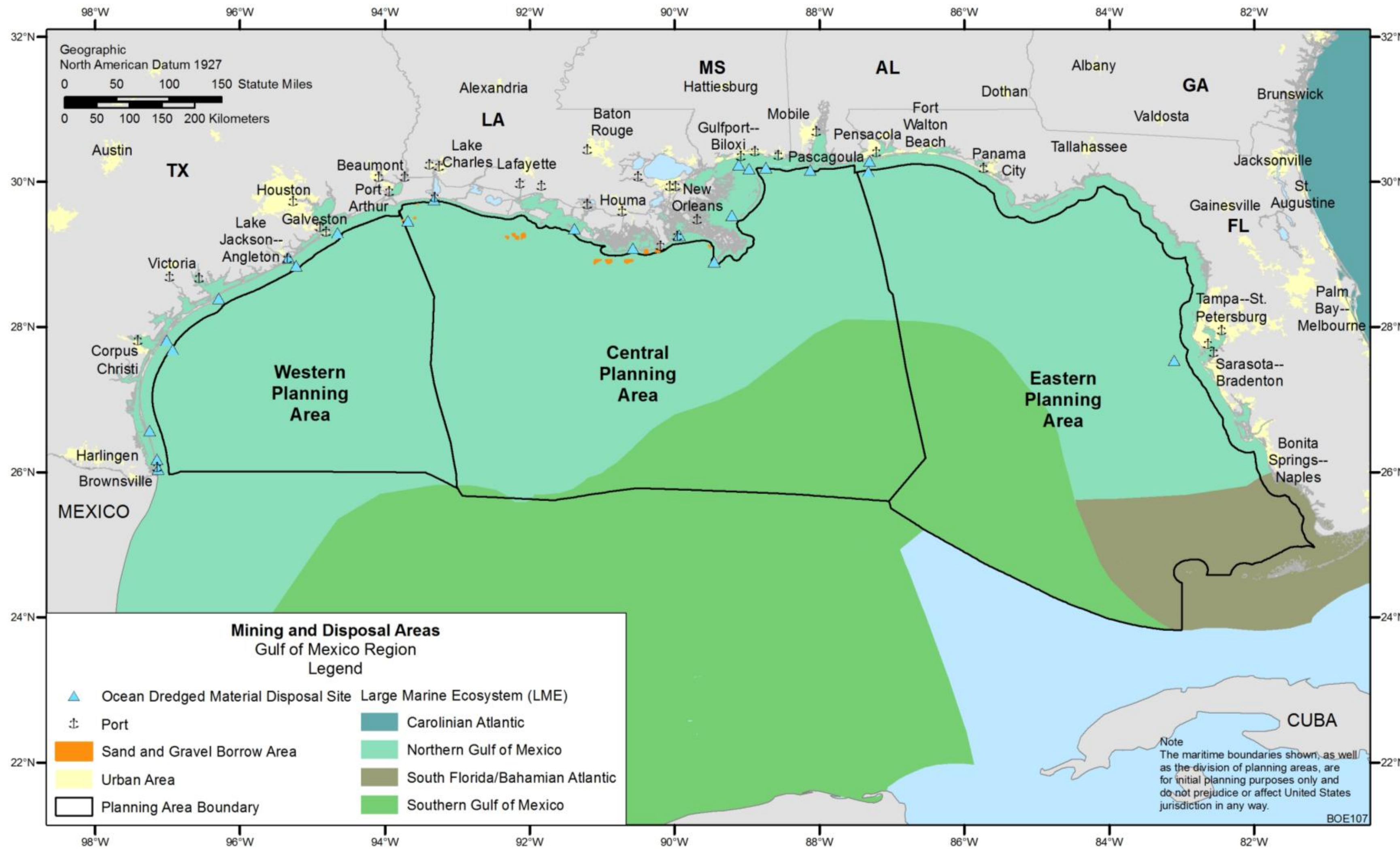

FIGURE 4.6.1-4 Marine Mining (Sand and Gravel) and Ocean Dredged Material Disposal Sites in the GOM

disturbance and resource consumption. It should be noted here that BOEM provides guidance to lessees and operators for the avoidance and protection of significant OCS sand and gravel resources in the GOM region through NTL 2009 G04, so they may be preserved for coastal restoration activities.

Mining from the cap rock of coastal and offshore salt domes has been active along the Texas-Louisiana coast since the 1890s (Kyle 2002). The Main Pass Block 299 mine, operated by McMoran Exploration Company, was leased to mine sulfur and salt in Federal waters of the GOM (lease OCS-G9372). The mine is located about 26 km (16 mi) offshore, east of Plaquemines Parish, Louisiana. It was closed in 2002 and is currently the location of what McMoRan refers to as Main Pass Energy Hub. The ROD for a closed-loop regasification (LNG) system at the Hub was issued by MARAD in 2007; the license for the project is pending (MARAD 2012). The hub would make use of the closed mine for natural gas storage (McMoran 2007).

Wastewater Discharge to MARB Watershed and GOM Waters. The major point sources of pollution to the MARB watershed, and GOM coastal and marine waters include discharges (by discrete conveyances such as pipes or man-made ditches) from sewage treatment plants, industrial facilities, and power generating plants. Also included are offshore discharges from drilling activities and marine vessels. Discharges are regulated through the NPDES permit program. Section 403 of the *Clean Water Act* (CWA) established the Ocean Discharge Criteria, which provide additional requirements for these types of discharges (USEPA 2003, 2012d, e).

Non-point sources of pollution in the GOM include rainfall, snowmelt, or irrigation water that runs over land or through the ground, entraining pollutants and depositing them into rivers, lakes, and coastal waters (including wetlands and estuaries). Pollutants such as fertilizers, herbicides, and insecticides; oil, grease, and toxic chemicals; sediment; and bacteria and nutrients can make their way to coastal waters and have harmful effects on drinking water supplies, recreation, fisheries, and wildlife. Non-point source management programs under Section 319 of the CWA regulate these pollutant sources. The USEPA and NOAA also co-administer State Coastal Non-Point Pollution Control Programs under Section 6217 of the *Coastal Zone Act Reauthorization Amendments of 1990* (USEPA 2011g).

Both point and non-point source discharges to waters of the GOM are expected to continue and will likely increase over the next 40 to 50 years (based on projected increases in population and development in the GOM region States). Pollutant discharges contribute to cumulative effects on water quality, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), commercial and recreational fisheries, and sociocultural systems (local communities and subsistence). Important impact-producing factors associated with discharges include contaminant releases via permitted conveyances and surface runoff.

Persistent Contaminants and Marine Debris. Persistent contaminants are natural and man-made substances introduced to the environment that are resistant to degradation naturally; these include various heavy metals (e.g., mercury, cadmium, lead, and chromium), as well as herbicides, pesticides, PCBs, and dioxin.

Because they do not degrade naturally, these substances are capable of long-range transport and may bioaccumulate in the tissues of ecological and human receptors. Sources of persistent contaminants include permitted discharges and surface runoff (with suspended sediments) from agricultural, industrial or urban areas; and atmospheric deposition. The presence of persistent contaminants in the waters and sediments of the GOM contributes to cumulative effects on water and sediment quality, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), commercial and recreational fisheries, and sociocultural systems (subsistence). Important impact-producing factors include exposure of marine fauna to toxic pollutants (resulting in mortality or reproduction problems) and habitat displacement and/or degradation. Such factors lead to unstable or contaminated fish stocks (or other species) that in turn affect species higher in the food web (via toxicity or bioaccumulation).

NOAA defines marine debris as "any persistent, manufactured, or processed solid material that is directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment" (NOAA 2009). Marine debris in the GOM includes a range of objects such as fishing gear, lost vessel cargo, or plastics, as well as natural objects (such as logs) that find their way into GOM waters after major storms and hurricane. All of these objects pose environmental and collision hazards to navigation and other ocean-related activities such as fishing and recreational boating; some also present hazards to birds and marine wildlife that may become entangled in or ingest them (Ryan 1990). Surveys have discovered as many as 5,000 items generated by Hurricane Katrina within an area of 3.4 km^2 (744 nautical mi^2) mainly in State waters of the north-central GOM region, about 40% of which were submerged in water depths less than 1.5 m (5 ft). The presence of marine debris in the waters and sediments of the GOM contributes to cumulative effects on the same resources as described for persistent contaminants. Important impact-producing factors include collisions of marine vessels with debris and entanglement in or ingestion of debris by marine wildlife.

Hypoxic Zone in Northern GOM. Excess nutrients released to the northern GOM have created a seasonally observed zone of oxygen depletion (hypoxic zone) at the bottom of the continental shelf off Louisiana and Texas that is harmful to aerobic organisms (see Section 3.4.1.2). The hypoxic zone generally stretches from the mouth of the Mississippi River westward to the coastal waters of Texas and extends up to 130 km (80 mi) offshore (Figure 4.6.1-5). The zone is attributed to the discharge of high nutrient loads, particularly nitrogen and phosphorus, from agricultural runoff and other human activities (such as industrial and sewage treatment plant discharges) within the MARB, and stratification due to salinity and temperature differences across the water column that prevents mixing of water (USEPA 2011f). In July 2011, scientists from NOAA measured the size of the hypoxic zone at 17,520 km^2 (6,765 mi^2), smaller than originally predicted based on recent trends (due to weather patterns not accounted for in forecast models). While its size varies from year to year, the hypoxic zone has increased in size and duration over the past 50 years. Its future trends are uncertain; however, the USEPA is currently using models to estimate several nutrient reduction scenarios to better understand what the allowable nutrient loads should be to limit the hypoxic zone to a 5-year running average of 5,000 km^2 (1,930 mi^2), the goal specified by the *Gulf Hypoxia Action Plan* (GOM Task Force 2008).

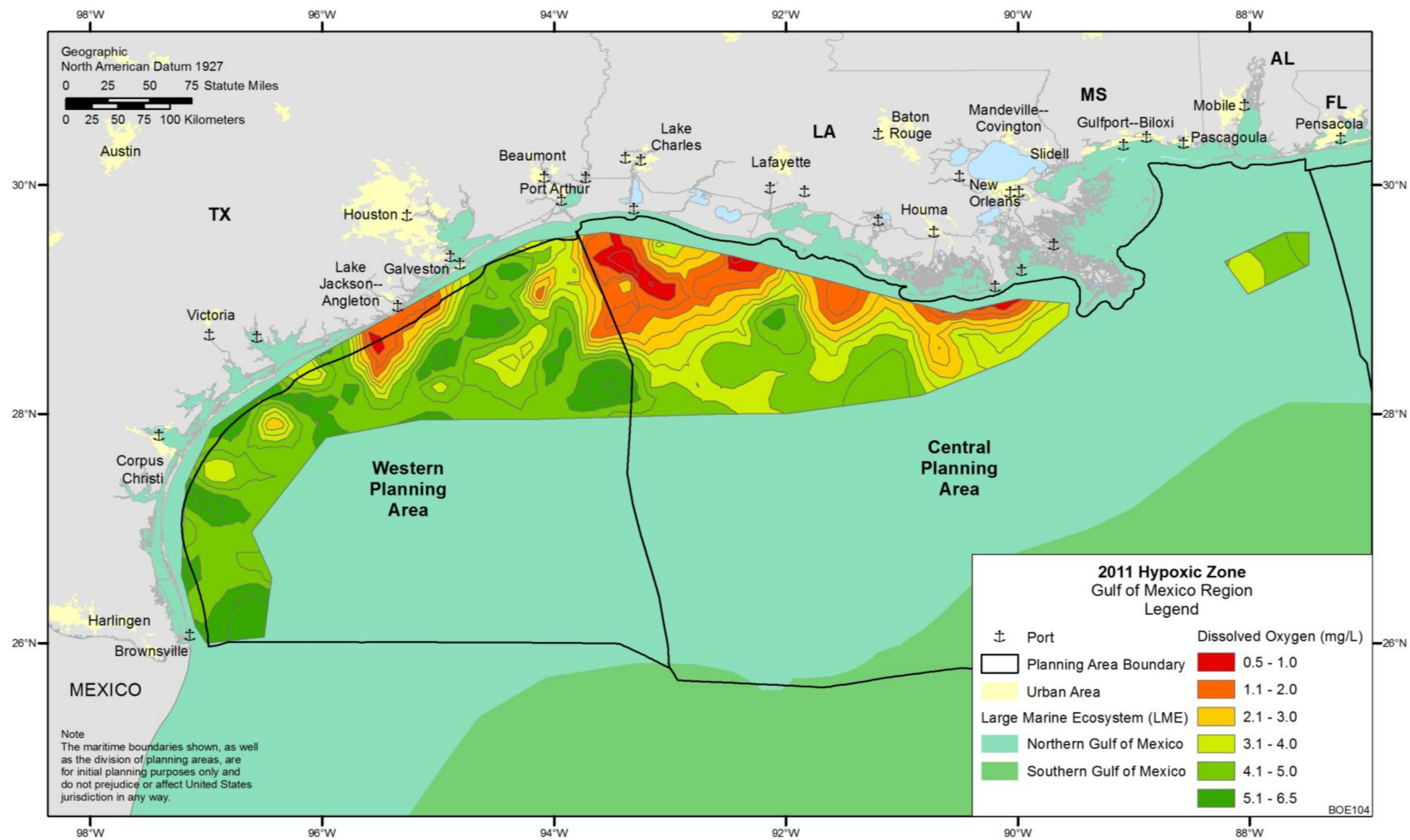

FIGURE 4.6.1-5 Hypoxic Zone in the Northern GOM, July 2011

The hypoxic zone contributes to cumulative effects on water quality, marine and coastal habitats, marine and coastal fauna (especially benthic organisms and fish), commercial and recreational fisheries, and sociocultural systems (subsistence). Important impact-producing factors include exposure of marine fauna to low dissolved oxygen (resulting in mortality or reproduction problems) and habitat displacement and/or degradation. Such factors cause unstable and reduced fish stocks that in turn affect other species relying on fish for food. Studies conducted by NOAA have found that some fish (i.e., the Atlantic croaker) exposed to low dissolved oxygen levels (mainly along the edge of the hypoxic zone where they congregate) suffer reproductive problems because low dissolved oxygen levels disrupt the female endocrine system (leading to masculinization and decreased reproduction) (GOM Task Force 2012).

Dredging and Marine Disposal. There are currently 23 designated ocean dredged material disposal sites (ODMDS) in the GOM, including 16 off the coast of Texas and Louisiana and in the Mississippi River GOM outlet (USEPA Region 6) and six off the coasts of Mississippi, Alabama, and Florida (USEPA Region 4), as shown in Figure 4.6.1-4 (USACE 2011a). Most disposal is of sediments dredged from the bottom of channels and water bodies to maintain adequate channel depth for navigation and berthing. The largest quantities of disposed materials come from dredging of the Mississippi River bar channel (USACE 2011a). The USEPA is responsible for designating and managing ODMDS, as authorized by the *Marine Protection*, *Research and Sanctuaries Act*. Permits for ocean dumping of dredged materials are granted by the USACE, subject to USEPA review and concurrence, as authorized by Section 404 of the CWA (USEPA 2011c). Dredged materials are also available for potential beneficial uses to restore and create habitat, beach nourishment projects, and industrial and commercial development. The amount of dredged material disposed of at ODMDS will likely vary over the next 40 to 50 years, depending on the needs of districts in Louisiana (New Orleans) and Texas (Galveston) where most dredging occurs. However, as more beneficial uses for dredged materials are identified, the disposal at ODMDS could decrease.

While dredging has beneficial effects on marine vessel navigation in the GOM and coastal restoration projects, dredging and disposal at ODMDS may contribute to adverse cumulative effects on water quality, the acoustic environment, coastal and marine habitats, coastal and marine fauna (fish and marine mammals), and cultural resources (if present). Important impact-producing factors for dredging and disposal are noise and turbidity/contaminant resuspension caused by bottom sediment disturbance.

Recreation and Tourism. The GOM coastal zone is one of the major recreational regions of the United States; marine fishing and beach-related activities are of particularly importance (see Section 3.13.1.1). Publicly owned and administered areas (such as national seashores, parks, beaches, and wildlife lands), as well as specially designated preservation areas (such as historic and natural sites and landmarks, wilderness areas, wildlife sanctuaries, and scenic rivers), attract residents and visitors throughout the year. Commercial and private recreational facilities and establishments, such as resorts, marinas, amusement parks, and ornamental gardens, are also popular with tourists and in-State visitors. In 2000, Florida was the most important destination for marine recreation, with more than 22 million people participating in the State (NOAA 2005). Reef fisheries established on oil and gas structures in the northern GOM provide significant benefits to recreational fishing (see Section 3.13.4.1).

Recreation and tourism are major sources of employment in the GOM States, with total employment exceeding one million in these sectors in 2008 (see Section 3.13.5.1). Most tourism-related employment is concentrated in the Miami and Tampa-St. Petersburg areas of Florida. These trends are likely to increase over the next 40 to 50 years (based on past trends).

While recreation and tourism have beneficial effects on local economies, they may also contribute to adverse cumulative effects on air and water quality, the acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), and sociocultural systems (subsistence). Important impact-producing factors include noise, disturbance or injury of fish and wildlife, habitat displacement and/or degradation, and economic activity.

Climate Change. Because a growing body of evidence shows that climate change is occurring (Section 3.3), we have included it as a current and foreseeable natural trend in the cumulative impacts analysis for some resources in the GOM. Analyses that take into account impact-producing factors related to climate change meet one or both of the following two criteria:

- The resource is already experiencing impacts from climate change, so the effects are observable and not speculative.

- The resource will be directly affected by warming temperatures.

In the GOM, climate change is expected to affect coastal ecosystems, forests, air and water quality, fisheries, and business sectors such as industry and energy (see Section 3.3.1). The GOM region has already experienced increasing atmospheric temperatures since the 1960s, and from 1900 to 1991, sea surface temperatures have increased in coastal areas and decreased in offshore regions. Impacts associated with sea level rise, including the loss of coastal wetland and mangrove habitats, saltwater intrusion into coastal aquifers and forests, and increases in shoreline erosion also have been observed along the GOM's northern coast.

Not all impacts from climatic and hydrologic changes that are the indirect result of temperature changes have been analyzed because they may be too uncertain to predict. For example, it is reasonable to expect changes in precipitation regimes as a result of climate change. Furthermore, it is also likely that precipitation changes would, in turn, affect the coastal salinity balance between freshwater flow and tidal influence in some areas, and that these changes would affect fisheries and fish populations in some way. Both the magnitude and direction of each factor in this sequence of occurrences, however, are uncertain. While we acknowledge that continuing climate change could result in changing regional ecological and socioeconomic patterns and distributions, at this stage of our understanding of underlying processes, the rates and directions of many of these changes are too speculative to include in the cumulative analyses that follow.

Legislative Actions. Major statutes governing the management and protection of resources within the GOM OCS planning areas are listed in Appendix C. Regulations and permitting programs based on these statutes, for example, the NPDES permitting program based on Section 402 of the *Clean Water Act*, are overseen by the USEPA and other regulating authorities. The statutes and regulations (including international agreements between the United States and Mexico) are discussed in the previous sections and in the resource impacts sections, as they apply.

In addition to legislative actions, there are several voluntary initiatives under way, such as those with the goal of reducing nutrient loads in the MARB, which aim to preserve and protect resources in the GOM by changing agricultural practices in watershed States.

4.6.1.2.3 Non-OCS Program Actions and Trends – Cook Inlet. Table 4.6.1-6 summarizes ongoing and reasonably foreseeable future actions and trends affecting resources and systems in Cook Inlet. Past and present actions are generally accounted for in the baseline environment (described in Chapter 3) and the analysis of direct and indirect impacts under each resource area (Section 4.4). These impacts are carried forward to the cumulative analysis, which also takes into account the effects of ongoing and reasonably foreseeable future actions and trends. Cumulative scenarios (based on types of actions) and impact-producing factors are described for each action or trend on the basis of recent environmental reports or NEPA reviews. Figure 4.6.1-6 shows general locations of ongoing and reasonably foreseeable future actions in the Cook Inlet Planning Area, which lies entirely within the Gulf of Alaska LME.

Ongoing Oil and Gas Exploration, Development, and Production Activities and Existing Infrastructure. The area of oil and gas discoveries in the upper Cook Inlet basin covers an estimated 11,400 km^2 (4,400 mi^2), extending from the Kachemak Bay area north to the Susitna River. This area includes fields in offshore Cook Inlet, the west shore of Cook Inlet, and the western half of the Kenai Peninsula. As of 2009, about 1,300 Mbbl of oil and 7,800 Bcf of natural gas (net) have been produced from reserves in Cook Inlet. Remaining reserves (including oil and natural gas liquids) through 2034 are estimated to be about 34 Mbbl, with annual production projected to decline from 3.4 Mbbl in 2010 to about 0.52 Mbbl in 2034 (ADNR 2009c).

The ADNR estimates that there are 393 active oil and gas leases in the Cook Inlet region, covering a total of 214,172 ha (529,230 acres) onshore and 182,321 ha (450,526 acres) offshore (ADNR 2012b). Currently, there are 16 offshore production platforms in Cook Inlet, all of which are in State waters (Figure 4.6.1-6; ADNR 2012b). Twelve of these platforms are currently active (World Oil Online 2012). Crude oil production is handled through the Trading Bay production facility, located on the west side of Cook Inlet, which pipelines crude oil it receives to the Drift River oil terminal. Almost all of the Drift River crude oil (most of which is consumed within Alaska) is transported to the Tesoro refinery in Nikiski; natural gas is also processed through several plants in Nikiski and consumed locally.

Existing infrastructure in the Cook Inlet region includes five onshore and 14 offshore pipeline systems, totaling about 251 km (156 mi) of pipeline. About 135 km (84 mi) of pipeline transport crude oil from offshore platforms to shore; onshore pipelines transport processed oil to either the Drift River oil terminal (west side) or Nikiski (east side). Offshore gas pipelines in the Trading Bay area are about 200 km (124 mi) in length; onshore pipelines on the Kenai Peninsula

TABLE 4.6.1-6 Ongoing and Reasonably Foreseeable Future Actions and Trends – Cook Inlet

Type of Action or Trend	Associated Activities, Facilities, or Trends	Impact-Producing Factors	Affected Resources and Systems
Ongoing oil and gas exploration, development, and production activities and existing infrastructure (onshore and in State waters)	Construction of infrastructure (ports, platforms, and pipelines) Onshore fuel storage tanks, refineries, pipelines, and transfer stations Pipeline landfalls Seismic surveys Exploratory drilling Waste generation (produced water, drilling fluids, and muds/cuttings) Oil and gas production Decommissioning (plugging production wells and removing infrastructure) Vessel traffic Air traffic	Subaerial noise and subsea noise and vibration Platform lighting (offshore) Engine emissions (marine vessels) Fuel spills (marine vessels) Oil spills (storage tanks and vessel casualty) Hazardous spills/releases Oil and chemical releases (wells and produced water) Disturbance or injury of fish and wildlife Habitat displacement or degradation Chronic seafloor disturbance (by anchors and mooring lines) Bottom sediment disturbance (turbidity and contaminant resuspension) Resource consumption Collisions (wildlife with infrastructure and marine vessels) Collisions (among vessels)	Air quality, water quality, acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, mammals, and birds), sociocultural systems (local jobs and revenue, and subsistence harvesting), and cultural resources (if present)
Commercial fishing	Fishing vessel traffic Use of gill nets, seines, purse seines, trawls, dredges, pots, jigs Use of diving equipment	Noise Fuel spills (fishing vessels) Disturbance of marine wildlife (e.g., ingestion and/or entanglement) Bottom sediment disturbance (turbidity and contaminant resuspension) Damage to hard bottoms Resource consumption	Water quality, acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), and sociocultural systems (local jobs and revenue)

TABLE 4.6.1-6 (Cont.)

Type of Action or Trend	Associated Activities, Facilities, or Trends	Impact-Producing Factors	Affected Resources and Systems
Harbors, ports, and terminals	Port of Anchorage Port McKenzie Tyonek/North Forelands Drift River Oil Terminal Nikiski Industrial Terminals Port of Homer Seldovia Harbor Port Graham Williamsport	Noise Engine emissions (marine vessels) Fuel spills (marine vessels) Permitted discharges to air and water Pollutant releases via surface runoff (non-point sources) Oil spills (vessel casualty, pipeline or storage tank release) Hazardous spills/releases Accidental explosions or fires Cooled water releases (LNG plant) Collisions (wildlife with infrastructure and marine vessels) Collisions (among marine vessels)	Air quality, water quality, acoustic environment, coastal habitats, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), commercial and recreational fisheries, sociocultural systems (local jobs, subsistence harvesting), and cultural resources (if present)
Port of Anchorage Intermodal Expansion Project	Dredging Placement of fill material Installation of sheet pile Additional road, rail, and utility extensions Installation of final docks Installation of fendering systems Demolition of existing docks Marine vessel traffic Land-based vehicle traffic and equipment	Noise and vibration Engine emissions (marine vessels and land-based vehicles and equipment) Fuel spills (marine vessels and land-based vehicles and equipment) Disturbance or injury of fish and wildlife Habitat displacement or degradation Bottom sediment disturbance (turbidity and contaminant resuspension) Permitted discharges to air and water Pollutant releases via surface runoff (non-point sources) Oil spills (marine vessel casualty) Collisions (wildlife with infrastructure and marine vessels) Collisions (among marine vessels)	Air quality, water quality, acoustic environment, coastal habitats, benthic and marine habitats, marine and coastal fauna (fish, marine mammals, and birds), commercial and recreational fisheries, sociocultural systems (local jobs, subsistence harvesting), and cultural resources (if present)

TABLE 4.6.1-6 (Cont.)

Type of Action or Trend	Associated Activities, Facilities, or Trends	Impact-Producing Factors	Affected Resources and Systems
Knik Arm Crossing Project	Construction of bridge and roads Pile driving Artificial lighting Vessel traffic Vehicle traffic across bridge (once operational)	Noise Engine emissions (marine vessels and land-based vehicles and equipment) Fuel spills (marine vessels and land-based vehicles and equipment) Disturbance or injury of fish and wildlife Habitat displacement and/or degradation Collisions (wildlife with marine vessels)	Air quality, water quality, acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, mammals, and birds), sociocultural systems (local jobs and recreational facilities), and cultural resources (historic buildings or properties)
Marine vessel traffic	Crude oil tankers LNG tankers Tugs and barges Ferries Commercial vessels Commercial fishing vessels Military vessels Coal carrier Government vessels Dredge vessels USCG vessels Cruise ships Small watercraft	Noise Engine emissions (marine vessels) Fuel spills (marine vessels) Discharges of bilge water and waste Oil spills (vessel casualty) Increased wave action (nearshore) Collisions (wildlife with marine vessels) Collisions (among marine vessels)	Air quality, water quality, acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), and sociocultural systems (subsistence harvesting)
Wastewater discharge to Cook Inlet	Discrete conveyances such as pipes or Man-made ditches from sewage treatment plants, industrial facilities, and power generating plants Drilling wastes (offshore) Marine vessel and platform discharges	Permitted releases to water Pollutant releases via surface runoff (non-point sources)	Water quality, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), commercial and recreational fisheries, and sociocultural systems (local communities and subsistence harvesting)

TABLE 4.6.1-6 (Cont.)

Type of Action or Trend	Associated Activities, Facilities, or Trends	Impact-Producing Factors	Affected Resources and Systems
Persistent contaminants and marine debris	Accumulation of contaminants from multiple sources (discharges, spills, and releases; and atmospheric deposition) Accumulation of floating, submerged, and beached debris	Exposure to contaminants in marine waters and sediments, and in the food web via toxicity or bioaccumulation Collisions (marine vessels with debris) Entanglement in or ingestion of debris by marine wildlife Habitat displacement and/or degradation	Water (and sediment) quality, marine and coastal habitats, marine and coastal fauna (fish, mammals, and birds), commercial and recreational fisheries, and sociocultural systems (subsistence harvesting)
Alternate energy development	Cook Inlet Tidal Energy Project (ORPC) Tidal energy (East Foreland) Wind energy project (Fire Island) Underwater transmission line Turnagain Arm Tidal Energy Corporation (TATEC) Tidal energy project (Turnagain Arm) Underwater transmission line	Subsea noise and vibration Bottom sediment disturbance (turbidity and contaminant resuspension) Collisions (wildlife with infrastructure)	Acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), and cultural resources (if present)
Military operations	Joint Base Elmendorf-Richardson Airfield and aircraft traffic Combat training center Munitions storage Community facilities and residences Communication centers Impact areas and firing ranges (onshore) Maneuver areas (onshore) Major ranges (onshore) Contaminated sites (currently undergoing remediation)	Noise and vibration Disturbance or injury of fish and wildlife Disturbance of nearby residents Contaminant releases	Air quality, water quality, acoustic environment, marine and coastal habitats, and marine and coastal fauna (fish, marine mammals, and birds), and sociocultural systems (local communities and subsistence harvesting)

TABLE 4.6.1-6 (Cont.)

Type of Action or Trend	Associated Activities, Facilities, or Trends	Impact-Producing Factors	Affected Resources and Systems
Mining (coal and minerals)	<u>Chuitna Coal Project</u> Surface coal mine Support facilities Mine access road Coal transport conveyor Personnel housing Air strip facility Logistic center Coal export terminal Marine vessel traffic Aircraft traffic Land-based vehicle traffic and equipment	Noise and vibration Coal particulate and dust releases to air Soil erosion (from land disturbance) Deposition of fugitive dust Permitted releases to water Pollutant releases via surface runoff (non-point sources) Engine emissions (marine vessels and land-based vehicles and equipment) Fuel spills (marine vessels and land-based vehicles and equipment) Disturbance or injury of fish and wildlife Collisions (wildlife with marine vessels) Collisions (among marine vessels)	Air quality, water use (and patterns of recharge/discharge), water quality, acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), and sociocultural systems (local jobs and revenue, and subsistence harvesting)
	<u>Pebble Mining Project</u> Mine pit or workings Access infrastructure Power facilities Mill Tailings storage Low-grade ore stockpiles Warehouses Administrative facilities Worker housing Land-based vehicle traffic and equipment	Particulate releases to air Engine emissions (land-based vehicles and equipment) Permitted releases to water Soil erosion (from land disturbance) Pollutant releases via surface runoff (non-point sources) Disturbance or injury of wildlife	Air quality, groundwater quality, surface water quality and stream flow, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), and sociocultural systems (local jobs and revenue, and subsistence harvesting)
	<u>Abandoned Mine Lands</u>		Air quality, groundwater quality, surface water quality and stream flow, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), and sociocultural systems (local jobs and revenue, and subsistence harvesting)

TABLE 4.6.1-6 (Cont.)

Type of Action or Trend	Associated Activities, Facilities, or Trends	Impact-Producing Factors	Affected Resources and Systems
Dredging and marine disposal	Excavation of subaqueous sediments by clamshell, hydraulic cutterhead, pipeline suction, or bulldozer Transport or conveyance of dredged materials (by barge or suction pipeline)	Bottom sediment disturbance (turbidity and contaminant resuspension)	Water quality, marine and coastal habitats, marine and coastal fauna (fish and marine mammals), and cultural resources (if present)
Recreation and tourism	Shores and beaches Recreational fishing Water sports Cruise ships	Noise Disturbance or injury of fish and wildlife Habitat displacement and/or degradation Economic activity	Water quality, marine and coastal habitats, marine and coastal fauna (fish, mammals, and birds), and sociocultural systems (jobs and revenues, and subsistence harvesting)
Climate change	Increase in atmospheric and ocean temperatures Increase in precipitation rate Sea level rise and coastal erosion Ocean acidification	Changes in water quality (temperature, salinity, and pH) Changes in water circulation	Air quality, water quality, marine and coastal habitats, and marine and coastal fauna (fish, marine mammals, and birds)
Legislative actions (existing and forthcoming)	Federal statutes and regulations Executive orders State statutes and regulations	Management and protection of various resources throughout the marine and coastal regions of Cook Inlet	All resources

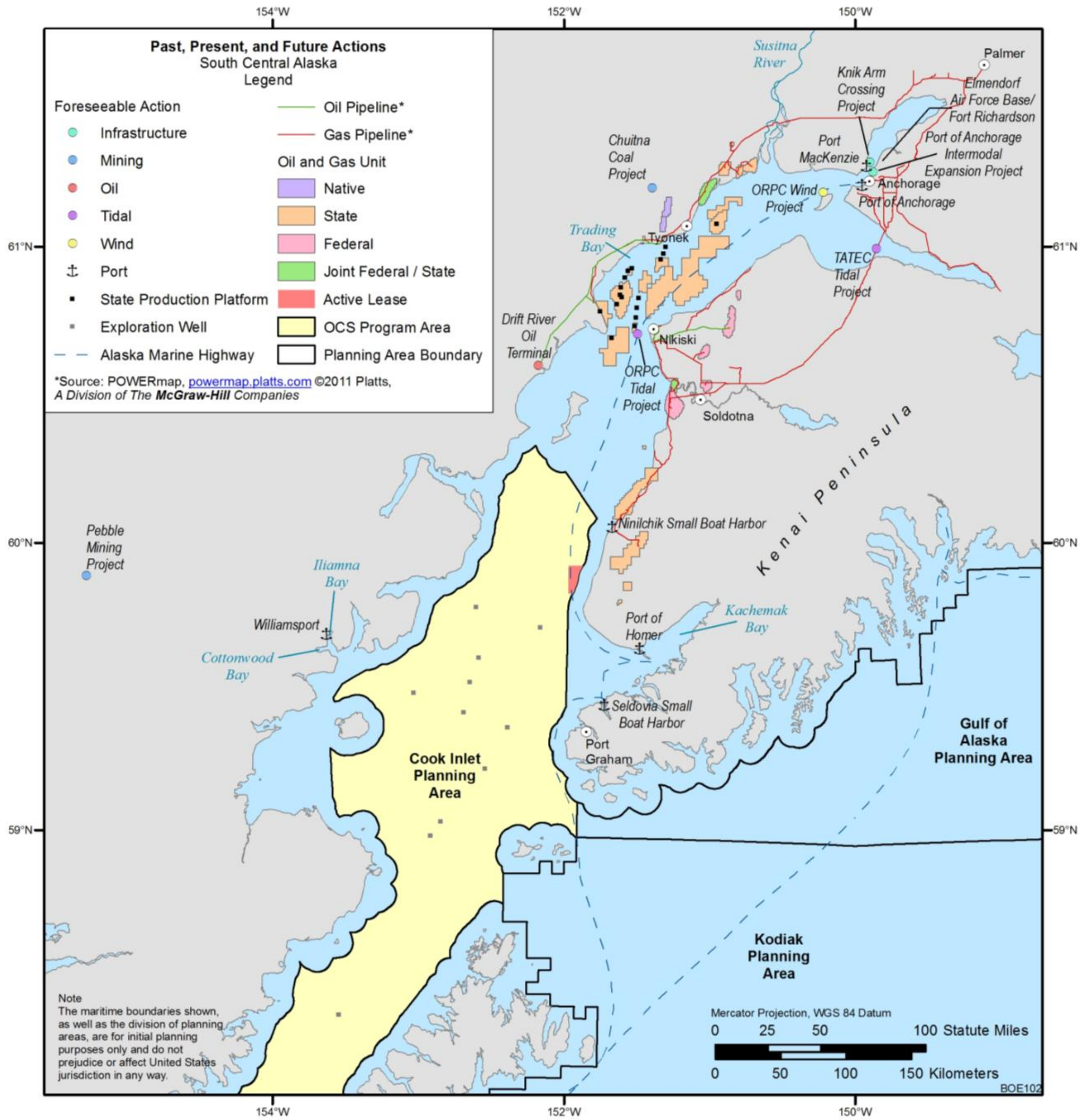

FIGURE 4.6.1-6 Ongoing and Reasonably Foreseeable Future Actions in Cook Inlet (within the Gulf of Alaska LME)

and on the west bank total about 322 km (200 mi) and 257 km (160 mi), respectively, in length (some of which are double lines) (MMS 2003a). Figure 4.6.1-6 shows the offshore production platforms and onshore producing wells; key processing, storage, and refining facilities; and oil and natural gas pipelines in and around Cook Inlet.

Ongoing oil and gas activities and existing infrastructure (both onshore and offshore) in the Cook Inlet region contribute to cumulative effects on air and water quality, the acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine and terrestrial mammals, and birds), sociocultural systems (local economies and subsistence), and cultural resources (if present). Important impact-producing factors include subaerial noise and subsea noise and vibration, platform lighting, engine emissions and fuel spills (marine vessels), oil spills (storage tanks and vessel casualty), hazardous spills and releases, oil and chemical releases (from wells and produced water), disturbance or injury of fish and wildlife, habitat displacement or degradation, chronic seafloor disturbance (by anchors and mooring lines), bottom sediment disturbance (turbidity and contaminant resuspension), resource consumption, wildlife collisions with marine vessels and infrastructure, and collisions among vessels.

Commercial Fishing. Commercial fisheries in Cook Inlet and the Gulf of Alaska are diverse and chiefly target groundfish, Pacific halibut, Pacific salmon, herring, crab, shrimp, clams, scallops, sea urchins, and sea cucumbers (see Section 3.12.1.2). In 2009, groundfish fisheries accounted for the largest share ($640 million or about 48%) of the ex-vessel value of all commercial fisheries in Alaska, followed by the Pacific salmon and shellfish fisheries, at $345 million (26%) and $195 million (15%).

All five species of Pacific salmon, razor clams, Pacific herring, and smelt are commercially harvested in the UCI Management Area.[37] The LCI Management Area supports commercial fisheries for salmon, groundfish, and scallops, but herring, king crab, Dungeness crab, and shrimp fisheries are currently restricted or closed while stocks rebuild. There are also gear restrictions in Cook Inlet, where the use of non-pelagic trawl gear is prohibited north of a line extending between Cape Douglas (58°51.10' N latitude) and Point Adam (59°15.27' N latitude).

The Pacific salmon commercial fisheries in State waters of the Gulf of Alaska are important to the economy of the region and are the second most valuable fisheries in Alaska ($345 million in 2009). The UCI Management Area supports gill net fisheries targeting Chinook, coho, pink, chum, and sockeye salmon. The LCI Management Area fisheries use gill net or seine gear and target pink, chum, and sockeye salmon. Total salmon harvest in LCI and UCI was approximately 3.85 million fish ($17.9 million ex-vessel value) in 2009. Pink salmon and sockeye salmon dominate the Cook Inlet salmon fishery by weight and monetary value.

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[37] The State of Alaska divides Cook Inlet into the Lower Cook Inlet (LCI) Management Area comprised of all waters west of the longitude of Cape Fairfield, north of the latitude of Cape Douglas, and south of the latitude of Anchor Point; and the Upper Cook Inlet (UCI) Management Area, which consists of Cook Inlet north of the latitude of the Anchor Point Light (see Section 3.12.1.2).

Pacific herring are targeted for food, bait, or herring roe. Depending on the area, herring harvested as food or bait may be commercially fished using trawl, seine, or gill net gear. Sac roe may be harvested using seine, purse seine, or gill net gear. In Cook Inlet, herring harvests are greatest in Kamishak Bay. Over the last decade, the abundance of Pacific herring has been stable, but historically very low, and the commercial Pacific herring fishery in LCI Management Area was closed during 2010 for the 12th successive season. The decline in herring may be attributable to the protozoan pathogen *Ichthyophonus*. In the UCI Management Area, eulachon and smelt are commercially harvested. The smelt harvest in the UCI Management Area has generally increased from 1978 (0.2 tons) to 2010 (63 tons [Shields 2010b]). Smelt are primarily sold as bait and have low commercial value.

While fishery-related activities have beneficial effects to local economies, they may also contribute to adverse cumulative effects on water quality, the acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), and sociocultural systems (local economies). Important impact-producing factors include noise, fuel spills (fishing vessels), disturbance of marine wildlife (ingestion and/or entanglement), bottom sediment disturbance (turbidity and contaminant resuspension), damage to hard bottoms, and resource consumption.

Harbors, Ports, and Terminals. The largest port facilities in Cook Inlet are Anchorage, MacKenzie, Tyonek, Nikiski, Drift River, Kenai, Anchor Point, and Homer (Figure 4.6.1-6). Alaska's largest seaport is the Port of Anchorage, located along the lower Knik Arm. The port is a deep draft facility that accommodates barges and ships of all types (although cruise ships are infrequent). It is the main port of entry for the south-central and interior regions of Alaska. Port MacKenzie is a barge port located at the head of Cook Inlet along the Knik Arm across from the Municipality of Alaska. It recently completed the second phase of its development, which includes a deep-draft marine port. The Tyonek/North Foreland's Dock is a light-draft port located on the west side of Cook Inlet; it did not have vessel calls in 2010 (NMFS 2010; Matanuska-Susitna Borough 2012; Eley 2006, 2012).

The Nikiski industrial terminals are located on the east side of Cook Inlet, between Homer and Anchorage. Three side-by-side deep-draft moorages extend about 1.6 km (1 mi) from Tesoro's Kenai pipeline pier at the north end of the complex to the Agrium wharf at the south end; the ConocoPhillips pier lies between them. At one time, activity here included the shipping and receiving of anhydrous ammonia (Agrium), dry bulk urea, LNG (ConocoPhillips), petroleum products, sulfuric acid, caustic soda, and crude oil. In 2010, however, only the Kenai pipeline dock was active. The Agrium dock and ConocoPhillips LNG facility were dormant in 2010 and 2011. The LNG facility is currently the only LNG export operation in the United States and at its peak exported about 64 Bcf of LNG per year. It has opened temporarily in 2012 and will lease a tanker to make four exports to Asia later in the year before shutting down its operations (Mazurek 2011; Eley 2012).

The Drift River oil terminal is located about 37 km (23 mi) west-southwest of Nikiski on the west shore of Cook Inlet. It is mainly used as a loading platform for shipping crude oil collected via pipeline from various production platforms in the inlet. The docking facility is connected to a shore-side tank farm (with a storage capacity greater than 1 Mbbl) and is designed to accommodate tankers in the 150,000 ton class. Tank ships moor at the terminal while loading crude oil, then transport it to Tesoro's Kenai pipeline at Nikiski, where the oil is offloaded and refined (NMFS 2010; Eley 2006, 2012).

The Port of Homer is located within Kachemak Bay. It consists of a boat harbor, two deep draft docks, two deep draft moorages, and one deep draft anchorage. It also has three shallow draft docks. Alaska Marine Highway ferries and USGC cutters are moored at the port year round; cruise ships call from May through September. There is a pilot "embarkation station" west of the Homer spit in Kachemak Bay; it is used by ships and tugs as they wait for favorable weather conditions in the inlet or the Gulf of Alaska (Eley 2012).

There is a 6-m (20-ft) draft dock at the City of Seldovia. Moorages there accommodate the Alaska Marine Highway System ferries and are available for fuel barges and small passenger vessels. There are shallow draft facilities at Port Graham (receiving fuel oil barges and fishing vessels) and Williamsport (in Iliamna Bay) (Eley 2012).

The Alaska Marine Highway System, part of the National Highway System, runs along the south-central coast of Alaska, the eastern Aleutian Islands, southeast Alaska, and British Columbia (Canada) to Bellingham, Washington. Portions of the highway operate in Cook Inlet, from Anchorage, Homer, and Seldovia, and various other ports in the Gulf of Alaska (Figure 4.6.1-6).

Activities and vessel calls at ports, harbors, and terminals in Cook Inlet are likely to increase over the next 40 to 50 years as several port expansion projects are completed and economic activity increases. Activities associated with port facilities contribute to cumulative effects on air and water quality, the acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), commercial and recreational fisheries, sociocultural systems (local economies and subsistence), and cultural resources (if present). Important impact-producing factors include noise, engine emissions, fuel spills (marine vessels), permitted discharges to air and water, pollutant releases via surface water runoff, oil spills, hazardous spills and releases, accidental explosions or fires, cooled water releases (LNG plant), wildlife collisions with infrastructure and marine vessels, and collisions among marine vessels.

Port of Anchorage Intermodal Expansion Project. The Port of Anchorage Intermodal Expansion Project, shown in Figure 4.6.1-6, is currently under way to create two new barge berths, two new large cargo vessel ship berths, deep draft for modern vessels (with greater spacing between berths), improved seismic capacity, 26 ha (65 ac) of new land designated for commercial and industrial use at the Port, and an 8-km (5-mi) haul road to provide secure access to Joint Base Elmendorf-Richardson (JBER). The project permit was obtained in 2007 and sheet pile installation began in 2008. The expansion project is scheduled to be completed by 2019 (Port of Anchorage 2012).

Marine vessel traffic at the Port of Anchorage will likely increase over the next 40 to 50 years as the expansion project is completed and marine vessel traffic increases. Activities associated the expansion project (both construction and operational phases) would contribute to cumulative effects on air and water quality, the acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), commercial and recreational fisheries, sociocultural systems (local economies and subsistence), and cultural resources (if present). Important impact-producing factors include noise, engine emissions and fuel spills (marine vessels and land-based vehicles and equipment), disturbance or injury of fish and wildlife, habitat displacement or degradation, bottom sediment disturbance (turbidity and contaminant resuspension), permitted discharges to air and water, pollutant releases via surface water runoff, oil spills (marine vessel casualty), wildlife collisions with infrastructure and marine vessels, and collisions among marine vessels.

Knik Arm Crossing Project. The Knik Arm Crossing Project, shown in Figure 4.6.1-6, would construct a 2,500-m (8,200-ft) bridge crossing of Knik Arm and 29 km (18 mi) of connector roads (on both sides) to connect the Municipality of Anchorage and the Matanuska-Susitna (Mat-Su) Borough. The project's objective is to improve regional connectivity and capacity needed to accommodate existing and projected growth in population, economic development, and transportation in the upper Cook Inlet region in the coming decades. A ROD for the project was issued by the Federal Highway Administration on December 15, 2010 (Miller 2010). Preconstruction for the bridge began in 2009; construction is expected to run through 2015 (KABATA 2012).

The benefits of the Knik Arm Crossing are numerous, including economic stimulus, lowered costs for Alaskan drivers, and reductions in carbon emissions (Miller 2010). Construction (and some operational) activities may also contribute to adverse cumulative effects on air and water quality, the acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), sociocultural systems (local economies and recreational facilities), and cultural resources (historic buildings or properties). Important impact-producing factors associated with bridge and road construction include noise, engine emissions and fuel spills (marine vessels and land-based vehicles and equipment), disturbance of wildlife, habitat displacement and/or degradation, fuel spills, and wildlife collisions with marine vessels.

Marine Vessel Traffic. Marine vessel traffic in Cook Inlet is moderate to low when compared to other west coast ports and water ways, with an average of 486 ships of 300 gross tons or more each year, about 8 to 10 ships per week (Eley 2006). Vessels range in size from the smallest fishing vessels to gas tankers weighing over 65,000 gross tons. In 2010, large vessel calls at marine facilities and terminals in Cook Inlet totaled 480 (similar to 2005 and 2006); of these, 218 were to the Port of Anchorage; 86 were to the Nikiski oil or gas terminals; and 123 were through Kachemak Bay. Most of these calls (67%) were container vessels, roll-on/roll-off cargo ships, or ferries; 20% were gas or liquid petroleum tankships; and 4% were bulk carriers and general cargo. Another 4% were fishing vessels and cruise ships (Eley 2012).

In 2010, crude oil and persistent product tank ships called at the Nikiski Tesoro facility and the Drift River oil terminal (no chemical tanker transits or port calls occurred in 2010). There were 12 gas tank ship calls to the ConocoPhillips LNG plant in Nikiski (all by the same tanker). Only refined product (jet fuel) tank ships called at the Port of Anchorage, including one military vessel (a product tank ship). One coal vessel docked at Port MacKenzie to obtain coal trucked from Healy, Alaska. Most deep draft vessel traffic occurs along the east side of the inlet, while tank ships travel between Nikiski and the Drift River terminal on the west side (Eley 2012).

Vessel traffic in the coming decade is expected to remain relatively flat or show only moderate increases (about 1.5 to 2.5% annually), although larger increases could be seen if the global demand for Alaska resources (oil, gas, coal) increases and the construction of the Alaska gas pipeline attracts cargo ship calls to the Port of Anchorage or Port McKenzie. Most of the vessel traffic is expected to be from U.S. tank ships (double-hulled) calling at Nikiski and other scheduled port calls (Eley 2012).

Oil spills from vessels in Cook Inlet are relatively rare. Between 1992 and 2006, there were 295 oil spills reported from vessels operating in Cook Inlet, all of which were classified by the USCG as "minor" (i.e., not connected to a vessel casualty). About 43% of these spills were small diesel or gasoline spills from fishing vessels and pleasure craft. A significant vessel spill occurred in 1987 when a tank ship (Glacier Bay) ran aground south of the mouth of the Kenai River en route to Nikiski. Hull damage caused the release of 492,000 L (130,000 gal) of oil[38] (Eley 2006).

Marine vessel traffic contributes to cumulative effects on air and water quality, the acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), and sociocultural systems (subsistence). Important impact-producing factors associated with tanker traffic in Cook Inlet include noise, engine emissions, fuel spills, discharges of bilge water and waste, oil spills (vessel casualty), wildlife collisions with marine vessels, increased wave action (nearshore), and collisions among marine vessels.

Wastewater Discharge to Cook Inlet. The major point sources of pollution in Cook Inlet include discharges (by discrete conveyances such as pipes and man-made ditches) from municipal wastewater treatment plants (e.g., Anchorage), seafood processors, and the petroleum industry (MMS 1995b). Also included are offshore discharges from drilling activities and marine vessels. Most of these activities would remain at present levels for the foreseeable future and are not expected to affect the overall water quality in Cook Inlet. Discharges are regulated through the USEPA NPDES permit program. Section 403 of the CWA established the Ocean Discharge Criteria, which provide additional requirements for these types of discharges. The Alaska Department of Environmental Quality issues all NPDES permits in Alaska except for those related to oil and gas, munitions, cooling water, pesticides, and offshore seafood processors, and those on tribal lands. Current NPDES permits in Alaska are available on the USEPA Region 10 Web site (see http://yosemite.epa.gov/r10/water.nsf/NPDES+Permits/CurrentAK822).

Non-point sources of pollution include stormwater and snowmelt that runs over land or through the ground, entraining pollutants and depositing them into the inlet. (The Cook Inlet watershed is home to two-thirds of Alaska's population; therefore, the quality of runoff in the

[38] The State of Alaska Department of Environmental Conservation (Division of Spill Prevention and Response) reports that the tanker spill was as high as 784,000 L (207,000 gal) (ADEC 2012a).

watershed is heavily influenced by human activity). The most common forms of pollution in Alaska's urban runoff include fecal coliform, sedimentation, and petroleum. Snow disposal into the marine environmental also introduces oil, grease, antifreeze, chemicals, trash, animal wastes, salt, and sediments (sand, gravel, suspended and dissolved solids) (ADEC 2007b). Non-point source management programs under Section 319 of the CWA regulate these pollutant sources. The USEPA and NOAA also co-administer State Coastal Non-Point Pollution Control Programs under Section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990 (USEPA 2011g).

Both point and non-point source discharges to Cook Inlet are expected to continue and could increase over the next 40 to 50 years (based on projected increases in population and development along the inlet). Pollutant discharges contribute to cumulative effects on water quality, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), commercial and recreational fisheries, and sociocultural systems (local communities and subsistence). Important impact-producing factors associated with discharges include contaminant releases via permitted conveyances and surface runoff.

Persistent Contaminants and Marine Debris. Persistent contaminants are natural and man-made substances introduced to the environment that are resistant to natural degradation; these include various heavy metals (e.g., mercury, cadmium, lead, and chromium), as well as herbicides, pesticides, PCBs, and dioxin. Because they do not degrade naturally, these substances are capable of long-range transport and may bioaccumulate in the tissues of ecological and human receptors. Sources of persistent contaminants include permitted discharges and surface runoff (with suspended sediments) from agricultural, industrial, or urban areas; and atmospheric deposition. The presence of persistent contaminants in the waters and sediments of Cook Inlet contributes to cumulative effects on water and sediment quality, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), commercial and recreational fisheries, and sociocultural systems (subsistence). Important impact-producing factors include exposure of marine fauna to toxic pollutants (resulting in mortality or reproductive problems) and habitat displacement and/or degradation. Such factors lead to unstable or contaminated fish stocks (or other species) that in turn affect species higher in the food web (via toxicity or bioaccumulation).

NOAA defines marine debris as "any persistent, manufactured, or processed solid material that is directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment" (NOAA 2009). Marine debris in Cook Inlet could include ocean-based materials such as fishing gear, oil and gas items (plastic drill pipe thread protectors, hard hats, gloves, and 55-gal storage drums), and lost vessel cargo. Materials from land-based sources can also find their way into Cook Inlet waters via blowing winds, waves washing ashore, littering, dumping in rivers and streams, and industrial losses. Weather also plays a role as storm water flows along streets and the ground carrying litter into storm drains; high winds, heavy rains, tsunamis, and tidal surges are also capable of dispersing solid objects into marine waters (NOAA 2012d). The presence of marine debris in the waters and sediments of Cook Inlet contributes to cumulative effects on the same resources as described for persistent contaminants. Important impact-producing factors include collisions of marine vessels with debris and entanglement in or ingestion of debris by marine wildlife.

Floating debris from the 2011 Japan tsunami (a soccer ball and a volleyball) was discovered in April 2012 in Middleton Island, Gulf of Alaska, about 80 km (50 mi) south of Prince William Sound. There is no longer a floating debris field as most of the tsunami-related objects have dispersed across a large area of the North Pacific, and there are no estimates of how much debris is still floating or whether this debris will reach the U.S. coast (AOOS 2012; NOAA 2012d).

Alternate Energy Development. Upper Cook Inlet has a large tidal range (9 m [30 ft]) that produces rapid currents throughout the inlet, especially through the constricted Forelands area. Two projects have been proposed to develop tidal energy in Cook Inlet (Figure 4.6.1-6). The Ocean Renewable Power Company (ORPC) proposes to build a project offshore of the East Foreland near Nikiski that would convert tidal currents into electricity and transmit it to the Alaskan Railbelt grid using an underwater transmission line. The pilot project would produce up to 5 MW of electricity; ORPC anticipates that each 1 MW of nameplate capacity would produce up to 3,450 MW-hours per year. A preliminary permit to produce 1,000 MW of electricity was issued by FERC in 2010 for this project; construction is scheduled to begin in 2012. The ORPC has also been awarded a preliminary permit to build a wind turbine on the west side of Fire Island, near Anchorage (Figure 4.6.1-6). The wind turbine would provide energy to the City of Anchorage and the Alaskan Railbelt grid (ORPC 2010; FERC 2012d).

The Turnagain Arm Tidal Energy Corporation (TATEC) proposes to build the Turnagain Arm Tidal Energy Project to develop tidal energy on 26 ha (65 acres) within Cook Inlet near Anchorage. The project would transmit tidal power to the Alaskan Railbelt grid. A preliminary permit to produce 240 MW of electricity (expandable to 1,200 MW) was issued by FERC in 2010 for this project. Construction is expected to occur between 2014 and 2018 (TATEC 2011; FERC 2012d).

Alternate energy projects provide beneficial effects in terms of providing cleaner sources of energy and adding jobs to local communities. They may also contribute to adverse cumulative effects (mainly during their construction) on the acoustic environment, marine and coastal habitats, and marine and coastal fauna (fish, marine mammals, and birds). Important impact-producing factors associated with alternate energy development in Cook Inlet include subsea noise and vibration, bottom sediment disturbance (turbidity and contaminant resuspension), and wildlife collisions with infrastructure).

Military Operations. JBER consists of the combined bases of Elmendorf Air Force Base and Fort Richardson (U.S. Army). JBER-Elmendorf sits on 5,445 ha (13,455 ac) within the Municipality of Anchorage, about 11 km (7 mi) northeast of downtown Anchorage (Figure 4.6.1-6). The base has an active duty Air Force, tenant units (U.S. Navy, U.S. Marine Corps, and U.S. Army and their dependents), a civilian and contractor workforce, and retired military in south-central Alaska. Its main facility is the airfield located in the southern part of the base. The northern part of the base includes a munitions storage area, an Explosive Ordnance Disposal range, a small arms range, a combat training center, and various communication centers. Its mission support activities include airfield flight line functions, munitions storage, base security, and readiness training for remote airbase development (JBER 2011).

JBER-Richardson is located about 11 km (7 mi) northeast of Anchorage (Figure 4.6.1-6). It encompasses 2,330 ha (5,760 ac) of developed land along the Glenn Highway and provides housing, community facilities (e.g., schools, libraries, medical and dental, and physical fitness, among others), and various activities for military residents. It has another 22,260 ha (55,000 ac) of maneuver areas, 31 training areas, numerous impact areas (artillery and mortar firing points), and major ranges (including small arms ranges, two demolition ranges, landing zones, and drop zones). The 4/25th Infantry Brigade Combat Team (Airborne) is located at Fort Richardson (JBER 2011).

Although the various activities at JBER are land- or air-based, they have the potential to impact resources in Cook Inlet. These include the types of activities mentioned above, as well as historical disposal practices (e.g., sites such as Eagle River Flats contaminated by white phosphorus, currently undergoing remediation; ADEC 2012a). JBER has detailed its current resource management practices and compliance with environmental requirements (e.g., pertaining to monitoring and protection of threatened or endangered species) in its *Integrated Natural Resource Management Plan* (JBER 2011).

Military operations at JBER are expected to continue and military use areas are expected to remain the same over the next 40 to 50 years. Such operations contribute to cumulative effects on air and water quality, the acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), and sociocultural systems (local communities and subsistence). Important impact-producing factors associated with military operations in Cook Inlet include noise and vibrations, disturbance or injury of fish and wildlife, disturbance of nearby residents, and contaminant releases.

Mining (Coal and Minerals).

Chuitna Coal Project. The proposed Chuitna Coal Project is a surface coal mining and export development located on public and private lands in the Beluga Coal Field of south-central Alaska, about 72 km (45 mi) west of Anchorage and 19 km (12 mi) northwest of the Native Village of Tyonek (Figure 4.6.1-4). The center of the proposed project is about 19 km (12 mi) from the Cook Inlet coast. As currently proposed, the project would consist of a surface mine, support facilities, a mine access road, a coal transport conveyor, personnel housing, an air strip facility, a logistics center, and a coal export terminal. The project would have a life of about 25 years, with a production rate of up to 12 million tons of ultra-low, sub-bituminous coal per year (an estimated lifetime production of 300 million tons). Project applications to the ADNR (the lead State permitting agency) by PacRim Coal LLC are currently undergoing revisions. The Draft EIS for the project is scheduled to be completed in late 2012 (ADNR 2012a; USACE 2012).

The Chuitna Coal Project would likely contribute to cumulative effects on air and water quality, water use (and patterns of recharge and discharge), the acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine and terrestrial mammals, and birds), and sociocultural systems (local economies and subsistence). Important impact-producing factors associated with surface mining include noise and vibration, coal particulate and dust releases to air, soil erosion (from land disturbance), deposition of fugitive dust, permitted releases to water, pollutant releases via surface runoff (non-point sources), engine emissions and fuel spills (marine vessels and land-based vehicles and equipment), disturbance or injury of fish and wildlife, wildlife collisions with marine vessels, and collisions among marine vessels.

Pebble Mining Project. The Pebble deposit is located north of Iliamna Lake, about 27 km (17 mi) northwest of Iliamna and Newhalen (Figure 4.6.1-6). The deposit is one of the world's largest copper-gold porphyry systems. It is estimated to contain 48 billion pounds of copper, 57 million ounces of gold, and 2.9 billion pounds of molybdenum and may also contain economically significant quantities of silver, palladium, and rhenium. The Pebble mining project would include mine pits (or workings), access infrastructure, power facilities, a mill, tailings storage, low-grade ore stockpiles, warehousing, administrative facilities, and worker housing (Pebble Limited Partnership 2011). Although the site is located at some distance from Cook Inlet, resources in the inlet could be affected by potential releases of contaminants via drainages discharging to the inlet and atmospheric deposition from the project area. To date, only an environmental baseline study has been completed (conducted between 2004 and 2008); there are no set plans for construction of the project.

The Pebble Mining Project would likely contribute to cumulative effects on air quality, groundwater (quality), surface water (quality and stream flow), marine and coastal habitats, marine and coastal fauna (fish, marine and terrestrial mammals, and birds), and sociocultural systems (local economies and subsistence). Important impact-producing factors associated with mining include particulate releases to air, engine emissions (land-based vehicles and equipment), permitted releases to water, soil erosion (from land disturbance), deposition of fugitive dust, pollutant releases (via surface runoff), and disturbance or injury of wildlife.

Abandoned Mine Lands. There are seven abandoned mine lands (coal projects) in south-central Alaska. The specific locations of these lands have not been reported by the ADNR. The types of risks associated with these lands include surface impoundments, gob piles, slurry deposits, and surface burning; and physical hazards such as portals, vertical openings, high walls, rock piles and embankments, spoil areas, hazardous equipment and facilities, and subsidence or slumping (ADNR 2011a).

Abandoned mine lands are currently undergoing restoration under the ADNR's Abandoned Mine Lands Program to reduce their environmental impact and the risk they pose to the public. Until they are restored, these lands could contribute to cumulative effects on air quality, groundwater (quality), surface water (quality and stream flow), marine and coastal habitats, marine and coastal fauna (fish, marine and terrestrial mammals, and birds), and sociocultural systems (local economies and subsistence). Important impact-producing factors associated with abandoned mines include particulate releases to air, pollutant releases (via surface runoff), releases to groundwater (via infiltration and leaching), soil erosion (from land disturbance), deposition of fugitive dust, and potential injury or mortality of humans and wildlife.

Dredging and Marine Disposal. As authorized by the *Rivers and Harbors Appropriation Act*, the USACE conducts annual maintenance dredging projects to prevent shoaling at several locations within Cook Inlet: in Anchorage Harbor (in Knik Arm), Homer

Small Boat Harbor, and Ninilchick Harbor (Anderson 2010). Dredging in Anchorage Harbor occurs during the ice-free season, beginning in the spring, and continuing into the summer when shoaling is greatest, and into the fall. Operations typically use a clamshell (with or without a small hopper dredge) and barge. Dredged material from the harbor is tested for various contaminants (pesticides, PCBs, petroleum hydrocarbons, volatile and semi-volatile organics, and heavy metals) and, if clean, moved by barge and tug to a deepwater site south of the project, where it is dispersed by tidal activity (USACE 2011b).

At Homer Small Boat Harbor, dredging typically occurs in September. Dredging is conducted with a hydraulic cutterhead and pipeline suction dredge. Dredged materials are tested for various contaminants, then conveyed via portable pipeline (from the floating dredge plant) to a bermed site on the pit where they are used to maintain its integrity. Because the harbor is located within the Kachemak Bay Critical Habitat Area, a CWA Section 404 permit is required for dredging (USACE 2011b).

Dredging at Ninilchik Harbor (in lower Cook Inlet) usually runs from December through mid-May (or as soon as possible to avoid conflicts with the in-coming salmon run). Material is either hydraulically dredged (from a floating plant with a hydraulic cutterhead) or removed with a bulldozer. Dredged material from the basin is tested for various contaminants and, if clean, conveyed by pipeline to a beach north of the project; material bulldozed from the entrance is used as a containment dike for dredge spoils from the basin (USACE 2011b).

In addition to annual maintenance dredging activities, several other dredging actions associated with ongoing and planned construction projects throughout Cook Inlet will continue and likely increase over the coming decades. These include dredging actions related to various USACE civil works projects, as well as those associated with the expansion of the Port of Anchorage, the Knik Crossing Bridge (new bridge piers), the Chuitna Coal Project (new terminal near Tyonek), the Diamond Point Granite Rock Quarry (vessel dock in Cottonwood Bay), and the Pebble Mine Project (new terminal in Iniskin Bay).

The beneficial effects of dredging include improving navigational depths for marine vessels and providing materials for restoration projects. Dredging and disposal may also contribute to adverse cumulative effects on water quality, the acoustic environment, coastal and marine habitats, coastal and marine fauna (fish and marine mammals), and cultural resources (if present). Important impact-producing factors of dredging and disposal are noise and turbidity/contaminant resuspension caused by bottom sediment disturbance.

Recreation and Tourism. The Cook Inlet offers many opportunities for recreational activities such as hunting, hiking, boating, wildlife viewing, and sightseeing, and tourism in the region is robust (see Section 3.13.1.2). Tour ships from the lower 48 States regularly travel to southeast Alaska, and independent travelers use the Alaska Maritime Highway (ferry) system to access the region. Sightseeing tours via small aircraft and helicopters have developed locally. Other tours involve small regional tour ships, river jet-boat tours, fishing charters, and bed-and-breakfast operations.

While recreation and tourism have beneficial effects on local economies, they may also contribute to adverse cumulative effects on water quality, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), and sociocultural systems (subsistence). Important impact-producing factors include noise, wildlife disturbance or injury, and habitat displacement and/or degradation.

Climate Change. Because a growing body of evidence shows that climate change is occurring (Section 3.3), we have included it as a current and foreseeable natural trend in the cumulative impacts analysis for some resources in Cook Inlet. Analyses that take into account impact-producing factors related to climate change meet one or both of the following two criteria:

- The resource is already experiencing impacts from climate change, so the effects are observable and not speculative, or
- The resource will be directly affected by warming temperatures.

Not all impacts from climatic and hydrologic changes that are the indirect result of temperature changes have been analyzed because they may be too uncertain to predict. For example, it is reasonable to expect changes in precipitation regimes as a result of climate change. Furthermore, it is also likely that precipitation changes would, in turn, affect the coastal salinity balance between freshwater flow and tidal influence in some areas, and that these changes would affect fisheries and fish populations in some way. However, both the magnitude and direction of each factor in this sequence of occurrences are uncertain. While we acknowledge that continuing climate change could result in changing regional ecological and socioeconomic patterns and distributions, at this stage of our understanding of underlying processes, the rates and directions of many of these changes are too speculative to include in the cumulative analyses that follow.

Legislative Actions. Major statutes governing the management and protection of resources within the Cook Inlet Planning Area are listed in Appendix C. Regulations and permitting programs based on these statutes, for example, the dredge permitting program based on Section 404 of the *Clean Water Act*, are overseen by the USACE and other regulating authorities. The statutes and regulations are discussed in the previous sections and in the resource impacts sections, as they apply.

4.6.1.2.4 Non-OCS Program Actions and Trends – Arctic Region. Table 4.6.1-7 summarizes ongoing and reasonably foreseeable future actions and trends affecting resources and systems in the Arctic region. Past and present actions are generally accounted for in the baseline environment (described in Chapter 3) and the analysis of direct and indirect impacts under each resource area (Section 4.4). These impacts are carried forward to the cumulative analysis, which also takes into account the effects of ongoing and reasonably foreseeable future actions and trends. Cumulative scenarios (based on types of actions) and impact-producing factors are described for each action or trend on the basis of recent environmental reports or NEPA reviews. Figures 4.6.1-7 and 4.6.1-8 show general locations of ongoing and reasonably

TABLE 4.6.1-7 Ongoing and Reasonably Foreseeable Future Actions and Trends – Arctic Region

Type of Action or Trend	Associated Activities, Facilities, or Trends	Impact-Producing Factors	Affected Resources and Systems
Ongoing oil and gas exploration, development, and production activities and existing infrastructure (onshore, in State waters, and Canadian and Russian waters)	*Ongoing activities onshore and in State waters:*		
	<u>35 producing oil fields</u> Seismic surveys Exploratory drilling Offshore drilling vessels Bridges, roadways, and docks Processing facilities Waste disposal facilities Gravel and ice pads Artificial gravel islands Production wells Pipelines (gathering and carrier) TAPS (Pump Station 1) Dredging Gravel mining Marine vessel traffic Land-based vehicles and equipment traffic Aircraft traffic	Subaerial noise and subsea noise and vibration Facility lighting Engine emissions (marine vessels and land-based vehicles and equipment) Fuel spills (marine vessels and land-based vehicles and equipment) Oil spills (storage tanks and vessel casualty) Hazardous spills/releases Oil and chemical releases (wells and produced water) Chronic seafloor disturbance (anchors) Bottom sediment disturbance (turbidity and contaminant resuspension) Disturbance or injury of fish and wildlife Habitat displacement or degradation Deposition of fugitive dust Altered wildlife migration patterns (e.g., caribou) Collisions (wildlife with marine vessels and infrastructure) Resource consumption	Air quality, water quality, acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, mammals, and birds), terrestrial habitat and fauna, sociocultural systems (local jobs and revenue, and subsistence harvesting), and cultural resources (if present)
	Ongoing activities in Canadian waters:		
	MacKenzie Valley and onshore Yukon Arctic Islands MacKenzie Delta/Beaufort Sea	Same as for ongoing activities onshore and in State waters	Same as for ongoing activities onshore and in State waters
	Ongoing activities in Russian waters (unknown)	Same as for ongoing activities onshore and in State waters	Same as for ongoing activities onshore and in State waters

TABLE 4.6.1-7 (Cont.)

Type of Action or Trend	Associated Activities, Facilities, or Trends	Impact-Producing Factors	Affected Resources and Systems
Foreseeable future oil and gas exploration, development, and production activities and infrastructure (onshore, and in State and Federal OCS waters)	*Foreseeable future activities onshore and in State waters:*		
	Alaska (Gas) Pipeline Project New gas treatment plant (Prudhoe Bay) 32- in. pipeline (Point Thomson to Prudhoe Bay) 48-in. (main) pipeline system Compressor stations Marine vessel traffic (sealifts) Land-based vehicles and equipment traffic LNG shippers (Valdez option)	Same as for ongoing activities onshore and in State waters	Same as for ongoing activities onshore and in State waters
	Point Thomson Project (Beaufort) Central and satellite pads Production and injection wells Processing facility (including flare stacks) Pipelines Support facilities (offices, warehouses, maintenance buildings, camps, waste management facilities, and boat ramp) Water and electricity distribution systems Ice and gravel roads Airstrip Service pier Sealift facility and barge mooring dolphins Dredging Gravel mining	Same as for ongoing activities onshore and in State waters	Same as for ongoing activities onshore and in State waters

TABLE 4.6.1-7 (Cont.)

Type of Action or Trend	Associated Activities, Facilities, or Trends	Impact-Producing Factors	Affected Resources and Systems
	Liberty Project (Beaufort) Expansion of existing infrastructure (Endicott Satellite Drilling Island) New bridge and ice road/ice pad Seismic surveys Marine vessel and land-based vehicle traffic Production wells Water and gas injection wells Pipeline transport (TAPS) Gravel mining	Same as for ongoing activities onshore and in State waters	Same as for ongoing activities onshore and in State waters
	Foreseeable future activities in Federal lands and OCS waters:		
	National Petroleum Reserve (BLM land) Exploratory drilling (past and future)	Same as for ongoing activities onshore and in State waters (if developed)	Same as for ongoing activities onshore and in State waters (if developed)
	ANWR - 1002 Area (FWS-managed) Research and monitoring (past)	Same as for ongoing activities onshore and in State waters (if developed)	Same as for ongoing activities onshore and in State waters (if developed)
	Beaufort and Chukchi Seas OCS Seismic surveys Exploratory drilling Marine vessel traffic Offshore drilling vessels Production wells	Same as for ongoing activities onshore and in State waters	Air quality, water quality, acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, mammals, and birds), and sociocultural systems (subsistence harvesting)
Subsistence activities	Hunting and trapping Fishing Whaling and sealing Onshore camping (crews) Small marine vessel traffic (*umiat* and aluminum skiffs)	Resource consumption	Marine, coastal, and terrestrial fauna

TABLE 4.6.1-7 (Cont.)

Type of Action or Trend	Associated Activities, Facilities, or Trends	Impact-Producing Factors	Affected Resources and Systems
Marine vessel traffic	Cargo vessels Tugs and barges Service vessels Cruise ships (limited) Spill-response vessels Hovercraft Military vessels Research vessels (icebreakers) Small watercraft (hunting and intra-village transportation)	Noise Fuel spills Engine emissions Discharges of bilge water and waste Oil spills (vessel casualty) Increased wave action (nearshore) Collisions (wildlife with marine vessels) Collisions (among vessels)	Air quality, water quality, acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), and sociocultural systems (subsistence harvesting)
Scientific research	Marine vessel traffic (including submersibles) Sampling, tagging, and tracking species of interest Seismic surveys Drilling Sediment and subsurface sampling Well installation and geophysical logging	Subsea noise and vibration Disturbance of wildlife Bottom sediment disturbance (turbidity and contaminant resuspension)	Water quality, acoustic environment, marine and coastal habitats, and marine and coastal fauna (fish, marine mammals, and birds)
Wastewater discharge to Arctic waters	Discrete conveyances such as pipes or man-made ditches from sewage treatment plants, industrial facilities, and power generating plants Drilling wastes (offshore) Marine vessel discharge	Permitted releases to water Pollutant releases via surface runoff (non-point sources)	Water quality, marine and coastal habitats, marine and coastal fauna (fish, mammals, and birds), commercial and recreational fisheries, and sociocultural systems (local communities and subsistence harvesting)
Persistent contaminants and marine debris	Accumulation of contaminants from multiple sources (discharges, spills, and releases; and atmospheric deposition) Accumulation of floating, submerged, and beached debris	Exposure to contaminants in marine waters and sediments, and in the food web via toxicity or bioaccumulation Collisions (marine vessels with debris) Entanglement in or ingestion of debris by marine wildlife Habitat displacement and/or degradation	Water (and sediment) quality, marine and coastal habitats, marine and coastal fauna (fish, mammals, and birds), commercial and recreational fisheries, and sociocultural systems (subsistence harvesting)

TABLE 4.6.1-7 (Cont.)

Type of Action or Trend	Associated Activities, Facilities, or Trends	Impact-Producing Factors	Affected Resources and Systems
Military operations	Aircraft traffic Marine vessel traffic (submarines and icebreakers)	Subaerial and subsea noise Engine emissions (marine vessels) Fuel spills (marine vessels) Discharges of bilge water and waste Oil spills (vessel casualty) Collisions (wildlife with marine vessels)	Air quality, water quality, acoustic environment, marine and coastal habitats, and marine and coastal fauna (fish, marine mammals, and birds), and sociocultural systems (subsistence harvesting)
Mining (coal and minerals)	Red Dog Mine (Chukchi) Open pit lode mine (lead and zinc) Mineral extraction (drilling, blasting, loading, and hauling of ore) Waste rock and ore stockpiles Tailings impoundments Incinerator Solid waste disposal areas Land-based vehicle traffic (transport of ore by to port facility) Marine vessel traffic (transport of ore by barge from port facility) Mine expansion (to include Aqqaluk deposit) Reclamation activities (e.g., grading) Coal Development in Northern Alaska Nanushak project (proposed) Other (placer) mining (Chukchi) Possible use of mercury amalgamation (of gold placers)	Noise Permitted releases to air and water Particulate and dust releases to air Pollutant releases via surface runoff (non-point sources) Engine emissions (marine vessels and land-based vehicles and equipment) Fuel spills (marine vessels and land-based vehicles and equipment) Deposition of fugitive dust Collisions (wildlife with marine vessels)	Air quality, water quality, marine and coastal habitats, marine and coastal fauna (fish, mammals, and birds), and sociocultural systems (local jobs and revenue, and subsistence harvesting).
Dredging and marine disposal	Excavation for artificial islands and shipping corridors (oil and gas industry) Excavation for harbors, and nearshore channels and mooring basins Transport or conveyance of dredged materials (by barge or pipeline)	Noise Bottom sediment disturbance (turbidity and contaminant resuspension)	Water quality, acoustic environment, marine and coastal habitats, marine and coastal fauna (fish and marine mammals), and cultural resources (if present)

TABLE 4.6.1-7 (Cont.)

Type of Action or Trend	Associated Activities, Facilities, or Trends	Impact-Producing Factors	Affected Resources and Systems
Recreation and tourism	Wildlife viewing Aircraft traffic Marine vessel traffic (cruise ships and commercial vessels) Recreational/sport fishing and hunting Recreational activities (e.g., rafting) Cruise ships and commercial vessels	Noise Disturbance or injury of fish and wildlife Habitat displacement and/or degradation	Water quality, marine and coastal habitats, marine and coastal fauna (fish, mammals, and birds), and sociocultural systems (jobs and revenues; subsistence harvesting)
Climate change	Increase in atmospheric temperatures Increase in precipitation rates Sea level rise and coastal erosion Reduction in extent of September sea ice Reduction in multi-year sea ice Thawing of permafrost	Changes in water quality (temperature, salinity, and pH) Changes in water circulation Increased navigability	Air quality, water quality, marine and coastal habitats, and marine and coastal fauna (fish, marine mammals, and birds), commercial and recreational fisheries, and sociocultural systems (community structures infrastructure, and subsistence harvesting)
Legislative actions (existing and forthcoming)	Federal statutes and regulations Executive orders State statutes and regulations International agreements	Management and protection of various resources throughout the marine and coastal regions of the Beaufort and Chukchi Seas	All resources

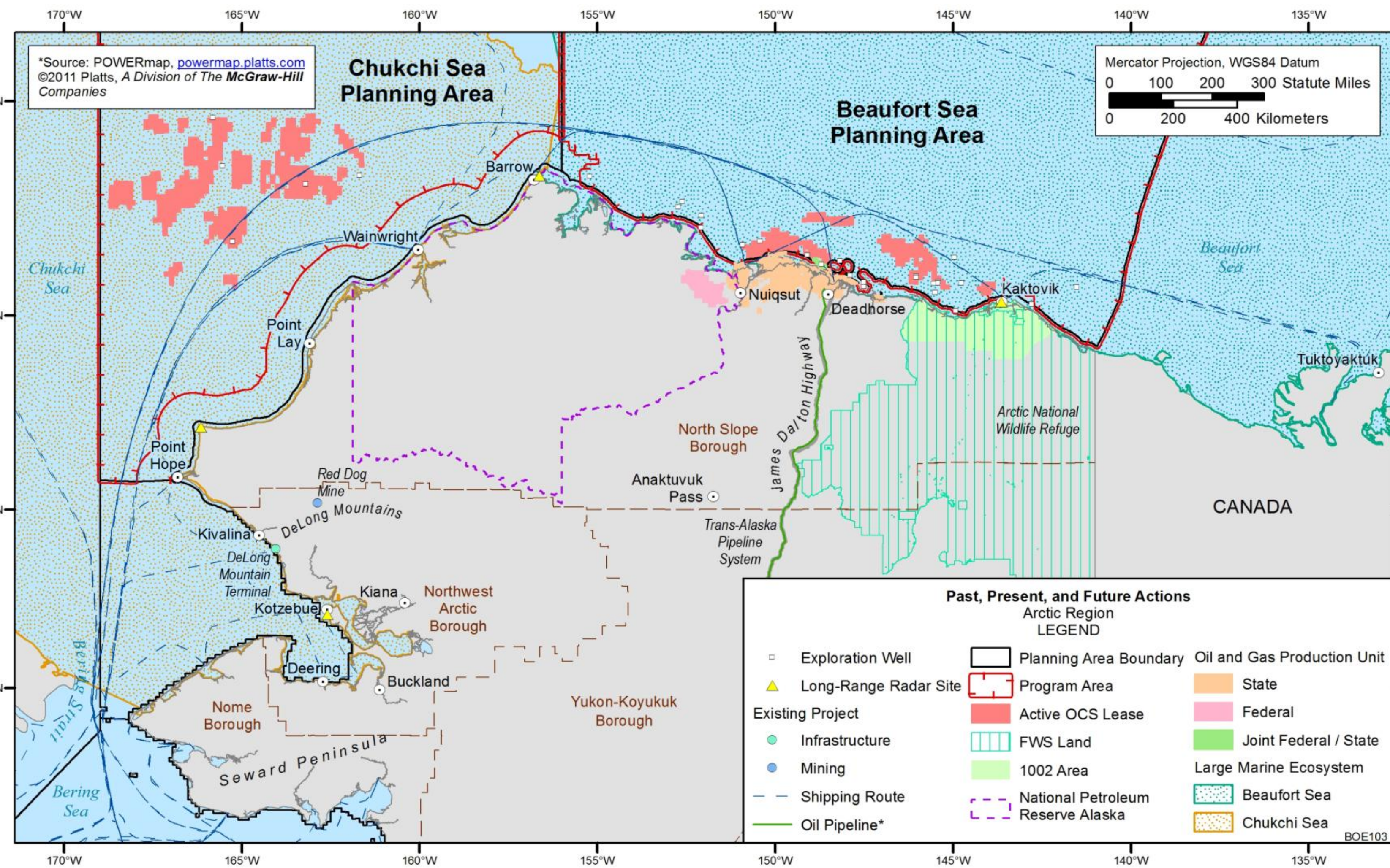

FIGURE 4.6.1-7 Ongoing and Reasonably Foreseeable Future Actions in the Arctic Region

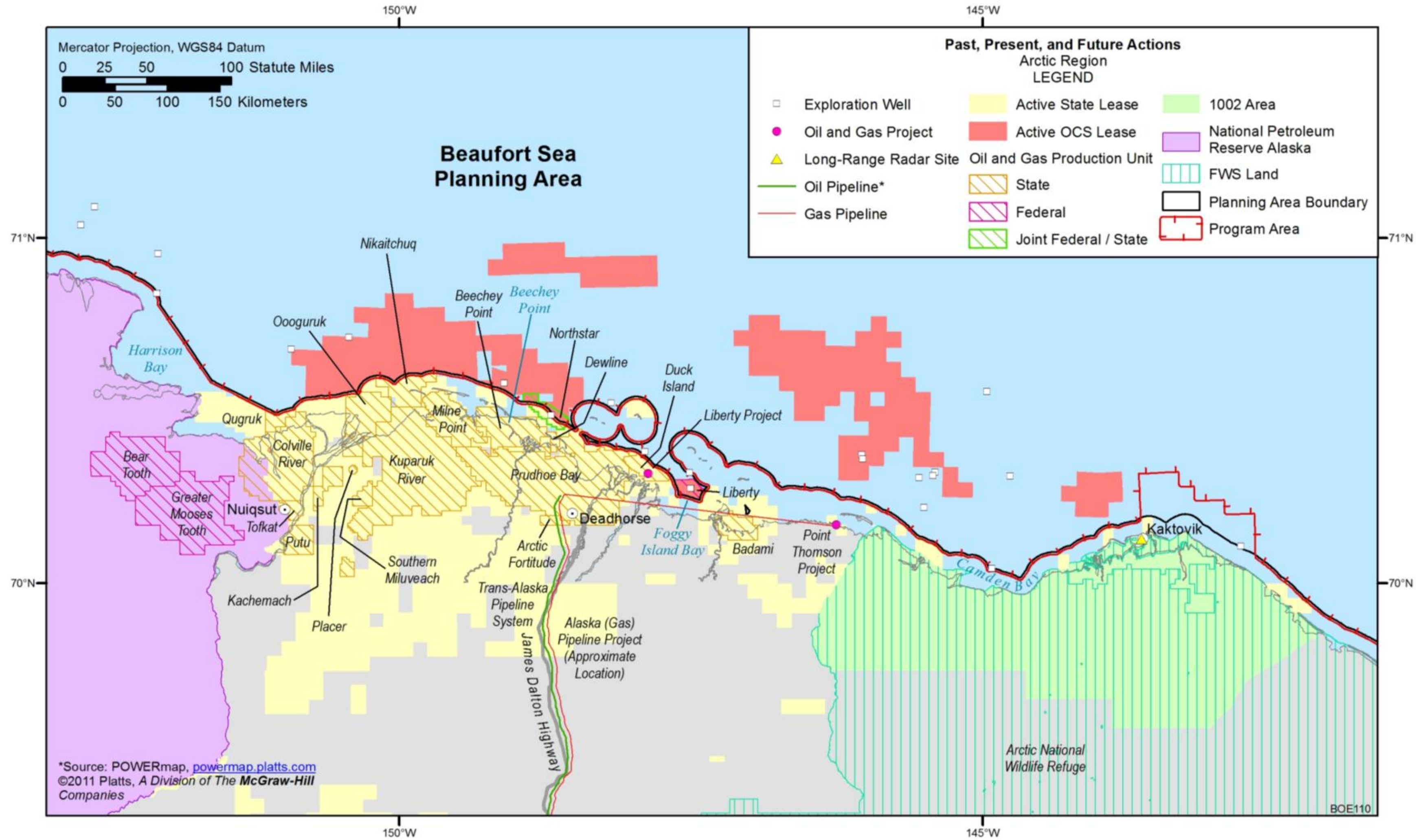

FIGURE 4.6.1-8 Ongoing and Reasonably Foreseeable Future Actions along the Beaufort Sea Coastline

foreseeable future actions in the Beaufort Sea and Chukchi Sea Planning Areas relative to the LMEs.

Ongoing Oil and Gas Exploration, Development, and Production Activities and Existing Infrastructure.

Onshore and in State Waters. Oil and gas exploration in the Arctic region of Alaska began in the late 1950s when federally-sponsored geological studies found that the region had significant oil reserve potential. The first State of Alaska lease sale on the North Slope took place in 1964, and by 1968, the Prudhoe Bay oil field (the largest oil field in North America) was in production. By 2001, oil development on the North Slope consisted of 19 producing fields and related infrastructure (roads, pipelines, power lines, production facilities, and transportation hubs). Because of the high cost of building infrastructure (due to the remoteness and harsh weather of the region), many Arctic fields remain undeveloped; for example, the EIA estimates that 35.4 Tcf of the discovered natural gas resources in the Arctic, two-thirds of which is in the Prudhoe Bay field, remain undeveloped due to lack of transportation infrastructure (NRC 2003; Budzik 2009).

Currently, there are 35 producing oil fields and satellites on the North Slope and nearshore areas of the Beaufort Sea. The oil fields are distributed among the various unit pools shown in Figure 4.6.1-8: Prudhoe Bay (12), Duck Island (3), Northstar (1), Badami (1), Kuparak (5), Milne Point (3), Colville River (8), Ooogaruk (1), and Nakiatchuq (1) (NTEL 2009). Industrial development centers on Prudhoe Bay; infrastructure includes artificial gravel islands, roadways, pipelines, production and processing facilities, gravel mines, and docks. Most oil and gas projects are onshore or are located offshore in State waters of the Beaufort Sea. Currently, there are no leases in the State waters of the Chukchi Sea, and no oil and gas production along its coast (MMS 2008b).

Two large diesel fuel spills occurred in the Beaufort Sea — one with a volume of 2,440 bbl, from a diesel tank on an eroded gravel island in the Canadian Beaufort Sea (September 1985); and another with a volume of 1,600 bbl, from a punctured barge delivering fuel to Kaktovik (August 1988) (MMS 2008b). Between 1995 and 2005, there were 4,481 spills of seawater, produced water, crude oil, diesel, and drilling muds on the Alaska North Slope subarea, with an estimated volume of 45,000 bbl (98% of which resulted from spills greater than 99 gal). Oil exploration and production facilities were responsible for more than 90% of the spills and about 90% of the volume. Over the past 20 years, however, most large spills were of diesel fuel and occurred in local villages (ADEC 2007a; MMS 2008b).

Ongoing oil and gas activities and existing infrastructure (both onshore and offshore) in the Arctic region contribute to cumulative effects on air and water quality, the acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine and terrestrial mammals, and birds), sociocultural systems (local economies and subsistence), and cultural resources (if present). Important impact producing factors include subaerial noise and subsea noise and vibration, facility lighting, engine emissions and fuel spills (marine vessels and land-based vehicles and equipment), oil spills, hazardous spills and releases, oil and chemical releases (from wells and produced water), chronic seafloor disturbance (by anchors), bottom sediment disturbance (turbidity and contaminant resuspension), disturbance or injury of fish and wildlife, habitat displacement or degradation, deposition of fugitive dust, altered wildlife migration patterns, wildlife collisions with marine vessels and infrastructure, and resource consumption.

Canadian Arctic Activities. Northern Canada contains about a quarter of Canada's remaining discovered resources of conventional petroleum and a third to a half of the country's estimated potential (Northern Oil and Gas Directorate 2007). This resource is distributed throughout northern Canada as follows:

- Mackenzie Valley and onshore Yukon – Twenty-six significant discoveries and three producing fields: the Norman Wells oil field produces oil at rates of 30,000 bbl per day (6.294 bbl = 1 m^3) with initial recoverable reserves of 235 Mbbl; the Kotaneelee and Pointed Mountain fields close to the British Columbia-Alberta border had produced 417 billion ft^3 (35.3 ft^3 = 1 m^3) of gas by the end of 1997.

- Arctic Islands – Nineteen significant discoveries after fewer than 200 exploration wells; the Bent Horn field in the Arctic Islands, which produced high-quality light oil for many years on a seasonal basis, has only recently been abandoned.

- Mackenzie Delta/Beaufort Sea – Discovered resources of in excess of 1 Bbbl of oil and 9 Tcf of gas in 53 significant discoveries. Four Tcf of marketable gas have been discovered in three onshore discoveries, and offshore discoveries include over 200 Mbbl in the Amauligak field. On the Mackenzie Delta, the Ikhil gas discovery is being developed to supply natural gas to the town of Inuvik, where it will replace imported diesel oil for power generation and domestic use.

There is little information on oil and gas exploration and development activities currently being conducted by Canada in the Arctic. If such activities are in progress, it is assumed that the effects would be similar to those resulting from oil and gas exploration and development in the Alaska Arctic region.

Russian Arctic Activities. There is little information on oil and gas exploration and development activities currently being conducted by Russia adjacent to the U.S. Arctic. If such activities are in progress, it is assumed that the effects would be similar to those resulting from oil and gas exploration and development in the Alaska Arctic region.

Foreseeable Future Oil and Gas Exploration, Development and Production Activities and Infrastructure.

Onshore and in State Waters. Several exploration wells on State oil and gas leases in the Beaufort Sea have either been drilled recently or are reasonably foreseeable in 2012 (Petroleum News 2012a). These include:

- Repsol – One exploratory well (Kachemak-1) was drilled and experienced a loss of well control releasing about 42,000 gallons of drilling mud; no oil was spilled (ADEC 2012d). A permit for a second well, Q-4, was approved on March 29. The North Slope Borough and Nuiqsut has set a limit of no more than three drilling rigs operating at any given time;

- Brooks Range Petroleum Corp. – One well completed;

- Savant – Permit approved for one well, drilling would begin sometime in April;

- ConocoPhillips – One well completed;

- Pioneer – One well completed, another being drilled; and

- Great Bear – Seismic surveys underway (as of April 2), six to eight wells to be drilled beginning in mid-May.

In addition to these wells, Brooks Range Petroleum Corporation plans to drill seven horizontal production wells in the Mustang prospect by 2014. The prospect is located in the new Southern Miluveach Unit, on the southwestern boundary of the Kuparuk River Unit (Figure 4.6.1-8). Several other prospects held by Brooks Range Petroleum Corporation (near the Prudhoe Bay and Badami Units and Beechey Point) are considered economically feasible and will likely be developed in the near future (Petroleum News 2012b).

There are three other oil and gas developments in the Beaufort Sea coastal region that are reasonably foreseeable in the next 5 to 10 years, including the Alaska (Gas) Pipeline Project, the Point Thomson Project, and the Liberty Project (Figure 4.6.1-8). These projects would take place onshore or nearshore, in areas where industry infrastructure is already well established, but would also involve activities that could contribute to cumulative impacts in the marine environment, especially air and water quality, the acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), sociocultural systems (local economies and subsistence), and cultural resources (if present).

Important impact-producing factors associated with new oil and gas projects in the Beaufort Sea coastal region include subaerial noise and subsea noise and vibration, engine emissions and fuel spills (marine vessels and land-based vehicles and equipment), oil spills, hazardous spills and releases, oil and chemical releases (in produced water), bottom sediment disturbance (turbidity and contaminant resuspension), disturbance or injury of fish and wildlife, habitat displacement or degradation, altered wildlife migration patterns, wildlife collisions with marine vessels and infrastructure, and resource consumption.

Alaska (Gas) Pipeline Project. The Alaska Pipeline Project (TransCanada) would connect the natural gas resources developed on the North Slope to markets both within and outside of Alaska. The project consists of a new gas treatment plant (GTP) near Prudhoe Bay; 93 km (58 mi) of 32-in.-diameter pipeline connecting the processing plant at the Point Thomson field to the GTP; and about 1,200 km (745 mi) of 48-in.-diameter mainline pipeline from the GTP to the Alaska-Yukon (Canada) border. TransCanada is currently in the process of conducting baseline studies and preparing reports in support of its Federal permit. The NOI to prepare an EIS for the pipeline project was issued by FERC on August 1, 2011, and public scoping took place in February 2012 (FERC 2012e). According to Office of the Federal Coordinator (Alaska Natural Gas Transportation Projects), further action on the pipeline to Alberta may be delayed while a second option, involving a pipeline to Valdez to facilitate large-scale LNG exports to Asia, is considered (OFC 2012). The pipeline project is estimated to take 10 years to permit and construct once its application is filed with FERC.

Point Thomson Project. The proposed Point Thomson Project (ExxonMobil) would delineate and evaluate hydrocarbon resources in the Point Thomson Unit (Figure 4.6.1-8), with the objective of initiating production of commercial hydrocarbon liquids by the winter season of 2015–2016. Hydrocarbon liquids would be delivered to the TAPS for shipment to market. Project activities include the construction of a central gravel pad for production and injection wells; support facilities, including offices, warehouses, maintenance buildings, temporary camps, drinking water and sanitary wastewater treatment systems, waste management facility, communication facilities, electric power generation and distribution facilities, and an emergency response boat ramp; two satellite gravel pads for production wells; ice roads; a gravel airstrip for year-round access to Point Thomson; a service pier; a sealift facility and barge mooring dolphins; a new gravel mine site; infield gravel roads; and infield gathering pipelines, one for each production well. Offshore portions of the reservoir would be reached using directional drilling. An export pipeline would also be constructed from the central pad to the existing Endicott common carrier pipeline connecting to TAPS Pump Station No. 1. Other infrastructure to be built includes water and power distribution systems, communications towers, and staging facilities (USACE 2011a).

Liberty Project. The proposed Liberty Project (British Petroleum) is an oil and gas development located about 8.9 km (5.5 mi) offshore on an expanded area of the Endicott Satellite Drilling Island (SDI) into the Beaufort Sea (Figure 4.6.1-8). The project involves expanding the Endicott SDI by about 8 ha (20 ac) to support drilling into the Liberty reservoir located on Federal offshore leases managed by BOEM and upgrading the Sagavanirktok River road bridge to accommodate the transportation of Liberty's drilling rig (both completed in 2009; Petroleum News 2009). The drilling program will include one to four production wells, and one or two water and gas injection wells. Oil produced from the project will be sent by existing pipeline infrastructure (Endicott production flowline system) from the Endicott SDI to the Endicott Main Production Island (MPI) for processing, then to the TAPS through the existing Endicott sales-oil pipeline. Produced gas will be used for fuel or re-injected into the reservoir for enhanced oil recovery. Equipment, supplies, and personnel will access the project site via the existing Endicott road system, which connects with roads at Prudhoe Bay and with the Dalton Highway. Onshore and offshore ice roads will be built to support project construction (and possibly drilling operations). No regularly scheduled helicopter access to the project site is expected (although there is sufficient area on the Endicott SDI for landing, if needed). A sealift by barge would necessitate travel through the Chukchi and Beaufort Seas; the barge would offload at an existing MPI dock. Extensive dredging is not anticipated (BP 2007).

Another onshore support activity associated with the Liberty project is the development of a new permitted gravel mine site. Water for the project is provided by the existing produced-water injection system and augmented with treated seawater (from the existing Endicott Seawater Treatment Plant), as needed (BP 2007).

The land use permit and easements for wellbores and injection wells into State subsurface were issued by the ADNR in January 2010 (ADNR 2010). The project was originally expected to start production in 2010, but has been delayed until 2013 or later (Petroleum News 2011a, b).

Federal Land and OCS Waters. There are three major areas of Federal land for which oil and gas activities are reasonably foreseeable in the next 5 to 15 years. These include the National Petroleum Preserve-Alaska (NPR-A), the Arctic National Wildlife Refuge (ANWR) Area 1002, and the Beaufort and Chukchi Seas OCS (discussed below).

<u>National Petroleum Reserve-Alaska.</u> The NPR-A is a 9.3-million-ha [23-million-ac] area of public land on the North Slope of Alaska managed by the BLM (Figures 4.6.1-7 and 4.6.1-8). The USGS estimates mean volumes of recoverable oil and natural gas in the NPR-A of 896 Mbbl and 53 Tcf, respectively. This estimate was lowered from the previous estimates on the basis of recent exploration drilling that showed an abrupt transition from oil to gas just 16 to 32 km (10 to 20 mi) west of the Alpine oil field and poor reservoir quality in key formations (Houseknect et al. 2010).

Integrated activity plans have been developed by BLM (2004, 2006a, and 2012a) that identify the lands within the NPR-A available for leasing, as well as those restricted from leasing, and specify stipulations and restrictions on surface activities in the lease areas of the NPR-A. There have been seven lease sales in the NPR-A (in 1999, 2002, 2004, 2006, 2008, 2010, and 2011) and as a result of these sales, the BLM currently administers 186 Federal oil and gas leases on the NPR-A (BLM 2012b). However, no production wells have been established in the NPR-A to date. A total of 29 exploration wells have been drilled within the reserve since 2000 (most focused to the west and southwest of Alpine), and additional exploratory drilling is likely in the coming decades (BLM 2012b). It is less certain at this time whether production facilities would be established within the NPR-A during the life of the Program.

<u>Arctic National Wildlife Refuge (1002 Area).</u> The ANWR is located on the northern coast of Alaska to the east of Prudhoe Bay (Figures 4.6.1-7 and 4.6.1-8). The area was designated by the Alaska National Interest Lands Conservation Act (ANILCA) in 1980. The USGS estimates that recoverable oil in the coastal plain area of ANWR (referred to as the 1002 Area) is between 5.7 and 16.0 Bbbl. Section 1002 of ANILCA deferred any decisions on oil and gas development until studies could be performed to better assess the extent and amount of petroleum resources, as well as potential impacts to the fish and wildlife resources in the region. These studies were completed and submitted to Congress in 1987. Currently, the 1002 Area is managed by the USFWS as a "minimal management" area and it will continue to be managed by the USFWS until Congress decides how petroleum resources in the 1002 Area will be developed. For this reason, it is uncertain whether leasing in ANWR will occur during the life of the Program (Budzik 2009; USFWS 2008).

The USFWS Comprehensive Conservation Plan (CCP) is a document that outlines and guides long-term management for a National Wildlife Refuge. The original CCP for Arctic Refuge was signed into effect in 1988. The USFWS is now midway through a 2-year process to revise the 1988 CCP and the accompanying EIS. The draft CCP contains six management alternatives but no preferred alternative. The USFWS will consider public comments before selecting a preferred alternative. The final CCP and EIS are anticipated in the summer of 2012 (see http://arctic.fws.gov/ccp.htm).

Beaufort and Chukchi Seas OCS. Exploratory drilling in Federal OCS lands began in 1981, a few years after construction of the TAPS was completed. After 33 years of leasing, however, there are no commercial oil or gas facilities on the OCS (see Figure 4.6.1-7 for active leases on the Federal OCS; Northstar accesses Federal reserves from a facility within State waters). Although exploratory drilling in the Beaufort Sea OCS has declined since 1990, there were several seismic programs in the region during the 1990s and early 2000s. Acquisitions of leases by Shell during OCS Lease Sale No. 195 (2005) and recent approval of its oil spill response plan by the BSEE indicate that drilling activity on the Beaufort Sea OCS is likely in the near term. Shell submitted its exploration plan to drill on three OCS lease blocks in the Camden Bay area of the Beaufort Sea in 2011. ConocoPhillips has also proposed drilling in the Chukchi Sea; however, at this date there in no approved plan (NRC 2003; NTEL 2009; BOEM 2012c).

Exploratory drilling in the Chukchi Sea OCS began in the late 1980s and continued into the 1990s; most of the seismic data acquisition was completed by the end of 1991 (although 2D and 3D surveys were conducted in 2006 and 2007). A second phase of activity began in early 2008 prior to OCS Lease Sale No. 193, where industry spent over 2.6 billion dollars acquiring leases. This sale is expected to initiate an exploration effort in the near term (NTEL 2009).

Exploration activities on the Beaufort and Chukchi Seas OCS could contribute to cumulative impacts in the marine environment, especially air and water quality, the acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), and sociocultural systems (subsistence). Important impact-producing factors associated with these activities include subaerial noise and subsea noise and vibration, engine emissions and fuel spills (marine vessels), hazardous spills and releases, oil and chemical releases (from wells and produced water), disturbance or injury of fish and wildlife, and wildlife collisions with marine vessels.

Subsistence Activities. The majority of permanent residents of the Arctic and Bering Sea coasts are Alaska natives for whom subsistence activities are group activities that further core values of community, kinship, cooperation, and reciprocity (see Section 3.14.3.2). In general, subsistence foods consist of a wide range of fish and game products; these include fish, such as Broad white fish, Arctic cisco, and Arctic char/Dolly Varden; marine mammals, such as bowhead whale, bearded seal, ringed seal, and walrus; terrestrial mammals, such as caribou, wolves, and wolverines; and waterfowl, such as geese and eider. Table 3.14.3-14 provides a more comprehensive list of subsistence resources used by Alaska Native villages.

Each community has its own unique harvest pattern and preferences. Subsistence harvesting follows a seasonal pattern and is constrained by changes in climate and by the migration patterns of whales, fishes, and birds. Bowhead whales are harvested during both their spring and fall migrations. Subsistence activities generally occur along the coast, concentrated in areas directly offshore from villages. The village of Nuiqsut stages its fall bowhead whale hunt on Cross Island. Seaward harvesting occurs within 40 km (25 mi) of shore, but may extend as far as three times that distance, depending on the conditions of sea and ice. Marine vessels used in subsistence marine harvesting include light seal-skin *umiat* and aluminum skiffs (in open water for the fall harvest).

Subsistence resources on Federal lands and the navigable waters along the Arctic coast are managed by the Federal Subsistence Management Program under the FSB. The program is a multi-agency effort to support a subsistence way of life by rural Alaskans on Federal public land and waters while maintaining healthy populations of fish and wildlife (through research and monitoring). Priority for subsistence harvesting of Federal public lands and water are expressed in ANILCA. The MMPA encourages cooperative agreements between Alaska Native organizations and Federal agencies to conserve marine mammals and provide management of subsistence use.

Marine Vessel Traffic. The current level of vessel traffic is low, consisting mainly of vessels supporting the oil and gas industry (e.g., cargo vessels, tugs/barges, service vessels, spill response vessels, and hovercraft). Other vessels include those used by the military, by Arctic researchers (icebreakers), and by local communities for hunting and between-village transportation during the open water period. As open water season begins earlier and ends later, vessel traffic is likely to increase for shipping, research, and cruise-ship tourism in the coming decades (MMS 2008b).

There is substantial international vessel traffic in the Bering Strait (the narrow international strait that connects the northern Pacific Ocean to the Arctic Ocean) and Chukchi Sea (Figure 4.6.1-7); activity in this region increased from 245 marine vessel transits in 2008 (in the Bering Strait) to 325 transits in 2010. This trend is expected to continue with ongoing exploration and drilling activities on the U.S. OCS and the Northern Sea Route along the Russian portion of the Chukchi shelf (USCG 2011a).

Scientific Research. Scientific research programs are ongoing in the offshore areas of the Beaufort and Chukchi Seas. These include studies of marine mammals, fish, birds, habitats, ecosystems, and physical oceanography conducted by Federal agencies such as BOEM, NOAA (NMFS), and the NSF. Activities related to scientific research of physical systems involve the use of marine vessels, and include seismic surveys, ocean floor drilling/sampling, well installation, and geophysical logging. Activities related to scientific research of biological systems requires some human presence and interaction with wildlife, such as sampling, tagging, or tracking species of interest.

Research-related activities in the Beaufort and Chukchi Seas are likely to increase over the next 40 to 50 years (in response to concerns over the environmental effects of oil and gas development and climate change in the Arctic region). While such activities are necessary and beneficial, they may also contribute to adverse cumulative effects on water quality, the acoustic environment, coastal and marine habitats, and coastal and marine fauna (fish, marine mammals, and birds). Important impact-producing factors include subsea noise and vibration, disturbance or injury of fish and wildlife, and bottom sediment disturbance (turbidity and contaminant resuspension).

Wastewater Discharge to Arctic Waters. Point-source discharges to the Beaufort and Chukchi Seas include those from facilities related to the oil and gas industry, hard-rock and placer mining, military operations, and seawater treatment (ADEC 2010; USEPA 2010c). Most of these activities would remain at present levels for the foreseeable future and are not expected to affect the overall water quality in these regions. Discharges are regulated through the USEPA NPDES permit program. Section 403 of the CWA established the Ocean Discharge Criteria, which provide additional requirements for these types of discharges. The Alaska Department of Environmental Conservation issues all NPDES permits in Alaska except for those related to oil and gas, munitions, cooling water, pesticides, and offshore seafood processors, and those on tribal lands. Current NPDES permits in Alaska are available on the USEPA Region 10 Web site (see http://yosemite.epa.gov/r10/water.nsf/NPDES+Permits/CurrentAK822).

Non-point sources of pollution include stormwater and snowmelt that run over land or through the ground, entraining pollutants and depositing them into Arctic waters. The most common forms of pollution in Alaska's urban runoff include fecal coliform, sedimentation, and petroleum. Snow disposal into the marine environment also introduces oil, grease, antifreeze, chemicals, trash, animal wastes, salt, and sediments (sand, gravel, suspended and dissolved solids) (ADEC 2007b). Non-point source management programs under Section 319 of the CWA regulate these pollutant sources. The USEPA and NOAA also co-administer State Coastal Non-Point Pollution Control Programs under Section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990.

Both point and non-point source discharges to Arctic waters are expected to continue and could increase over the next 40 to 50 years (based on projected increases in economic development in the Beaufort and Chukchi Seas coastal regions). Pollutant discharges contribute to cumulative effects on water quality, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), commercial and recreational fisheries, and sociocultural systems (local communities and subsistence). Important impact-producing factors associated with discharges include contaminant releases via permitted conveyances and surface runoff.

Persistent Contaminants and Marine Debris. Persistent contaminants are natural and manmade substances introduced to the environment that are resistant to degradation naturally; these include various heavy metals (e.g., mercury, cadmium, lead, and chromium), as well as herbicides, pesticides, PCBs, and dioxin. Because they do not degrade naturally, these substances are capable of long-range transport and may bioaccumulate in the tissues of ecological and human receptors. Sources of persistent contaminants include permitted discharges and surface runoff (with suspended sediments) from agricultural, industrial, or urban areas; and atmospheric deposition. The presence of persistent contaminants in the waters and sediments in the Arctic region contributes to cumulative effects on water and sediment quality, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), commercial and recreational fisheries, and sociocultural systems (subsistence). Important impact-producing factors include exposure of marine fauna to toxic pollutants (resulting in mortality or reproduction problems) and habitat displacement and/or degradation. Such factors lead to unstable or contaminated fish stocks (or other species) that in turn affect species higher in the food web (via toxicity or bioaccumulation).

NOAA defines marine debris as "any persistent, manufactured, or processed solid material that is directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment" (NOAA 2009). Marine debris in Arctic waters could include ocean-based materials such as fishing gear, oil and gas items (plastic drill pipe thread protectors, hard hats, gloves, and 55-gal storage drums), and lost vessel cargo. Materials from land-based sources can also find their way into Arctic waters via blowing winds, waves washing ashore, littering, dumping in rivers and streams, and industrial losses. Weather also plays a role as storm water flows along streets and the ground carrying litter into storm drains; high winds and heavy rains are also capable of dispersing solid objects into marine waters (NOAA 2012d). The presence of marine debris in the waters and sediments of the Beaufort and Chukchi Seas contributes to cumulative effects on the same resources as described for persistent contaminants. Important impact-producing factors include collisions of marine vessels with debris and entanglement in or ingestion of debris by marine wildlife.

Military Operations. As an effect of changing climate in the Arctic (the opening of Arctic waters in the coming decades) and in response to security concerns (boundary disputes and competition for resources), the military plans to increase its presence in the Arctic region to monitor the air, land, maritime, space, and cyber domains for potential threats to the United States. This effort would include coordination with various domestic (e.g., USCG) and international partners (e.g., Russia and Canada). Military activities in the region would mainly involve the use of aircraft, submarines, icebreakers, or ice-strengthened surface vessels. The military does not anticipate a need for a deep-draft port between now and 2020. It is uncertain whether (or when) basing infrastructure would be needed; the military plans to reassess these needs periodically. Its strategy is finding balance between investing in Arctic capabilities in a timely fashion without making premature investments that draw resources away from more pressing needs (O'Rourke 2012).

Currently, the U.S. Air Force maintains four long range radar sites along the coasts of the Beaufort and Chukchi Seas: Kotzebue, Cape Lisburne, Point Barrow, and Barter Island (Figures 4.6.1-7 and 4.6.1-8). Four others have been deactivated: Point Lay (in 1994), and Wainwright, Bullen Point, and Flaxman Island (in 2007) (National Air Defense Radar Museum 2012).

In the coming decades, the military will likely increase its presence in the Arctic region via aircraft and marine vessels, including submarines and icebreakers. Increased air and marine vessel traffic contributes to cumulative effects on air and water quality, the acoustic environment, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), and sociocultural systems (subsistence). Important impact-producing factors associated with increased traffic in the Beaufort and Chukchi Seas include subaerial and subsea noise, engine emissions and fuel spills (marine vessels), discharges of bilge water and waste, oil spills (vessel casualty), and wildlife collisions with marine vessels.

Mining (Coal and Minerals).

Red Dog Mine. The Red Dog Mine, operated by Teck Cominco Alaska, (Teck Cominco is now known as Teck Alaska, a subsidiary of Teck Resources) is one of the largest lead and zinc mines in the world and the only base-metal lode mine currently in production in northwest Alaska (Figure 4.6.1-7). The open-pit mine (with processing mill, tailings impoundment, and support facilities) is located in the DeLong Mountains about 130 km (82 mi) north of Kotzebue and 74 km (46 mi) inland from the Chukchi seacoast; it produced more than a million tons of zinc and lead concentrates annually, but is estimated to be mined out by 2012. Teck Cominco Alaska is proposing to mine an adjacent deposit (Aqqaluk Deposit) and continue its operations until 2031 (USEPA 2010e; TCAK 2009 2012).

Processed ore (concentrate) is transported from the Red Dog Mine by an 84-km (52-mi) road to the DeLong Mountain Terminal, a port facility located on the Chukchi Sea (Figure 4.6.1-7). The terminal consists of a housing unit, six diesel storage tanks, two concentrate storage buildings, a laydown area, and a concentrate conveyor/ship loading system. Although concentrate is shipped from the mine to the terminal year-round, shipping of concentrate by barge (to deep sea cargo ships) occurs only during months when the waters are ice free (generally from July through October). The port site also includes a small domestic wastewater treatment system that discharges to the Chukchi Sea under a NPDES permit (USEPA 2006).

The Red Dog Mine would likely contribute to cumulative effects on air and water quality, marine and coastal habitats, marine and coastal fauna (fish, marine and terrestrial mammals, and birds), and sociocultural systems (local economies and subsistence). Important impact-producing factors associated with mining include noise, permitted releases to air and water, particulate and dust releases to air, engine emissions and fuel spills (marine vessels, and land-based vehicles and equipment), pollutant releases (via surface runoff), deposition of fugitive dust, and wildlife collisions with marine vessels.

Coal Development in Northern Alaska. Most of the coal resources in Alaska occur north of the Brooks Range, in the Northern Alaska-Slope coal province. The USGS estimates coal reserves in this region to be 3,870 billion short tons (1,910 billion short tons of bituminous and 1,960 billion short tons of sub-bituminous); however, the remoteness of the region and high cost of logistics and transport currently make large-scale coal development in northern Alaska uneconomical. Depending on infrastructure availability (e.g., if a gas pipeline were to be built), however, coalbed methane could be a target of future development (Flores et al. 2004).

The ADNR's Division of Mining, Land, and Water is currently considering a coal prospecting permit for the proposed Nanushak coal project, a small project located along the northern foothills of the Brooks Range near Anaktuvuk Pass. Currently, there are no large-scale coal mining proposals in the region (ADNR 2012c).

Other Mining Activities. Mining of placer gold in beach deposits and bench gravels along the Seward Peninsula (Chukchi Sea) continued through the 1950s (Koschmann and Bergendahl 1968). Past mining of this nature could have contaminated nearby water and sediments with metals such as mercury (if used in collecting gold). Most of the current placer operations are taking place near Nome, in the South Seward Peninsula, and would not affect the waters of the Beaufort or Chukchi Seas (BLM 2005).

There are no abandoned mine lands in the Arctic region (ADNR 2011a).

Dredging and Marine Disposal. Mechanical and hydraulic dredges have been used to excavate materials to construct artificial islands (drilling platforms), helipads, and coastal harbors/shipping corridors in the Beaufort Sea. All past dredging activities have been conducted to support the oil and gas industry — in the 1950s and 1960s, it was for shipping and transportation; in the 1970s and 1980s, it was mainly for the construction of islands (30 islands were built during this time). Most dredging occurred during the open water season in water depths less than 50 m (150 ft). Harbors, channels, and mooring basins were dredged in MacKinley Bay, Tuft Point, and Tuktoyaktuk (IMG Golder Corp. 2004). Several State and Federal regulations and permitting processes govern dredging operations in Arctic waters. The likelihood of future dredging projects is not certain, but is considered to be low.

The main benefit of dredging in Arctic waters is the improvement of navigational depths for marine vessels. Dredging and disposal may also contribute to adverse cumulative effects on water quality, the acoustic environment, coastal and marine habitats, coastal and marine fauna (fish and marine mammals), and cultural resources (if present). Important impact-producing factors of dredging and disposal are noise and turbidity/contaminant resuspension caused by bottom sediment disturbance.

Recreation and Tourism. Most nonresident recreational activity in the North Slope Borough consists of tour groups visiting Barrow or Deadhorse (see Section 3.13.1.3). Travel to these areas is primarily by air, although bus tours occasionally arrive via the Dalton Highway between Deadhorse and Fairbanks. Hikers and river rafters also visit the Arctic National Wildlife Refuge and other areas, using scheduled (to Kaktovik) or chartered (for remote locations) airplanes for access. An increasing number of cruise ships enter the Chukchi and Beaufort Seas, and a growing number of hikers and rafters visit coastal areas of the Chukchi Sea; lodging is currently available in Kaktovik. Gates of the Arctic National Park receives limited visitation, accessed through Anuktuvuk Pass or by chartered airplane. Hunters also visit the area using aircraft for access, and some hunters may enter the area using the Dalton Highway. Tourism and recreation in the Arctic region will likely increase in the coming decades as more enterprises take advantage of the longer summer (ice-free) seasons.

While recreation and tourism may have beneficial effects on local economies, they also contribute to adverse cumulative effects on water quality, marine and coastal habitats, marine and coastal fauna (fish, marine mammals, and birds), and sociocultural systems (subsistence). Important impact-producing factors include noise, disturbance or injury of fish and wildlife, and habitat displacement and/or degradation.

Climate Change. Because a growing body of evidence shows that climate change is occurring (Section 3.3), it is included as a current and foreseeable natural trend in the cumulative impacts analysis for some resources in the Arctic region. Analyses that take into account impact-producing factors related to climate change meet one or both of the following criteria:

- The resource is already experiencing impacts from climate change, so the effects are observable and not speculative.

- The resource will be directly affected by warming temperatures.

In the Arctic region, impacts of climate change include warming ocean temperatures, reductions in sea ice, permafrost thawing, and coastal erosion, which all affect terrestrial, coastal, and marine ecosystems (see Section 3.3.2). In addition to ecosystem effects, the loss of sea ice contributes to an ice-albedo feedback process that affects regional atmospheric circulation patterns and global heat budgets. Changes to the Arctic climate have been documented in several studies; these include an increase in atmospheric temperature (by 2 to 4°F since 1960), an increase in precipitation (by a rate of about 1% per decade), a decrease in the extent of sea ice (by a rate of about 3% per decade for March and 12% per decade for September since the 1970s); and a decrease in multi-year sea ice (by a rate of about 9 to 12% per decade since the 1980s).

Not all impacts from climatic and hydrologic changes that are the indirect result of temperature changes have been analyzed because they may be too uncertain to predict. For example, it is reasonable to expect changes in precipitation regimes as a result of climate change. Furthermore, it is also likely that precipitation changes would, in turn, affect the coastal salinity balance between freshwater flow and tidal influence in some areas, and that these changes would affect fisheries and fish populations in some way. Both the magnitude and direction of each factor in this sequence of occurrences, however, are uncertain. While we acknowledge that continuing climate change could result in changing regional ecological and socioeconomic patterns and distributions, at this stage of our understanding of underlying processes, the rates and directions of many of these changes are too speculative to include in the cumulative analyses that follow.

Legislative Actions. Major statutes governing the management and protection of resources within the Beaufort Sea and Chukchi Sea Planning Areas are listed in Appendix C. Regulations and permitting programs based on these statutes (e.g., the NPDES permitting program based on Section 402 of the Clean Water Act) are overseen by the USEPA and other regulating authorities. The statutes and regulations (including international agreements between the United States, Canada, and Russia) are discussed in the previous sections and in the resource impacts sections, as they apply.

4.6.2 Marine and Coastal Physical Resources

4.6.2.1 Gulf of Mexico Region

4.6.2.1.1 Water Quality. Section 4.4.3.1 discusses potential water quality impacts in coastal (bays and estuaries), marine (State offshore and Federal OCS), and deepwater environments in the GOM resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on water quality result from the incremental impacts of the Program (described in Section 4.4.3.1) when added to impacts from ongoing and reasonably foreseeable future actions, including those of ongoing and future OCS programs and other non-OCS program activities. Table 4.6.1-2 presents the exploration and development scenario for the GOM cumulative case, which takes into account activities associated with the Program in combination with those from ongoing and future programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in the GOM are summarized in Table 4.6.1-5 and discussed below, as applicable.

Ongoing and future routine OCS program activities, including those of the Program, involve vessel traffic, well drilling, pipelines (trenching, landfalls, and construction), chemical releases (drilling, operation discharges, and sanitary wastes), platforms (anchoring, mooring, and removal, except in deep waters), and onshore construction (coastal waters only). All of these activities have the potential to adversely affect water quality in the GOM over the next 40 to 50 years. Accidental oil spills are also counted among OCS program-related activities; assumptions for oil spills under the cumulative case scenario are provided in Table 4.6.1-4.

OCS program-related service vessel traffic in the GOM (to new facilities) could be as high as 1,900 trips per week over the next 40 to 50 years; service vessel traffic associated with the Program (a maximum of 600 trips per week) represents about 32% of this traffic.

Other types of marine vessel traffic occur in the GOM, one of the world's most concentrated shipping areas (USACE 2010). Non-OCS program traffic includes that related to crude oil and natural gas imports, commercial container shipments, tugs and barges, military and USCG operations, cruise ships, commercial fishing, and small watercraft. In 2010, the Port of New Orleans alone handled about 7,500 vessel calls (mainly tanker and dry bulk carrier), about 140 vessel calls per week (USDOT 2011b). Impacts on water quality from marine traffic arise from regular discharges of bilge water and waste, leaching of antifouling paints, and incidental spills (MMS 2001d), although operational discharges and spillage from marine vessels have declined substantially in the past few decades (NRC 2003b). Oil releases associated with vessel casualty are rare, but have been documented in the GOM.

The number of development and production wells and platforms constructed over the duration of the Program (at most 2,600 and 450, respectively) would be proportional to the amount of oil produced; these numbers represent about 22% of the total number of production wells and platforms (respectively) anticipated to be built in the GOM over the next 40 to 50 years as part of ongoing and future OCS programs. The length of new pipeline (at most

12,070 km [7,500 mi]) added as part of the Program represents about 17% of that anticipated as part of ongoing and future OCS programs.

The area of disturbed sea bottom from construction of platforms and pipelines over the duration of the Program (as much as 14,000 ha [34,600 ac] total) represents about 17% of that associated with ongoing and future OCS programs over the next 40 to 50 years. Bottom disturbance degrades water quality by increasing water turbidity in the vicinity of the operations and adding contaminants to the water column. It also changes sediment composition as suspended sediments (and contaminants, if present) are entrained in currents and deposited in new locations.

An inventory conducted by NOAA found that there were about 766 major and 8,147 minor land-based point sources of pollution releasing to watersheds and coastal drainage areas of the GOM; these included discharges from industrial facilities (6,909), wastewater treatment plants (1,925), and power plants (79) — most of which were located in the watersheds of the Atchafalaya/Vermilion Bays and Galveston Bays at the time of the inventory (NOAA 1995). The kinds of contaminants released include nitrogen (from organic chemicals, petroleum refining, industrial plants, and pesticide sources), phosphorus, metals (zinc, arsenic, cadmium, lead, and mercury), oil and grease, suspended solids (turbidity), biocides, and heat (from power plant cooling water discharges). Non-point sources release pollutants to the GOM via rivers and on-land drainages and are primarily from urban and agricultural runoff (containing animal waste and residual fertilizer, in particular nitrogen and phosphorous compounds), but also originate from seepage from landfills and industrial facilities and various kinds of on-land spills. These sources (together with similar sources from Mexico) combine to degrade water quality in the GOM, especially in coastal waters. Coastal water quality is also adversely affected by the loss of wetlands (Section 3.7.1).

Other types of actions taking place within GOM waters also contribute to the degradation of water quality in the GOM. These include marine mining operations, sediment dredging and disposal operations (suspended sediments and contaminants), LNG terminal operations (biocide-laden, cooled water), and activities related to the oil and gas industry, which operates hundreds of platforms in State and Federal waters and discharges large volumes of drilling wastes, produced water, and other industrial waste streams into GOM waters. Hydrocarbon releases through natural oil seeps along the continental slope and accidental oil spills are additional sources of water and sediment contamination.

There are 23 designated ocean dredged material disposal sites in the GOM, including 16 off the coast of Texas and Louisiana and in the Mississippi River GOM outlet and six off the coasts of Mississippi, Alabama, and Florida. Dredging operations are routinely conducted for channel construction and maintenance, pipeline emplacement, access to support facilities, creation of harbor and docking areas, and siting for onshore facilities. Offshore disposal, authorized under Title I of the *Marine Protection, Research and Sanctuaries Act of 1972*, as amended (33 USC 1401), and the *Federal Water Pollution Control Act*, as amended (33 USC 1251), consists primarily of dredged sediments but may also include fish wastes and decommissioned vessels. The site management and monitoring plans for many of these sites are available on the USEPA's website (http://www.epa.gov). The USACE maintains an online database that tracks the projects (including quantities of materials, dredging and transport methods, and dumping frequency, size, and location) that dispose of materials at designated offshore disposal sites (http://el.erdc.usace.army.mil/odd). The direct impacts of dredging on water quality (increased turbidity and decreased dissolved oxygen at the dredge site) are fairly short lived; however, long-term landscape-scale changes can have significant adverse impacts on aquatic organisms and their habitats (Nightingale and Simenstad 2001) (Sections 4.6.3 and 4.6.4).

Currently, there is only one offshore LNG terminal in the GOM (Gulf Gateway Deepwater Port off the coast of Louisiana). However, natural gas demand growth in the United States has accelerated since the 1980s, and LNG imports are expected to increase significantly to meet this demand. As a result, 25 LNG terminal proposals have been approved to serve the U.S. market (Parfomak and Vann 2009). At least seven new licenses have been issued for additional facilities in the GOM, and it is anticipated that more LNG facilities will be built over the coming decades (USDOT 2012b) (Section 4.6.1.5). The impacts of LNG transport and LNG receiving terminals are associated with explosions and fires and with the cryogenic and cooling effects of either an accidental release of LNG or the release of cooled water during the vaporization process.

The majority of oil released to the GOM comes from chronic releases, mainly from naturally occurring seeps and runoff from land-based sources (NRC 2003b). Oil seeps are estimated to contribute up to 62% of the oil input in U.S. marine waters overall; runoff from land-based sources, about 21% (NRC 2003b). As many as 350 crude oil and tar seeps have been identified in the GOM. Seepage rates for the northern part of the GOM (along the continental slope) have been estimated at about 73,000 tons (526,000 bbl) per year,[39] comparable to that estimated for spills from OCS programs over the next 40 to 50 years (based on a worst-case scenario of about 559,600 bbl per year, excluding catastrophic events; Table 4.6.1-4). Spills associated with the Program (based on a worst-case scenario of about 114,500 bbl per year, excluding catastrophic events (Table 4.4.2-1), represent a small fraction, about 11%, of the combined annual oil inputs from oil seeps and oil spills (from pipelines, platforms, and tankers/barges and incidental spills) from OCS programs over the next 40 to 50 years. Natural gas seeps are also common, but little is known about their seepage rates (Kvenvolden and Cooper 2003).

The second largest contribution to oil releases in U.S. marine waters overall is related to oil consumption (about 32%): land-based runoff and river discharge (21%), recreational marine and non-tank vessels (2.6%), tank vessel operational discharges (<1%), atmospheric deposition (8.1%), and jettisoned aircraft fuel (<1%). Other important sources of oil releases include those associated with non-OCS program oil extraction/transportation activities (about 4.7% in total): platforms, produced water, atmospheric deposition, pipeline and tank vessel spills, operational discharges (cargo washings), and coastal facility spills (NRC 2003b).

[39] Total estimates for the GOM, taking into account oil seeping from the Campeche Basin offshore of Mexico in the southern part of the Gulf, run as high as 140,000 tons (1 Mbbl) per year (Kvenvolden and Cooper 2003).

Another issue of importance to the water quality in the GOM concerns the hypoxic zone in the GOM coast shelf waters (offshore of Louisiana and Texas to the west of the Mississippi Delta) (see Figure 4.6.1-5). The hypoxic zone is an area near the sea bottom that contains less than 2 ppm of dissolved oxygen, causing a condition of hypoxia that is inhospitable to fish and causes stress or death to benthic organisms (USGS 2011c). The hypoxic zone is attributed to water column stratification (driven by weather and river flow) and the decomposition of organic matter in bottom waters, as well as organic matter and nutrients (that fuel phytoplankton growth) carried by waters of the MARB. In July 2011, the hypoxic zone measured 17,520 km^2 (6,765 mi^2), which is smaller than originally predicted by the USEPA based on recent trends (USEPA 2011f). River discharge from the MARB watershed is projected to increase by as much as 20% in the coming decades. This phenomenon, in addition to natural upwelling of nutrient-rich deep ocean water into shallow areas (which may be an effect of climate change), could increase the extent of the hypoxic zone in the northern GOM over the next 40 to 50 years (USGCRP 2009). Activities associated with the Program are not expected to have a large effect on the hypoxic zone, because inflows of contaminants causing hypoxia are mainly from MARB waters discharging to the GOM.

Catastrophic oil spills are rare events, but their releases have a high potential to degrade water quality in both coastal and deep waters. Since the 1970s, there have been two CDEs in the GOM: the Ixtoc I event in the Cantarell oil field (Mexico), in 1979; and the DWH event, in 2010. The DWH event released an estimated 4.9 Mbbl between April 22 and July 15, 2010 (see Section 3.4.1.4.1 for a more detailed discussion on the effects of the DWH event). In response to the spill, 7,000 m^3 (1.84 million gal) of chemical dispersants were also released (Section 3.4.1.3). The short- and long-term impacts of the spill on water quality in the GOM are still being assessed, but as of January 2011, 134 km (83 mi) of shoreline were classified as heavily or moderately oiled (NOAA 2012b). SCAT observations in March 2012 indicated that oiling was still present in some areas along barrier islands and coastal areas in Louisiana, Mississippi, Alabama, and Florida (ERMA 2012a, b).

Studies conducted two months after the start of the DWH event (at depths of 1,500 m [4,921 ft]) found a continuous plume of dispersed oil at a depth of approximately 1,100 m (3,609 ft) that extended for 35 km (22 mi) from the DWH event site (Camilli et al. 2010). The plume consisted of droplets between 10 and 60 μm in size and contained monoaromatic hydrocarbons (benzene, toluene, ethyl benzene, and xylene) at concentrations greater than 50 μg per liter and persisted for months at this depth with no substantial biodegradation. High concentrations of aromatic hydrocarbons were detected in the upper 100 m (328 ft). PAHs were found at concentrations as high as 189 μg per liter extending as far as 13 km (8 mi) from the subsurface DWH event site, at depths between 1,000 and 1,400 m (3,281 and 4,593 ft) and extending as far as 13 km (8 mi) from the subsurface DWH site (Diercks et al. 2010).

Joye et al. (2011) estimated that the DWH event released 450 million kg (500,000 tons) of hydrocarbon gases at depth. In May through June 2010, high concentrations of dissolved hydrocarbon gases (methane, ethane, propane, butane, and pentane) were detected in a water layer between 1,000 and 1,300 m (3,281 and 4,265 ft) (Joye et al. 2011).

The fate of the estimated 771,000 gal of chemical dispersants injected at the DWH wellhead near the seafloor (at depths of about 1,500 m [4,921 ft]) was studied by Kujawinski et al. (2011). The study concluded that chemical dispersants at this depth underwent slow rates of biodegradation and recommended further studies to assess the impact of dispersant-oil mixtures on pelagic biota.

Global climate change will also affect water quality in the GOM in the coming decades, especially in terms of surface temperature, salinity, vertical stratification, and pH (USGCRP 2009). Increases in sea surface temperature in the GOM are thought to be correlated to increased hurricane intensity, similar to the way the “Loop Current” played a part in intensifying Hurricanes Ivan, Katrina, and Rita. Increased surface temperatures also increase thermal expansion of marine waters, thus adding to sea level rise. Changes in temperature and salinity affect density parameters, which in turn affect vertical mixing and stratification of the water column, processes that are especially important in estuaries (in terms of oxygen concentrations and nutrient availability). Estuaries with low-amplitude tides, such as those in the northeastern GOM, are highly susceptible to stratification and hypoxia. As sea surface temperatures increase, the ocean’s ability to absorb CO_2 is also decreased (because CO_2 is less soluble in warmer waters). Currently, healthy coastal wetlands (e.g., seagrasses, salt marsh, and mangroves) are important natural CO_2 “sinks.” As coastal wetlands are lost through coastal development and sea level rise, their function as CO_2 sinks is diminished.

The GOM region has already experienced increasing atmospheric temperatures since the 1960s. From 1900 to 1991, sea surface temperatures increased in coastal areas and decreased in offshore areas. Sea level rise along the northern coast is as high as 0.01 m/yr (0.03 ft/yr) and has contributed to the loss of coastal wetland and mangroves and increased the rates of shoreline erosion. Future sea level rise is expected to cause saltwater intrusion into coastal aquifers, potentially making some unsuitable as potable water supplies (Section 3.3.1).

Significant changes (increases or decreases) in precipitation and river discharges to the GOM would affect salinity and water circulation — which in turn affects water quality. Water quality impacts associated with increased river discharges result from increases in nutrients (nitrogen and phosphorous) and contaminants to estuaries, increases in harmful algal blooms, and an increase in stratification. Such changes could also affect dissolved oxygen content and the extent of the GOM hypoxic zone. Decreased discharge would diminish the flushing of estuaries and increase concentrations of pathogens.

Conclusion. Water quality in GOM coastal and marine waters would be affected by various activities associated with OCS programs over the next 40 to 50 years. These include service vessel traffic, well drilling, pipelines (trenching, landfalls, and construction), chemical releases (drilling, operation discharges, and sanitary wastes), platforms (anchoring, mooring, and removal, except in deep waters), construction of shore-based infrastructure (coastal waters only), and accidental oil spills. Coastal waters in the GOM are also affected by numerous other factors, including river inflows, urbanization, agricultural practices, municipal waste discharges, and coastal industry. Non-OCS activities likely to contribute to cumulative impacts include marine vessel traffic, wastewater discharge to coastal and marine waters, dredging and marine disposal, oil and gas production in State waters, oil and gas infrastructure, marine mineral mining, existing oil and gas-related infrastructure in State waters, military operations, and renewable energy development. Natural seepage of oil along the continental slope is also significant.

The cumulative impacts of ongoing and reasonably foreseeable future activities on water quality in the GOM are unavoidable and may, in cases like salinity and pH, be irreversible, since such trends are natural and are occurring on a global scale. However, because many other impacts could be mitigated (i.e., minimized) by the various regulatory controls already in place to protect the marine waters of the GOM, the overall cumulative impacts are considered to be moderate. The incremental contribution of the Program to cumulative impacts on water quality in the GOM would be small to medium relative to the cumulative case and relative to other ongoing and reasonably foreseeable future actions in the GOM (see Section 4.4.3.1).

The USEPA, in collaboration with other Federal and coastal State agencies, has assessed the coastal conditions of each region of the United States, including the GOM coast, by evaluating five indicators of condition, one of which was water quality, based on such parameters as dissolved oxygen, chlorophyll *a*, nitrogen, phosphorus, and water clarity.[40] The most recent assessment found the overall condition of the coastal waters of the GOM coast region to be fair to poor, with an overall condition rating score of 2.2 (on a 5.0-point scale) and an individual indicator score of 3.0 for water quality. Parameters such as dissolved oxygen and water clarity vary in relation to climatic factors (e.g., annual rainfall) (USEPA 2008a).[41] In addition, the hypoxic zone has been a perennial feature in the northern GOM since the 1950s.

The number of expected accidental oil spills in GOM waters associated with the Program would represent only a small increase over the number of expected spills from ongoing and future OCS programs and non-OCS program activities, comparable in volume to releases from naturally occurring oil seeps (discounting catastrophic spills). The incremental increase in adverse water quality impacts from these spills would depend on the weather and sea conditions at the spill location, the type of waves and tidal energy at the spill locations, the type of oil spilled (very light to very heavy), the depth of the spill event (deep water, shallow water, or surface water), and the volume and rate of spillage; therefore, the incremental contribution of expected oil spills to cumulative water quality impacts could range from small to large. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from moderate to major if it were to occur. Spill response and cleanup activities (e.g., *in situ* burning and use of chemical dispersants) could contribute to water quality impacts regardless of the size of spill. A more detailed discussion of the effects of oil spills on water quality in the GOM is presented in Section 4.4.3.1.2.

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[40] Other indicators used to assess coast conditions include sediment quality (toxicity, contaminants, and total organic carbon), benthic community condition, coastal habitat loss, and fish tissue contaminants. The assessment found sediment quality in the Gulf coast region also to be poor (with sediments containing pesticides, metals, PCBs, and PAHs) (USEPA 2008b).

[41] The water quality score does not include the impact of the hypoxic zone in offshore GOM coast waters or the recent DWH event (USEPA 2008a).

4.6.2.1.2 Air Quality. Section 4.4.4.1 discusses potential air quality impacts in onshore and offshore areas of the GOM resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on air quality result from the incremental impacts of the Program (described in Section 4.4.4.1) when added to impacts from ongoing and reasonably foreseeable future actions, including those of ongoing and future OCS programs and other non-OCS program activities. Table 4.6.1-2 presents the exploration and development scenario for the GOM cumulative case, which takes into account activities associated with the Program in combination with those from ongoing and future programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in the GOM are summarized in Table 4.6.1-5 and discussed below, as applicable.

Ongoing and future routine OCS program activities, including those of the Program, involve production platforms, exploration wells, platform construction and removal, service vessels (pipelaying, support, and survey), helicopters, and tanker and barge transport. All these activities have the potential to adversely affect air quality in the GOM over the next 40 to 50 years. Accidental oil spills are also counted among OCS program-related activities; assumptions for expected oil spills under the cumulative case scenario are provided in Table 4.6.1-4. Other emission sources on the OCS that are not associated with oil and gas development activities include commercial marine vessels, commercial and recreational fishing, tanker lightering, military vessels, and natural sources such as oil or gas seeps. Onshore emission sources include power generation, industrial processing, manufacturing, refineries, commercial and home heating, on-road vehicles, and non-road engines (e.g., aircraft, locomotives, and construction equipment).

Criteria Pollutants. Over the past 20 years, the USEPA has promulgated a series of measures to reduce regional and nationwide emissions from fuel combustion sources (e.g., diesel marine engines), and the beneficial effects of these measures are evident in the data collected in 2006 (the most recent year for which data are reported).[42] NO_x emissions, mainly from transportation and fuel combustion sources, decreased nationwide by about 29% between 1990 and 2006. Most of the reductions in NO_x emissions occurred between 1998 and 2006 and are attributed to implementation of the Acid Rain Program and the NO_x State Implementation Plan (SIP) Call. SO_2 emissions, mainly from fuel combustion, industrial processes, and transportation sources, also decreased nationwide by about 38% between 1990 and 2006. During this same period, emissions from $PM_{2.5}$, PM_{10}, and CO decreased by 14, 30, and 38%, respectively (USEPA 2008b). At the State level, data collected between 1990 and 2002 indicate overall emissions have also declined in the five GOM coast States (Alabama, Florida, Louisiana, Mississippi, and Texas) in total: NO_x, down by 31%; SO_2, down by 15%; PM_{10}, down by 34%;

[42] This does not include new USEPA regulations that will apply international emission standards for ships operating off North American coasts, beginning in August 2012. The U.S. and Canada have designated waters off North American coasts collectively as an area in which stringent emission standards are needed (USEPA 2010f). In August 2012, the USEPA will require that ships operating within 200 nautical miles of the majority of U.S. and Canadian coastline, including the GOM (an area designated as the North American Emission Control Area), use lower sulfur fuels. The fuel standards are expected to reduce emissions of SO_x and fine particulate matter ($PM_{2.5}$) by as much as 85% from current levels. Engine-based controls (such as the use of high efficiency engines) would also reduce NO_x emissions.

and VOCs, down by 8%. Increases were observed only in Florida (NO_x up by 15% and VOCs up by 20%) and Alabama (VOCs up by 2%) during this period (USEPA 2011h).

Table 4.6.2-1 lists the estimated total emissions associated with ongoing and future OCS oil and gas activities in the GOM, including the 2012-2017 Program, over the next 40 years. These emissions were estimated by BOEM using emission factors from the *2008 Gulfwide Emission Inventory Study* (Wilson et al. 2010). In terms of absolute amounts, the largest emissions would be NO_x, followed by CO, with lesser amounts of VOC, SO_x, PM_{10}, and $PM_{2.5}$, in order of decreasing emissions. Under both the high and low scenarios, well drilling would be the largest source of NO_x; support vessels would be the largest source of SO_x. Well drilling and support vessels would be the largest sources of PM (equally); new production platforms would be the largest source of VOCs and CO. Emissions from Program activities in the GOM generally represent about 17 to 22% of the cumulative case emissions.

The USEPA's Acid Rain Program (established under Title IV of the 1990 CAA amendments) sets a permanent cap on the total amount of SO_2 that can be released from the electric power sector, with the final 2010 cap set at 8.95 million tons (about half of the emissions from the electric power industry in 1980). NO_x emissions from coal-fired boilers were also limited under the program (to about 8.1 million tons). Between 1980 and 2008, SO_2 emissions were reduced by about 52% compared to 1990 levels. In 2008, SO_2 emissions had already fallen below the emissions cap set for 2010 and monitoring data indicated the national composite average of SO_2 mean ambient concentrations declined by 71% between 1980 and 2008. NO_x emissions from the electric power sector in 2008 were also greatly reduced (by as much as 63% relative to projected levels in 2000 without the program). The USEPA also reports significant improvements in acid deposition indicators (wet sulfate and nitrogen deposition) (USEPA 2011i).

The Cross-State Air Pollution Rule was finalized in 2011 (replacing the USEPA's 2005 Clean Air Interstate Rule) and will take effect in 2012. The rule requires 27 States in the eastern half of the United States (including all of the GOM coast States) to reduce power plant emissions contributing to ozone and/or fine particulate pollution in other States by mandating significant reductions in SO_2 and NO_x emissions from power plants. The USEPA estimates that these actions will reduce SO_2 and NO_x emissions by 73% and 54%, respectively, from 2005 levels (USEPA 2011j).

MMS (currently BOEM) performed a cumulative air quality modeling analysis of platform emissions in a portion of the GOM in 1992 (MMS 1997b). The modeling incorporated a 40% increase in emissions above the 1992 levels to account for growth in oil and gas development. Predicted concentrations were well within the NAAQS and the Prevention of Significant Deterioration (PSD) Class II maximum allowable increases. An inventory study in the Breton National Wilderness Area (BNWA), a Class I area under the USEPA's PSD regulations, was conducted by MMS to estimate the contribution of OCS and non-OCS program emissions to concentrations of NO_x and SO_2 in the BNWA[43] (Billings and Wilson 2004). A

[43] Under the CAA, water quality degradation is limited in Class I areas by establishing stringent "increment" limits for NO_x and SO_2. These increments are the maximum increases in ambient pollutant concentrations allowed over baseline concentrations (Billings and Wilson 2004).

TABLE 4.6.2-1 Estimated Total Air Emissions for the Offshore Exploration and Development Scenario for the OCS GOM Cumulative Case

	Pollutant (10^3 tons for 40 yr)[a]					
Activity	NO_x	SO_x	PM_{10}	$PM_{2.5}$	CO	VOC
Well Drilling (D&P)	2,341.95–3,177.43	1.97–2.2	36.3–49.34	35.87–48.75	429.58–592.49	46.15–63.11
Well Drilling (E&D)	1,807.5–2,560.34	1.55–2.2	28.03–39.78	27.69–39.29	336.14–477.62	35.83–50.87
Helicopters	9.79–14.02	2.42–3.46	1.91–2.73	1.91–2.73	119.85–171.65	23.67–33.9
Oil Tanker/Barge Idling	0–29.67	0–3.85	0–0.57	0–0.57	0–3.15	0–28.91
Pipe-laying Vessels	250.54–574.33	42.54–97.53	9.45–21.67	9.45–21.67	52.00–119.2	9.45–21.67
Platform Construction	43.7–65.34	6.24–9.34	1.03–1.54	1.03–1.54	5.67–8.49	1.03–1.54
Platform Production	660.22–945.58	9.04–12.94	6.06–8.67	5.94–8.51	726.44–1,040.42	591.00–846.44
Platform Removal	43.7–65.34	6.24–9.34	1.03–1.54	1.03–1.54	5.67–8.49	1.03–1.54
Support Vessels	1,188.5–1,702.19	160.15–229.37	20.58–29.48	20.58–29.48	113.21–162.14	20.58–29.48
Survey Vessels	22.09–31.49	2.67–3.8	0.34–0.48	0.34–0.48	1.84–2.63	0.34–0.48
Total (Cumulative OCS)	6,367.98–9,165.72	232.81–374.56	104.73–155.82	103.85–154.57	1,790.4–2,586.27	729.95–1,079.16
Total (Program)[b]	1,031.11–1,983.79	40.49–81.11	16.78–32.97	16.64–32.71	304.63–575.9	132.25–250.22

[a] The range of values reflects the low and high end of new exploration and development activity.

[b] Values from Table 4.4.4-1.

recent modeling-based cumulative increment analysis for SO_2 and NO_2, conducted by MMS, considered the cumulative effect of all onshore and offshore emission sources in the area with respect to the baseline year (Wheeler et al. 2008). The model results are summarized as follows:

- The increase in the 3-hr SO_2 concentration within the BNWA since 1977 (the baseline year) ranges from 0.42 to 1.70 μg/m^3; the maximum increment of 25.0 μg/m^3 has not been exceeded within the BNWA but a small portion of the increment may have been consumed. The largest change within a 50-km (31-mi) radius of the BNWA is 2.6 μg/m^3 and occurs to the south and east of Breton Island.

- The increase in the 24-hr SO_2 concentration within the BNWA since 1977 ranges from 0.11 to 1.18 μg/m^3; the maximum increment of 5.0 μg/m^3 has not been exceeded within the BNWA but a portion of the increment may have been consumed. The maximum 24-hr average SO_2 has increased over most of the GOM since 1977; it has increased or decreased over land, depending on location. For example, it has decreased as much as 7.7 μg/m^3 near Mobile, Alabama. In areas east of the Chandeleur Islands and southeast of the Breton Islands, it has increased between 1.0 and 1.64 μg/m^3.

- The annual SO_2 concentration within the BNWA has decreased by 1.07 to 1.89 μg/m^3 since 1977. The decrease in annual SO_2 is less than 0.5 μg/m^3 over much of the GOM and is greatest (more than 1.5 μg/m^3) near the GOM coast and inland over south Mississippi, Alabama, and eastern Louisiana. Isolated increases at grid points in Louisiana and the GOM are likely due to local additions of SO_2 point sources since 1977.

- The maximum increase in annual NO_2 concentration within the BNWA since 1988 (the baseline year) is 0.10 μg/m^3, well below the maximum allowable increment of 2.5 μg/m^3. Only a very small portion of the increment has been consumed. Since 1988, annual NO_2 concentrations have decreased over land where controls have been implemented, but have increased over the GOM due to the addition of offshore NO_x emission sources. The boundary between decreased onshore concentrations and increased offshore concentrations follows the southern Louisiana coastline then turns northeastward away from the Louisiana coast and over the GOM where it crosses the BNWA and runs through the northern part of the Chandeleur Island chain. Part of the BNWA has experienced an increase in NO_2 concentrations since 1988. Larger increases are observed in areas within 75 km (47 mi) of the BNWA boundaries.

BOEM continues to consult with the USFWS, which manages the BNWA, on any plans within 100 km (62 mi) of the BNWA.

Ozone Formation. In the Nation's ozone (O_3) nonattainment areas, emissions of NO_x and VOCs are being reduced through the SIP process in order for those areas to achieve compliance with the national O_3 standard. Prior to the revocation of the 1-hr O_3 standard in 2004, the Houston-Galveston-Brazoria (Texas) and Baton Rouge (Louisiana) areas were classified as severe nonattainment; the Beaumont-Port Arthur (Texas) nonattainment classification was serious. While the 1-hr O_3 standard no longer applies, the same emission controls will remain in effect while each State develops its plan to reach compliance with the new 8-hr standard. In October 2008, the USEPA reclassified the Houston-Galveston-Brazoria O_3 nonattainment area from a moderate 8-hr O_3 attainment area to a severe 8-hr O_3 nonattainment area and required the State to submit a revised SIP addressing the severe O_3 requirements of the CAA (73 FR 56983). In September 2010, the USEPA published a notice that the Baton Rouge moderate 8-hr O_3 attainment area had attained the 1997 8-hr O_3 NAAQS (75 FR 54778); the Beaumont-Port Arthur area was also designated an attainment area for the 1997 8-hr O_3 NAAQS in 2010 (75 FR 64675). There are no O_3 nonattainment areas in Alabama, Florida, or Mississippi.

Ozone levels in the southeast Texas have been in a steady downward trend since 1995. The maximum observed fourth highest 8-hr O_3 concentration in the Houston-Galveston area decreased from about 0.140 parts per million (ppm) in 1995 to around 0.100 ppm in 2005. Ozone levels in the Baton Rouge area remained steady over the same period, but the number of exceedances of the O_3 standard decreased. This data indicates that emission-reduction measures have been effective in reducing O_3 levels.

Modeling studies were performed using the preliminary emissions inventory prepared by Wilson et al. (2010) to examine the O_3 impacts with respect to the 8-hr O_3 standard of 80 parts per billion (ppb). One modeling study focused on the coastal areas of Louisiana extending eastward to Florida (Douglas et al. 2009). This study showed that the impacts of OCS emissions on onshore O_3 levels were very small, with the maximum contribution at locations where the standard of 1 ppb or less was exceeded. Another study, conducted by Yarwood et al. (2004), evaluated O_3 levels in southeast Texas. The results of this study indicated a maximum contribution to areas exceeding the standard of 0.2 ppb or less. The projected emissions for the cumulative case would be about the same as the emissions used in these modeling studies. The contributions to O_3 levels would therefore be similar. As emissions within the nonattainment areas are expected to decrease further in the future, the cumulative impacts from the OCS oil and gas program on O_3 levels would likely be reduced.

Visibility Impairment. Gaseous and fine particulate matter in the atmosphere can potentially degrade atmospheric visibility. Existing visibility in the eastern United States, including the GOM coast States, is impaired due to fine particulate matter containing primarily sulfates and carbonaceous material. High humidity is an important factor in visibility impairment in the GOM coastal areas. The absorption of water by the particulate matter makes them grow to a size that enhances their ability to scatter light and reduce visibility. The estimated natural mean visibility in the eastern United States is 97 to 129 km (60 to 80 mi) (Malm 1999).

Based on data presented by Malm (2000), the observed mean visual range in coastal Louisiana, Mississippi, and Alabama is about 38 to 48 km (24 to 30 mi). In the Texas coastal areas, the average visibility is about 48 to 64 km (30 to 40 mi). In the GOM coast States, about

60 to 70% of the human-induced visibility degradation (impairment) is attributed to sulfate particles, while about 20% is from organic or elemental carbon particles. About 8% of the visibility degradation is attributed to nitrate particles (Malm 2000; USEPA 2001).

Visibility degradation in large urban areas, such as Houston, can be especially pronounced during air pollution episodes. In some severe cases, it may hinder navigation by boats and aircraft. Degraded visibility also adds to the perception by the observer of bad air quality even when monitors do not record unhealthful pollutant levels.

A study of visibility from platforms off Louisiana revealed that significant reductions in Louisiana coastal and offshore visibility are almost entirely due to transient occurrences of fog (Hsu and Blanchard 2005). Episodes of haze are short-lived and affect visibility much less. Offshore haze often appears to result from plume drift generated from coastal sources. The application of visibility screening models to individual OCS facilities has shown that the emissions from a single facility are not large enough to significantly impair visibility. It is not known to what extent aggregate OCS sources contribute to visibility reductions; however, the effects from OCS sources are likely to be very minor because offshore emissions are substantially smaller than the onshore emissions.

In July 1999, the USEPA published its Regional Haze Regulations Final Rule to address visibility impairment in the Nation's National Parks and Wilderness Areas (64 FR 35714). These regulations established goals for improving visibility in Class I areas through long-term strategies for reducing emissions of air pollutants that cause visibility impairment. The rule requires States to establish goals for each affected Class I area to improve visibility on the haziest days and to ensure no degradation occurs on the clearest days. Since visibility impairment involves considerable cross-boundary transport of air pollutants, States are encouraged to coordinate their efforts through regional planning organizations. Texas and Louisiana are part of the Central States Regional Air Planning Association. Mississippi, Alabama, and Florida are members of the Visibility Improvement State and Tribal Association of the Southeast. The USEPA provides funding to the regional planning organizations to address regional haze by developing regional strategies to reduce emissions of particulate matter and other pollutants that lead to haze (USEPA 2011k).

The Regional Haze Regulations along with the rules on ozone and acid rain should result in a lowering of regional emissions and improvement in visibility. Projected emissions from all cumulative OCS program activities are not expected to be substantially different from year 2000 emissions. The contribution of OCS program-related emissions to visibility impairment is expected to be very minor.

Greenhouse Gases. Table 4.6.2-2 lists the total calculated emissions of CO_2, CH_4, and N_2O from OCS activities related to the GOM portion of the 2012-2017 Program and compares them to the 2012-2017 Program overall (accounting for OCS program activities in GOM, Cook Inlet, and the Arctic region); the total U.S. emissions from all sources in 2009 are also provided for reference. Activities in the GOM account for most of the GHG emissions associated with the 2012-2017 Program, comprising between 95% and 98% of all Program-related GHG emissions. For reference, the estimated annual emissions of CO_2 and CH_4 from OCS activities in the GOM

TABLE 4.6.2-2 Estimated Greenhouse Gas Emissions for the 2012-2017 Program in the GOM Relative to the OCS Program Overall over the Next 40 Years

Pollutant	2012-2017 OCS Program (all) (Tg CO_2e)[a, b]	2012-2017 GOM Program (Tg CO_2e)	Total U.S. Emissions from All Sources (2009) (Tg CO_2e)	Percent of Total U.S. Emissions (2009) from GOM Program[c]
CO_2	336.25–512.6	341.54–487.94	5,505.2	0.15–0.22
CH_4	3.98–120.22	3.17–115.88	686.3	0.01–0.42
N_2O	2.85–4.23	2.83–4.14	295.6	0.02–0.04
$CO_2 + CH_4 + N_2O$	348.37–637.05	342.25–607.97	6,487.1	0.13–0.23
All GHG	348.37–637.05	342.25–607.97	6,633.2	0.13–0.23
Total	348.37–637.05	342.25–607.97	38,726.0	

[a] One Tg is equal to 10^{12} g, or 10^6 metric tons. The CO_2e for a gas is derived by multiplying the mass of the gas by the associated GWP, which accounts for the relative effectiveness of a gas to contribute to global warming with respect to the same amount of CO_2. In these calculations, CH_4 is given a GWP of 21, while NO_2 is given a GWP of 310.

[b] Values represent the total emissions for the 2012-2017 Program in the GOM, Cook Inlet, and Arctic regions.

[c] Values are calculated by dividing the estimated annual emissions of the GOM program (equal to the value in the third column divided by 40) by the total U.S. emission from all sources in 2009 (fourth column).

Source: USEPA 2011l.

were less than 0.5% of CO_2 and CH_4 emissions in the United States from all sources in 2009; the estimated annual N_2O emissions from OCS activities in the GOM comprise less than 0.05% of N_2O emissions in the United States from all sources in 2009. Although these are small contributions, it should be noted that some GHGs (e.g., CO_2) can persist in the atmosphere for a century, well beyond the life of the Program.

GHG emissions are one of the causes of climate change; however, assessing their impact requires consideration on a global scale. For this reason, it is not possible to estimate the impact of GHG emission from particular sources, such as the OCS activities associated with the Program. On a global scale, the contribution from the Program to total GHG emissions is small. On a national scale, the contribution of the Program could be significant, although greater contributions of GHG to the U.S. total come from energy consumption (generated mainly by the combustion of coal and natural gas). Total U.S. GHG emissions increased by 11% between 1990 and 2010 (at an average annual rate of 0.5%); GHG emissions from the Program would contribute to this trend in future years.

Oil Spills. Accidental oil spills are sources of gaseous emissions. No more than 40 large spills (greater than 1,000 bbl) and 2,280 small spills (1,000 bbl or less) are expected for the GOM cumulative case as a result of the OCS program (Table 4.6.1-4). Oil spills cause localized increases in VOC concentrations (proportional to the size of the spill) due to evaporation. Most of these emissions would occur within a few hours of the spill and decrease (by dispersion) drastically after that period (MMS 2003a). A more detailed discussion of the effects of oil spills on air quality in the GOM is presented in Section 4.4.4.1.

Unexpected catastrophic discharge events at well locations may result in fires; *in situ* burning is also a preferred technique for cleanup and disposal of oil spills (documented in soil spill contingency plans). Smoke generated from such fires would be expected to reach shore quickly (within a day), but would be limited in geographic extent (MMS 2003a). A discussion of the effects of fires on air quality in the GOM is presented in Section 4.4.4.1.

Conclusion. The effects of various U.S. EPA regulations and standards are expected to result in a steady, downward trend in future air emissions. This trend should be realized in spite of continued industrial and population growth along the GOM coast. Previous O_3 nonattainment areas in the GOM coast region (Beaumont-Port Arthur, Texas, and Baton Rouge, Louisiana) were reclassified as attainment areas in 2010. States such as Texas are required to implement SIPs to reduce emissions in their O_3 nonattainment areas. The overall cumulative impacts on air quality in the GOM over the next 40 to 50 years are expected to be minor to moderate, and the incremental contribution of the routine Program activities to air quality impacts would be small (see Section 4.4.4.1).

The Program would contribute slightly to onshore levels of NO_2, SO_2, and PM_{10}, but concentrations are well within the national standards and PSD increments. The effects from future OCS program activities are expected to remain about the same as in previous years. Portions of the GOM coast region have O_3 levels that exceed the Federal standard, but the contribution from all OCS program activities to ozone levels is very small (about 1%; see Section 4.4.4.1.1). Ozone levels are on a declining trend due to air pollution control measures that have been implemented by the States. This trend is expected to continue as a result of local as well as nationwide control efforts. The contribution of the Program to onshore O_3 would therefore remain very small. The GOM coast region has significant visibility impairment from anthropogenic emission sources. However, visibility is expected to improve somewhat as a result of regional and national programs to reduce emissions. The contribution from OCS program activities to visibility impairment, therefore, is expected to remain small. The number of expected accidental oil spills in GOM waters associated with the Program would represent only a small increase over the number of expected spills from ongoing and future OCS programs and non-OCS program activities. The incremental increase in adverse air quality impacts from these spills (and *in situ* burning of spilled crude or diesel) would be localized and temporary (due to the spreading of oil and action by winds, waves, and currents that disperse volatile compounds to extremely low levels over a relatively large area); therefore, the incremental contribution of expected oil spills to cumulative air quality impacts could range from small to medium. Air quality impacts associated with an unexpected, low-probability CDE (and *in situ* burning) would also be reduced by these factors, and could be moderate if it were to occur. Spill response and cleanup activities (e.g., *in situ* burning and use of chemical dispersants) could contribute to air quality impacts regardless of the size of spill. A more detailed discussion of the effects of oil spills on air quality in the GOM is presented in Section 4.4.4.1.2.

4.6.2.1.3 Acoustic Environment. Section 4.4.5.1 discusses impacts on the acoustic environment in the GOM resulting from the Program. Section 4.4.7 evaluates the direct and indirect impacts of noise on marine fauna (fish, marine mammals, sea turtles, and birds), and Section 4.6.4 addresses the cumulative impacts of noise on marine fauna. Cumulative impacts on the acoustic environment result from the incremental impacts of the Program when added to impacts from existing and reasonably foreseeable future OCS program activities (that are not part of the Program) and other non-OCS program activities. Table 4.6.1-2 presents the exploration and development scenario for the GOM cumulative case (encompassing the Program and other OCS program activities). Ongoing and reasonably foreseeable non-OCS program activities contributing to adverse cumulative impacts on the acoustic environment in the GOM include marine subsurface and surface vessel traffic, aircraft traffic (helicopters and fixed-wing aircraft), dredging, construction of onshore and offshore facilities (e.g., production platforms and drilling rigs in State waters), LNG facility operations, renewable energy projects (foreseeable), marine geophysical (seismic) surveys, active sonars, underwater explosions, ocean science studies, and mining operations. This section addresses the quality of the acoustic environment only; the cumulative impacts of noise on GOM marine fauna are discussed in Section 4.6.4.1.

Ambient (background) noise has numerous natural and man-made sources that vary with respect to season, location, depth of occurrence, time of day, and noise characteristics (e.g., frequency and duration).[44] Natural sources of ambient noise include wind and waves, surfs (produced by waves breaking onshore), precipitation (rain and hail), lightning, volcanic and tectonic noise, and biological noise (from fishes, shrimp, and marine mammals). Vessels are the greatest man-made contributors to overall marine noise in the GOM. Underwater explosions in open water are the strongest point sources of man-made sound. Baseline acoustic conditions in the GOM are discussed in more detail in Section 3.6.1.

Ongoing and future routine OCS program activities, including those of the Program, that generate noise include operating airgun arrays (during marine seismic surveys), drilling, pipeline trenching, and onshore and offshore construction and decommissioning of platforms and drilling rigs. New marine vessel and aircraft traffic (including those associated with emergency-response and cleanup activities in the event of a spill), accidental releases (e.g., loss of well control events), and marine vessel collisions also contribute to noise. A preliminary study of the noise impacts of OCS-related geophysical surveys found that marine seismic surveys have the greatest impact on marine mammals, sea turtles, fish, and commercial and recreational fisheries (MMS 2004a). Noise generated from OCS and non-OCS program activities would be transmitted through both air and water, and may be transient or more extended (occurring over the long term). Table 3.6.1-1 provides a listing of the source levels and frequencies associated with various anthropogenic activities in the GOM.

Conclusion. The quality of the acoustic environment in the GOM would continue to be adversely affected by routine operations of ongoing and future OCS program and non-OCS program activities. The magnitude of cumulative impacts in the GOM is time- and

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44 Higher frequencies are attenuated with distance from the source more rapidly than lower frequencies. Traffic noise generated in deep water contributes to background noise levels at greater distances than traffic noise generated in shallow water.

location-specific and could range from minor to major, depending on the ambient acoustic conditions and the nature and combination of all OCS and non-OCS program activities taking place in the GOM over the next 40 to 50 years. The incremental contributions due to noise generated by routine Program activities could range from small to medium, depending on the timing of the disturbance and the location and characteristics of noise sources present (e.g., their frequency and duration). The cumulative impacts of noise on marine fauna (fish, marine mammals, sea turtles, and birds) are discussed in Section 4.6.4.

The number of expected accidental oil spills in GOM waters associated with the Program would represent only a small increase over the number of expected spills from ongoing and future OCS programs and non-OCS program activities. The incremental increase in adverse acoustic environment impacts from these spills (mainly due to noise sources associated with response and cleanup activities) would be localized and temporary; therefore, the incremental contribution of expected oil spills due to noise would be small. Impacts associated with an unexpected, low-probability CDE could be minor to moderate if it were to occur. Most of the impacts to the acoustic environment are due to noise sources (e.g., mechanical equipment, skimmers, support vessel traffic, and aircraft traffic) associated with spill response and cleanup activities. A more detailed discussion of the effects of oil spills on the acoustic environment in the GOM is presented in Section 4.4.5.1.

4.6.2.2 Alaska Region – Cook Inlet

4.6.2.2.1 Water Quality. Section 4.4.3.2 discusses potential water quality impacts in coastal (bays and estuaries), marine (State offshore and Federal OCS), and deepwater environments in Cook Inlet resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on water quality result from the incremental impacts of the Program (described in Section 4.4.3.2) when added to impacts from ongoing and reasonably foreseeable future actions, including those of ongoing and future OCS programs and other non-OCS program activities. Table 4.6.1-3 presents the exploration and development scenario for the Cook Inlet cumulative case, which takes into account activities associated with the Program in combination with those from ongoing and future programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in Cook Inlet are summarized in Table 4.6.1-6 and discussed below, as applicable.

OCS program activities (i.e., those of the Program; there are no existing OCS program activities) involve service vessel traffic, chemical releases (permitted discharges), and disturbance of bottom sediments. Accidental oil spills are also counted among OCS program-related activities; assumptions for oil spills under the cumulative case scenario are provided in Table 4.6.1-4. All these activities have the potential to adversely affect water quality in Cook Inlet.

OCS program-related service vessel traffic in Cook Inlet could be as high as one to three trips per week over the next 40 to 50 years, all of which are associated with the Program. Extensive non-OCS program marine traffic also occurs in Cook Inlet. Non-OCS program traffic includes that related to crude oil and finished product transport, LNG and ammonia carriers (at the Nikiski industrial complex), tugs and barges, ferries, commercial fishing vessels, military and USCG vessels, a coal carrier, dredge vessels, cruise ships, and small watercraft. Fuel barge traffic is minimal since much of the refined oil for regional consumption is transported to Anchorage by a pipeline from the Tesoro refinery in Nikiski. An estimated 480 large vessels (other than fuel barges on domestic trade) called at Cook Inlet ports in 2010. About 67% of these were made by container vessels, roll-on/roll-off cargo ships, or ferries; 20% were gas or liquid tank ships calling at Nikiski. The remaining traffic consisted of bulk carriers, general cargo ships, tugs, and fishing and passenger vessels. Impacts on water quality from vessel traffic in Cook Inlet result mainly from oil and gasoline spills when vessels run aground, collide, catch fire, or sink (Eley 2012).

The number of platform production wells constructed over the period of the Program (at most, 110) would be proportional to the amount of oil produced and reflects the total number of new platform production wells anticipated to be built in Cook Inlet over the next 40 to 50 years as part of the OCS program (no subsea production wells are planned). The length of new pipeline (at most 241 km [150 mi] offshore and 169 km [105 mi] onshore) added as part of the Program represents all of that anticipated over the next 40 to 50 years as part of the OCS program.

The area of sea bottom disturbed from construction of platforms and pipelines over the period of the Program (as much as 215 ha [530 ac] total) also represents that associated with the OCS program over the next 40 to 50 years. Bottom disturbance degrades water quality by increasing water turbidity (i.e., suspended sediment concentration) in the vicinity of the operations and adding contaminants to the water column. It also changes sediment composition as suspended sediments (and contaminants, if present) are entrained in currents and deposited in new locations.

As summarized in Section 3.4.2, the principal point sources of pollution in Cook Inlet include municipal discharges, as well as discharges from seafood processors and the petroleum industry. Point-source pollution is rapidly diluted by the energetic tidal currents in Cook Inlet, and the USEPA *National Coastal Condition Report III* has rated the coastal waters of south central Alaska, including Cook Inlet, as good (although water clarity in upper Cook Inlet was rated poor because of very high loadings of glacial river sediments) (USEPA 2008a). Non-point sources release a range of contaminants via rivers and on-land drainages and are primarily from urban runoff (related to land development); forest practices (e.g., timber harvest operations); harbors and marinas; roads, highways, and bridges; hydromodification (related to dams, channel modification, and stream bank erosion); mining; and agriculture (ADEC 2007). Point-source discharges are anticipated to remain at present levels for the foreseeable future; non-point-source discharges should improve as a result of Alaska's water pollution control strategy (as outlined in ADEC 2007). Low concentrations of hydrocarbons are found throughout the waters of Cook Inlet and are attributed to natural sources — natural oil seeps, river discharges carrying carbon compounds of biogenic origin, and the deposition of fuel and natural organic matter (e.g., from fires) (MMS 2003a).

Activities taking place within Cook Inlet waters also contribute to the degradation of water quality. These include oil spills associated with marine vessel traffic, sediment dredging and disposal in local harbors (suspended sediments and contaminants), and activities related to the oil and gas industry, which operates platforms in State waters and discharges drilling wastes, produced water, and other industrial waste streams into Cook Inlet waters (MMS 2003a).

Most of the oil released to Cook Inlet is from commercial and recreational vessels (MMS 2003a). Small spills (less than 1,000 bbl) from commercial and recreational vessels or from OCS program activities (e.g., accidental releases) are not expected to affect the overall quality of Cook Inlet water (because they would be localized and short in duration); however, large spills (greater than 1,000 bbl) could temporarily degrade the overall quality of its water (MMS 2003a). Oil spills in ice-covered waters during winter months are generally contained within a much smaller area (compared with spills in open waters) because oil weathering (i.e., spreading, evaporation, and migration) is much slower and some oil may solidify. While such factors have proven to be favorable for most response strategies, the presence of ice can also complicate response efforts. Spills on ice are fairly easy to detect and map, unless there is fresh snowfall at the time of the spill; however, oil spilled within and under the ice can be hidden from view. Broken ice also makes spilled oil difficult to detect and map, and it can reduce the effectiveness of conventional recovery systems (MMS 2009b; DF Dickens Associates, Ltd. 2004).

Climate change predictions are based on models that simulate all relevant physical processes under a variety of projected greenhouse gas emission scenarios (Section 3.3). Because the complexity of modeling global and region climate systems is so great, uncertainty in climate projections can never be eliminated. The IPCC projections relating generally to water and water quality over the next two decades include:

- Sea level will rise by 0.18 to 0.59 m (0.6 to 2 ft) by the end of the twenty-first century;
- Sea ice, glaciers, and ice sheets in polar regions will continue melting;
- Ocean pH will decrease by 0.14 to 0.35 over the twenty-first century;
- Precipitation will increase at high latitudes (>90% likely); and
- Annual river discharges (runoff) will increase by 10 to 40% at high latitudes and decrease by 10 to 30% in the dry regions at mid-latitudes.

Alaska has experienced extensive regional warming since the 1960s, with a rise in annual temperature of about 3°C (5°F) since the 1960s. The general effects of warming include the extensive melting of glaciers, thawing of permafrost, and increased precipitation (Section 3.3). Modeling studies of warming in Cook Inlet project very large warming trends, ranging from 4°C to 10°C (7°F to 18°F) by the year 2100; precipitation is projected to increase by 20 to 25% (Kyle and Brabets 2001).

Conclusion. Water quality in Cook Inlet would be affected by various activities associated with the Program over the next 40 to 50 years. These include marine vessel traffic, chemical releases (sanitary wastes), disturbance of bottom sediments, and accidental oil spills (from marine vessel casualty and the oil and gas industry). Water quality is also affected by many other factors, including river inflows, urbanization, forest practices, mining, municipal waste discharges, and agriculture. Non-OCS program activities likely to contribute to cumulative impacts include marine vessel traffic, wastewater discharge to the inlet, dredging and marine disposal, and oil and gas related activities, as well as infrastructure in State-owned marine waters. Natural seepage of oil along the west part of the inlet also may be significant. The cumulative impacts on Cook Inlet water quality from all OCS and non-OCS activities in Cook Inlet over the next 40 to 50 years are expected to be minor to moderate, and the incremental contribution of the routine Program activities to water quality impacts would be small to medium. These impacts may lessen with time since oil and gas production in the Cook Inlet is currently on the decline (see Section 4.4.3.2).

The USEPA, in collaboration with other Federal and coastal State agencies, has assessed the coastal conditions of each region of the United States, including Cook Inlet, by evaluating five indicators of condition, one of which was water quality, based on such parameters as dissolved oxygen, chlorophyll *a*, nitrogen, phosphorus, and water clarity. The most recent assessment found the overall condition of the coastal waters of south central Alaska, including Cook Inlet, good (although water clarity in upper Cook Inlet was rated poor). Point source discharges are anticipated to remain at present levels for the foreseeable future; non-point source discharges should improve as a result of Alaska's water pollution control strategy. Low concentrations of hydrocarbons are found throughout the waters of Cook Inlet and are attributed to natural sources.

The number of expected accidental oil spills in Cook Inlet waters associated with the Program would represent only a small increase over the number of expected spills from ongoing non-OCS program activities (mainly oil and gas production in State waters). The incremental increase in adverse water quality impacts from these spills would depend on the weather and sea conditions at the spill location (e.g., whether ice is present), the type of waves and tidal energy at the spill locations, the type of oil spilled (very light to very heavy), the depth of the spill event (deep water, shallow water, or surface water), and the volume and rate of spillage; therefore, the incremental contribution of expected oil spills to cumulative water quality impacts could range from small to large. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from moderate to major if it were to occur. Spill response and cleanup activities (e.g., *in situ* burning and use of chemical dispersants) could contribute to water quality impacts regardless of the size of spill. A more detailed discussion of the effects of oil spills on water quality in Cook Inlet is presented in Section 4.4.3.2.2.

4.6.2.2.2 Air Quality. Section 4.4.4.2 discusses potential air quality impacts in onshore and offshore areas of Cook Inlet resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on air quality result from the incremental impacts of the Program (described in Section 4.4.4.2) when added to impacts from ongoing and reasonably foreseeable future actions, including those of ongoing and future OCS programs and other non-OCS program activities. Table 4.6.1-3 presents the exploration and development scenario for Cook Inlet cumulative case, which takes into account activities associated with the Program in combination with those from ongoing and future programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in Cook Inlet are summarized in Table 4.6.1-6 and discussed below, as applicable.

OCS program activities, i.e., those of the Program (there are no existing OCS program activities), involve production platforms, exploration wells, platform construction and removal, marine vessels (pipelaying, support, and survey), helicopters, and tanker and barge transport. All these activities have the potential to adversely affect air quality in the Cook Inlet region via direct emissions or other releases to air (e.g., volatile components of fuel). Accidental oil spills are also counted among OCS program-related activities; assumptions for oil spills under the cumulative case scenario are provided in Table 4.6.1-4. Existing emission sources in the Cook Inlet Planning Area include oil production activities in State waters, onshore petroleum processing and refining, onshore oil and gas production, marine terminals, and commercial shipping.

Criteria Pollutants. Except for a few population centers such as Anchorage, Fairbanks, and Juneau, the existing air quality in Alaska is relatively pristine, with pollutant concentrations well within ambient standards (Section 3.5.2.2). The primary industrial emissions in the Cook Inlet region are associated with oil and gas production, power generation, small refineries, paper mills, and mining. Other sources include vessel traffic in Cook Inlet and emissions from on-land motor vehicles and refuse burning (MMS 2003a). While some growth of these activities is likely to take place in the future, overall emissions are expected to remain low. More stringent emission standards on motor vehicles and new USEPA standards on non-road engines and marine vessels would result in a downward trend in emissions.

Modeling studies of proposed OCS production facilities in the Cook Inlet show that concentrations of NO_2, SO_2, and PM_{10} are within the PSD Class II and Class I maximum allowable increments and the NAAQS. Pollutant concentrations within the Tuxedni NWA, the only Class I area adjacent to the Cook Inlet Planning Area, exceed the Class I significance levels. As a consequence, any proposed facilities that would exceed the Class I significance levels, would need a comprehensive PSD increment consumption analysis done before permitting (MMS 2003a).

New USEPA regulations will apply international emission standards for ships off North American coasts. The U.S. and Canada have designated waters off North American coasts as an area in which stringent emission standards will become enforceable in August 2012 (USEPA 2010f). The area, called the North American Emission Control Area (NA ECA), will require the use of lower sulfur fuels in ships operating within 200 nautical miles of the majority of U.S. and Canadian coastline, including Cook Inlet. The fuel standards are expected to reduce emissions of SO_x and fine particulate matter ($PM_{2.5}$) by as much as 85% from current levels. Engine-based controls (such as high efficiency engines) would also reduce NO_x emissions.

Ozone Formation and Visibility Impairment. The baseline conditions and impacts from OCS activities on ozone and visibility are discussed in Sections 3.5.2.2 and 4.4.4.2, respectively. Because conditions in Alaska are seldom favorable for significant O_3 formation, the contribution of leasing activity associated with the Program to O_3 levels in the Cook Inlet region is expected to be small. OCS emission sources affecting visibility are also small; however, preliminary visibility screening for the Tuxedni NWA suggests sources within about 50 km (30 mi) may result in a plume visible from the site (MMS 2003a).

Greenhouse Gases. GHG emissions are one of the causes of climate change; however, assessing their impact requires consideration on a global scale. For this reason, it is not possible to estimate the impact of GHG emission from particular sources, such as the OCS activities associated with the Program. On a global scale, the contribution from the Program to total GHG emissions is small. On a national scale, the annual contribution of the Program is also small (generally less than 0.5%, much less significant than from activities in the GOM).

Oil Spills. Accidental oil spills are sources of gaseous emissions. No more than one large spill (1,000 bbl or greater) and 18 small spills (less than 1,000 bbl) are projected for the Cook Inlet Planning Area cumulative case as a result of the OCS program (Table 4.6.1-4). Most accidental spills in the Cook Inlet region are of non-crude products caused by onshore train derailments, pipeline failures, and leaks (crude oil comprises about 4% of all product spills) (ADEC 2007b). Since 1976, there have been nine major crude oil spills in the inlet, ranging in volume from 10,000 to 396,000 gal (with the largest of these coming from construction barges, offshore platforms, and jet fuel releases); the last oil spill (9,000 gallons; 214 barrels) occurred in 1997 as a result of a loss of well control incident at the Steelhead Platform (State of Alaska 2011). Oil spills cause localized increases in VOC concentrations (proportional to the size of the spill) due to evaporation. Most of these emissions would be expected to occur within a few hours of the spill and decrease (by dispersion) drastically after that period (MMS 2003a). However, oil spills in ice-covered waters during winter months would be contained within a much smaller area (compared with spills in open waters) because oil weathering (i.e., spreading, evaporation, and migration) is much slower and some oil may solidify (MMS 2009b). A more detailed discussion of the effects of oil spills on air quality in Cook Inlet is presented in Section 4.4.4.2.

Catastrophic events at well locations may result in fires; *in situ* burning is also a preferred technique for cleanup and disposal of oil spills (documented in soil spill contingency plans). Smoke generated from such fires would be expected to reach shore quickly (within a day), but would be limited in geographic extent (MMS 2003a). A discussion of the effects of fires on air quality in Cook Inlet is presented in Section 4.4.4.2.

Conclusion. OCS program activities in combination with other oil and gas exploration, development, and production activities in the Cook Inlet Planning Area could affect air quality in the region over the next 40 to 50 years. Air pollutant concentrations associated with offshore and onshore emission sources are expected to remain well within applicable State and Federal standards over the life of the Program. Therefore, the overall cumulative impacts on air quality in Cook Inlet from all OCS and non-OCS activities over the next 40 to 50 years are expected to be minor to moderate, and the incremental contribution of the routine Program activities to air quality impacts would be small (see Section 4.4.4.2).

The number of expected accidental oil spills in Cook Inlet associated with the Program would represent only a small increase over the number of expected spills from ongoing non-OCS program activities (mainly oil and gas production in State waters). The incremental increase in adverse air quality impacts from these spills (and *in situ* burning of spilled crude or diesel) would be localized and temporary (due to the spreading of oil and action by winds, waves, and currents that disperse volatile compounds to extremely low levels over a relatively large area); therefore, the incremental contribution of expected oil spills to cumulative air quality impacts could range from small to medium. Air quality impacts associated with an unexpected, low-probability CDE (and *in situ* burning) would also be reduced by these factors, and could be moderate if it were to occur. Spill response and cleanup activities (e.g., *in situ* burning and use of chemical dispersants) could contribute to air quality impacts regardless of the size of spill. A more detailed discussion of the effects of oil spills on air quality in Cook Inlet is presented in Section 4.4.4.2.2.

4.6.2.2.3 Acoustic Environment. Section 4.4.5.2 discusses impacts on the acoustic environment in Cook Inlet resulting from the Program (OCS program activities from 2012 to 2017). Section 4.4.7 evaluates the direct and indirect impacts of noise on marine fauna (mammals, birds, and fish), and Section 4.6.4 addresses the cumulative impacts of noise on marine fauna. Cumulative impacts on the acoustic environment result from the incremental impacts of the Program when added to impacts from reasonably foreseeable future OCS program activities (that are not part of the Program) and other non-OCS program activities.[45] Table 4.6.1-3 presents the exploration and development scenario for the Cook Inlet cumulative case (encompassing the Program and other OCS program activities). Ongoing and reasonably foreseeable non-OCS program activities contributing to adverse cumulative impacts on the acoustic environment in the Cook Inlet include aircraft overflights, vessel activities and traffic, construction and decommissioning of onshore and offshore facilities (e.g., related to ongoing oil and gas exploration and development in State waters), and other activities (e.g., seismic surveys) conducted as part of the existing oil and gas industry in the inlet. This section addresses the quality of the acoustic environment only; the cumulative impacts of noise on Cook Inlet marine fauna are discussed in Section 4.6.4.2.

Ambient (background) noise has numerous natural and man-made sources that vary with respect to season, location, depth of occurrence, time of day, and noise characteristics (e.g., frequency and duration).[46] Natural sources of ambient noise include wind and wave action, strong tidal fluctuations, currents, ice, precipitation (rain and hail), lightening, volcanic and tectonic noise, and biological noise (from marine mammals and coastal birds). Vessels (e.g., tankers, supply ships, tugboats, barges, and fishing boats) are the greatest man-made contributors to overall marine noise in Cook Inlet. Baseline acoustic conditions in Cook Inlet are discussed in more detail in Section 3.6.2.

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[45] Currently, there are no existing OCS program activities in Cook Inlet.

[46] Higher frequencies are attenuated with distance from the source more rapidly than lower frequencies. Traffic noise generated in deep water contributes to background noise levels at greater distances than traffic noise generated in shallow water.

Future routine OCS program activities, including those of the Program, that generate noise include operating airgun arrays (during marine seismic surveys), drilling, pipeline trenching, and onshore and offshore construction of platforms and drilling rigs. Vessel and aircraft traffic (including that associated with emergency response and cleanup activities in the event of a spill), accidental releases (e.g., loss of well control events), and vessel collisions also contribute to noise. A preliminary study of the noise impacts of OCS-related geophysical surveys found that marine seismic surveys have the greatest impact on marine mammals, sea turtles, fish, and commercial and recreational fisheries (MMS 2004a). Noise generated from OCS and non-OCS program activities would be transmitted through both air and water, and may be transient or more extended (occurring over the long term).

Conclusion. The quality of the acoustic environment in Cook Inlet would continue to be adversely affected by ongoing and future non-OCS program activities and by future OCS program activities (currently there are no existing OCS activities). The magnitude of cumulative impacts due to noise in Cook Inlet water from all OCS and non-OCS activities taking place in the inlet over the next 40 to 50 years is time- and location-specific and could range from minor to major, depending on the ambient acoustic conditions and the nature of activities taking place. The incremental contributions due to noise generated by routine Program activities could range from small to medium, depending on the timing of the disturbance and the location and characteristics of noise sources present (e.g., their frequency and duration). The cumulative impacts of noise on marine fauna (fish, marine mammals, sea turtles, and birds) are discussed in Section 4.6.4.

The number of expected accidental oil spills in Cook Inlet waters associated with the Program would represent only a small increase over the number of expected spills from ongoing non-OCS program activities. The incremental increase in adverse acoustic environment impacts from these spills (mainly due to noise sources associated with response and cleanup activities) would be localized and temporary; therefore, the incremental contribution of expected oil spills due to noise could range from small to medium. Impacts associated with an unexpected, low-probability CDE could be minor to moderate if it were to occur. Most of the impacts to the acoustic environment are due to noise sources (e.g., mechanical equipment, skimmers, support vessel traffic, and aircraft traffic) associated with spill response and cleanup activities. A more detailed discussion of the effects of oil spills on the acoustic environment in Cook Inlet is presented in Section 4.4.5.2.

4.6.2.3 Alaska Region – Arctic

4.6.2.3.1 Water Quality. Section 4.4.3.3 discusses potential water quality impacts in coastal (bays and estuaries), marine (State offshore and Federal OCS), and deepwater environments in the Arctic region resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on water quality result from the incremental impacts of the Program (described in Section 4.4.3.3) when added to impacts from ongoing and reasonably foreseeable future actions, including those of ongoing and future OCS programs and other non-OCS program activities.[47] Table 4.6.1-3 presents the exploration and development scenario for the Arctic region cumulative case, which takes into account activities associated with the Program in combination with those from ongoing and future programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in the Arctic are summarized in Table 4.6.1-7 and discussed below, as applicable.

Ongoing and future routine OCS program activities (i.e., those of the Program and existing OCS program activities) involve service vessel traffic, waste disposal, chemical releases (permitted discharges), and disturbance of bottom sediments. All these activities have the potential to adversely affect water quality in the Beaufort and Chukchi Seas. Accidental oil spills are also counted among OCS program-related activities; assumptions for oil spills under the cumulative case scenario are provided in Table 4.6.1-4.

OCS program-related service vessel traffic in the Beaufort and Chukchi Seas could be as high as 78 trips per week (up to 30 in the Beaufort Sea and 48 in the Chukchi Sea) over the next 40 to 50 years; vessel traffic associated with the Program represents about 35% of this traffic but would occur only during open-water and broken ice conditions (typically during August and September). Non-OCS program traffic in the Beaufort and Chukchi Seas is relatively low and includes that related to the oil and gas industry (e.g., cargo vessels, spill response vessels, and hovercraft), military operations, and Arctic research. Small marine vessels are used by local communities for hunting and between-village transportation during the open water period (MMS 2008b). Impacts on water quality from marine vessel traffic arise from regular discharges of bilge water and waste, leaching of anti-fouling paints, and incidental spills.

In the Beaufort Sea Planning Area, the number of platform and subsea production wells constructed over the period of the Program (at most 120 and 10, respectively) would be proportional to the amount of oil produced; these numbers represent about 39 and 40% (respectively) of the total number of platform and subsea production wells to be built in the planning area over the next 40 to 50 years as part of the Program. The lengths of new onshore and offshore pipeline (at most 129 km [80 mi] and 250 km [155 mi], respectively) added as part of the Program represent about 28 and 37%, respectively, of that anticipated as part of the OCS program over the next 40 to 50 years.

In the Chukchi Sea Planning Area, the number of platform and subsea production wells constructed over the period of the Program (at most 280 and 82, respectively) would be proportional to the amount of oil produced; these numbers represent about 32 and 35%%, respectively, of the total number of new platform and subsea production wells anticipated to be built in the planning area over the next 40 to 50 years as part of the OCS program. The lengths of new onshore and offshore pipeline (at most 0 km [0 mi] and 402 km [250 mi], respectively) added as part of the Program represent about 0 and 19%, respectively, of that anticipated as part of the OCS program.

47 Currently, there are no existing OCS program activities in the Beaufort Sea and Chukchi Sea Planning Areas, but it is assumed that exploration and development activities as a result of Sale 193 (Chukchi Sea) will have occurred before commencement of the exploration and development activities associated with the Program (Section 4.4.1.3).

The area of sea bottom disturbed from construction of platforms and pipelines over the period of the Program (as much as 581 ha [1,440 ac] in the planning areas combined) represents about 29% of that associated with the OCS program over the next 40 to 50 years. Bottom disturbance degrades water quality by increasing water turbidity in the vicinity of the operations and adding contaminants to the water column. It also changes sediment composition as suspended sediments (and contaminants, if present) are entrained in currents and deposited in new locations.

As summarized in Section 3.4.3.3, the water quality in the Beaufort and Chukchi Seas is relatively uncontaminated by anthropogenic pollutants (compared to other regions that typically receive pollutants from industrial, agricultural, and municipal discharges and related runoff). The principal point sources of pollution are facilities related to the oil and gas industry, hard-rock mining, military operations, and seawater treatment. Non-point sources release a range of contaminants via rivers and on-land drainages that could include contaminated runoff related to mining operations (e.g., gold mining on the Seward Peninsula). Most of these activities would remain at present levels for the foreseeable future and are not expected to affect the overall water quality in these regions.

Activities taking place within Arctic waters also contribute to the degradation of water quality. These include oil spills associated with vessel traffic, sediment dredging and disposal in local harbors (suspended sediments and contaminants), and activities related to the oil and gas industry, which operates platforms in State waters and discharges drilling wastes, produced water, and other industrial waste streams into the Beaufort Sea (MMS 2008b; ADEC 2007a).

Most of the oil released to Arctic waters is from leaks related to the oil industry (ADEC 2007a). Small spills (less than 1,000 bbl) from commercial and recreational vessels or from OCS program activities (e.g., accidental releases) are not expected to affect the overall quality of the Beaufort or Chukchi Seas because they are localized and short in duration; however, large spills (1,000 bbl or greater) could temporarily degrade the overall quality of their water (MMS 2003a). Oil spills in ice-covered waters are generally contained within a much smaller area (compared with open-water spills) because in the cold Arctic environment, oil weathering (i.e., spreading, evaporation, and migration) is much slower and some oil may solidify or become contained within sea ice. While such factors have proven to be favorable for most response strategies, the presence of ice can also complicate the response strategy. Spills on ice are fairly easy to detect and map, unless there is fresh snowfall at the time of the spill; however, oil spilled within and under the ice can be hidden from view. Broken ice also makes spilled oil difficult to detect and map, and it can reduce the effectiveness of conventional recovery systems (MMS 2009b; DF Dickens Associates, Ltd. 2004).

Climate change predictions are based on models that simulate all relevant physical processes under a variety of projected greenhouse gas emission scenarios (Section 3.3). Because the complexity of modeling global and region climate systems is so great, uncertainty in climate projections can never be eliminated. Changes to the Arctic climate include:

- Atmospheric temperature increases of 1 to 2°C (2–4°F) since the 1960s and continuing increases at a rate 1°C (2°F) per decade in winter and spring;

- Precipitation increases at a rate of about 1% per decade;

- Decreases in March sea ice extent at a rate of about 3% per decade and September sea ice at a rate of about 12% per decade (since the 1970s);

- Multi-year ice decreases at a rate of about 9% per decade (since the 1980s);

- Temperatures increases at the top of the permafrost layer by up to 3°C (5°F) since the 1980s; and

- Thawing of the permafrost base at a rate of up to 0.04 m/yr (0.13 ft/yr).

The retreat of sea ice is increasing impacts on coastal areas from storms. In areas where permafrost has thawed, coastlines are more vulnerable to erosion from wave action.

Conclusion. Water quality in the Beaufort and Chukchi Seas would be affected by the following activities associated with the Program: marine vessel traffic, waste disposal, chemical releases (permitted discharges), disturbance of bottom sediments, and accidental oil spills (from vessels and the oil and gas industry). Non-OCS program activities likely to contribute to cumulative impacts include marine vessel traffic, wastewater discharge, dredging and marine disposal, oil-related, and gas-related activities and infrastructure in State-owned marine waters, and other industrial activities (e.g., Red Dog Mine). Impacts related to marine vessel traffic in the Beaufort and Chukchi Seas (especially shipping and research vessels, icebreakers, and cruise ships) would likely increase in the coming decades as the open-water season begins earlier and ends later.

The cumulative impacts of ongoing and reasonably foreseeable future activities on water quality in the Arctic are unavoidable and may, in cases of melting sea ice, be irreversible, since such trends are natural and are occurring on a global scale. However, because many other impacts could be mitigated (i.e., minimized) by the various regulatory controls already in place to protect the marine waters of the Beaufort and Chukchi Seas, the overall cumulative impacts are considered to be moderate. The incremental contribution of the Program to cumulative impacts on water quality would be small to medium relative to the cumulative case and relative to other ongoing and reasonably foreseeable future actions in the Arctic (see Section 4.4.3.3).

The number of expected accidental oil spills in Arctic waters associated with the Program would represent only a small increase over the number of expected spills from future OCS programs and ongoing and future non-OCS program activities (mainly oil and gas development in State waters). The incremental increase in adverse water quality impacts from these spills would depend on the weather and sea conditions at the spill location (e.g., whether ice is present), the type of waves and tidal energy at the spill locations, the type of oil spilled (very light to very heavy), the depth of the spill event (deep water, shallow water, or surface water), and the volume and rate of spillage; therefore, the incremental contribution of expected oil spills to cumulative water quality impacts could range from small to large. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from moderate to major if it were to occur. Spill response and cleanup activities could contribute to water quality impacts regardless of the size of spill. A more detailed discussion of the effects of oil spills on water quality in Arctic waters is presented in Section 4.4.3.3.2.

4.6.2.3.2 Air Quality. Section 4.4.4.3 discusses potential air quality impacts in onshore and offshore areas of the Beaufort and Chukchi Seas resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on air quality result from the incremental impacts of the Program (described in Section 4.4.4.3) when added to impacts from ongoing and reasonably foreseeable future actions, including those of ongoing and future OCS programs and other non-OCS program activities.[48] Table 4.6.1-3 presents the exploration and development scenario for the Arctic cumulative case, which takes into account activities associated with the Program in combination with those from ongoing and future programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in the Arctic are summarized in Table 4.6.1-7 and discussed below, as applicable.

Ongoing and future routine OCS program activities, including those of the Program, involve production platforms, exploration wells, platform construction and removal, marine vessels (pipelaying, support, and survey), helicopters, and tanker and barge transport. All these activities have the potential to adversely affect air quality in the Beaufort and Chukchi Seas. Accidental oil spills are also counted among OCS program-related activities; assumptions for oil spills under the cumulative case scenario are provided in Table 4.6.1-4. Existing emission sources in the Beaufort Sea and Chukchi Sea Planning Areas include oil and gas exploration, development, and production activities in State waters (Beaufort Sea only); onshore petroleum processing and refining; marine terminals (e.g., DeLong Mountain Terminal on the Chukchi Sea); aircraft traffic; and vessel traffic.

Except for a few population centers such as Anchorage, Fairbanks, and Juneau, the existing air quality in Alaska is relatively pristine with pollutant concentrations well within ambient standards (Section 3.5.2.3). This is also the case in the Chukchi and Beaufort Seas and the North Slope area, with the exception of "Arctic haze," which is attributed to combustion sources in Russia (MMS 2010). The primary industrial emissions in the Beaufort and Chukchi Sea Planning Areas are associated with onshore oil development and production, offshore oil development and production (in State waters), power generation, mining (Red Dog Mine), and marine transportation. While some growth of these activities is likely to take place in the future, overall emissions are expected to remain low. More stringent emission standards on motor vehicles and new USEPA standards on non-road engines and marine vessels would result in a downward trend in emissions.

Criteria Pollutants. On the Alaska North Slope, the main sources of air emissions are associated with onshore oil production from the Prudhoe Bay, Kuparuk River, Colville River, Oooguruk, Milne Point, and Badami fields and oil production in State waters (Northstar and

48 Currently, there are no existing OCS program activities in the Beaufort Sea and Chukchi Sea Planning Areas, but it is assumed that exploration and development activities as a result of Sale 193 (Chukchi Sea) will have occurred before commencement of the exploration and development activities associated with the Program (Section 4.4.1.3).

Duck Island fields). As of 2009, about 16.2 Bbbl[49] of oil have been produced from North Slope reservoirs, including the Beaufort Sea (ADNR 2009c). Production from the region peaked at about 730 Mbbl in 1988 and has been in decline since then (EIA 2011c). The USDOE projects that the annual production of oil will continue to decline, from about 234 Mbbl in 2010 to 37 Mbbl in 2050 (EIA 2009n). There are a number of planned and potential future oil development projects, both onshore and in State and Federal waters in the Beaufort Sea Planning Area. There are very few other emission sources in the Chukchi Sea Planning Area.

Air monitoring at a number of sites in the Kuparuk and Prudhoe Bay fields has shown that concentrations of NO_2, SO_2, and PM_{10} are well within the NAAQS. Modeling studies for the Liberty project indicate that emissions from these areas have little effect on ambient concentrations in other locations (with maximum concentrations occurring within 100 to 200 m [330 to 660 ft] from the facility boundary and considerably lower concentrations at a distance of 1 km [0.62 mi]) (MMS 2010). For this reason, it is anticipated that emissions from new facilities would be small and localized with little interaction between facilities.

Table 4.6.2-3 lists the estimated total emissions associated with all future OCS oil and gas activities in the Beaufort and Chukchi Seas, including the 2012-2017 Program, over the next 50 years. These emissions were estimated by BOEM using emission factors from the *2008 Gulfwide Emission Inventory Study* (Wilson et al. 2010).[50] In terms of absolute amounts (using the high scenario), the largest emissions would be NO_x, followed by VOCs, CO, and SO_x, with lesser amounts of PM_{10} and $PM_{2.5}$, in order of decreasing emissions. Under both the high and low scenarios, support vessels would be the largest source of NO_x; the drilling of exploration and development wells would be the largest source of SO_x and PM; and platform production would be the largest source of CO and VOCs. Emissions from Program activities in the Arctic region generally represent about 37 to 39% of the Arctic cumulative case emissions.

Ozone Formation and Visibility Impairment. The baseline conditions and impacts from OCS activities on ozone and visibility are discussed in Sections 3.5.2.3 and 4.4.4.3, respectively. Because conditions in Alaska are seldom favorable for significant O_3 formation, the contribution of leasing activity associated with the Program to O_3 levels in the Beaufort and Chukchi Sea Planning Areas is expected to be small. OCS emission sources affecting visibility are also small.

Greenhouse Gases. Table 4.6.2-4 lists the total calculated emissions of CO_2, CH_4, and N_2O from OCS activities related to the Beaufort and Chukchi Seas (Arctic region) portion of the 2012-2017 Program and compares them to the 2012-2017 Program overall (accounting for OCS program activities in GOM, Cook Inlet, and the Arctic region) and to the total U.S. emissions from all sources in 2009. Activities in the Arctic region account for a small portion of the GHG emissions associated with the 2012-2017 Program, comprising between 1.8 and 4.6% of all program-related GHG emissions. For reference, the estimated annual emissions of CO_2, CH_4,

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[49] Historic figures include both oil and natural gas liquids produced at Prudhoe Bay and surrounding fields.

[50] In the absence of Arctic-specific data, the emission factors from the Wilson et al. (2010) study are considered the best approximation for estimating total emissions related to exploration and development in the Arctic region. Another source, Shell Offshore Inc. (2010), was used to estimate emissions related to icebreakers.

TABLE 4.6.2-3 Estimated Total Air Emissions for the Offshore Exploration and Development Scenario for the OCS Program Arctic Region Cumulative Case

	Pollutant (10^3 tons for 50 yr)[a]					
Activity	NO_x	SO_x	PM_{10}	$PM_{2.5}$	CO	VOC
Well drilling (D&P)	6.57–27.7	1.34–5.66	0.45–1.89	0.45–1.89	0.03–0.15	0.17–4.93
Well drilling (E&D)	11.86–46.46	3.07–12.03	0.54–2.10	0.49–1.92	0.01–0.04	0.51–2.01
Helicopters	0.1–0.53	0.02–0.13	0.02–0.1	0.02–0.1	1.21–6.43	0.24–1.27
Pipe-laying vessels	2.65–18.84	0.45–3.2	0.1–0.71	0.1–0.71	0.55–3.91	0.1–0.71
Platform construction	4.63–24.06	1.09–5.65	0.18–0.95	0.17–0.88	0.14–0.75	0.16–0.83
Platform production	6.64–35.41	0.09–0.47	0.06–0.33	0.06–0.33	7.31–39.01	5.95–31.74
Platform removal	4.63–24.06	1.09–5.65	0.18–0.95	0.17–0.88	0.14–0.75	0.16–0.83
Support vessels	11.95–63.77	1.61–8.59	0.21–1.10	0.21–1.10	1.14–6.07	0.21–1.10
Survey vessels	0.15–0.80	0.02–0.1	0–0.01	0–0.01	0.01–0.07	0–0.01
Total (Cumulative OCS)	49.18–241.63	9.78–41.47	1.74–8.14	1.66–7.82	10.55–57.18	8.5–43.45
Total (Program)[b]	19.59–89.16	3.65–15.04	0.71–2.92	0.68–2.8	3.77–22.2	3.15–16.79

[a] The range of values reflects the low and high end of new exploration and development activity.

[b] Values from Table 4.4.4-5.

TABLE 4.6.2-4 Estimated Greenhouse Gas Emissions for the 2012-2017 Program in the Arctic Region Relative to the 2012-2017 OCS Program Overall over the Next 40 Years

Pollutant	2012-2017 Program (all) (Tg CO_2e) [a, b]	2012-2017 Arctic Program (Tg CO_2e)	Total U.S. Emission from All Sources (2009)	Percent of Total U.S. Emissions from Arctic Program [c]
CO_2	341.54–512.6	5.29–24.66	5,505.2	0.003–0.010
CH_4	3.98–120.22	0.81–4.33	686.3	0.004–0.014
N_2O	2.85–4.23	0.02–0.09	295.6	0.00–0.001
CO_2 + CH_4 + N_2O	348.57–637.05	6.12–29.08	6,487.1	0.003–0.010
All GHG	348.57–637.05	6.12–29.08	6,633.2	0.003–0.010
Total	348.57–637.05	6.12–29.08	38,726.0	

[a] One Tg is equal to 10^{12} g, or 10^6 metric tons. The CO_2e for a gas is derived by multiplying the mass of the gas by the associated GWP, which accounts for the relative effectiveness of a gas to contribute to global warming with respect to the same amount of CO_2. In these calculations, CH_4 is given a GWP of 21, while NO_2 is given a GWP of 310.

[b] Values represent the total emissions for the 2012-2017 Program in the GOM, Cook Inlet, and Arctic regions.

[c] Values are calculated by dividing the estimated annual emissions of the Arctic Program (equal to the value in the third column divided by 40) by the total U.S. emission from all sources in 2009 (fourth column).

Source: USEPA 2011l.

and N_2O from OCS activities in the Arctic region were less than 0.05% of CO_2, CH_4, and N_2O emissions in the United States from all sources in 2009. Although these are small contributions, it should be noted that some GHGs (e.g., CO_2) can persist in the atmosphere for a century, well beyond the life of the Program.

GHG emissions are one of the causes of climate change; however, assessing their impact requires consideration on a global scale. For this reason, it is not possible to estimate the impact of GHG emissions from particular sources, such as the OCS activities associated with the Program. On a global scale, the contribution from the Program to total GHG emissions is small. On a national scale, the contribution of the Program is also small (much less significant than from activities in the GOM).

Oil Spills. Accidental oil spills are a source of gaseous emissions. No more than six large spills (1,000 bbl or greater) and 450 small spills (less than 50 bbl) are projected for the Beaufort and Chukchi Sea Planning Areas cumulative case as a result of the OCS program (Table 4.6.1-4). Most of the accidental spills in the North Slope region are of non-crude products during fuel transfer operations at remote villages (ADEC 2007a). While there is no discernible trend in the annual number of spills or total volume released, there is a seasonal pattern to spill events, with increases occurring during winter months (likely coinciding with increased exploration activities). Since 1976, there have been no major crude oil spills in Arctic waters (State of Alaska 2011). Oil spills cause localized increases in VOC concentrations (proportional to the size of the spill) due to evaporation. Most of these emissions would be expected to occur within a few hours of the spill and decrease (by dissipation) drastically after that period (MMS 2010). However, oil spills in ice-covered waters during winter months would be contained within a much smaller area (compared with spills in open waters) because oil weathering (i.e., spreading, evaporation, and migration) is much slower and some oil may solidify (MMS 2009b). A more detailed discussion of the effects of oil spills on air quality in the Arctic region is presented in Section 4.4.4.3.

Catastrophic events at well locations may result in fires; *in situ* burning is also a preferred technique for cleanup and disposal of oil spills (documented in oil spill contingency plans). Smoke generated from such fires would be expected to reach shore quickly (within a day), but would be limited in geographic extent (MMS 2003a). A discussion of the effects of fires on air quality in the Arctic region is presented in Section 4.4.4.3.

Conclusion. OCS program activities in combination with other oil and gas exploration, development, and production activities in the Beaufort and Chukchi Sea Planning Areas could affect air quality in the region. Air pollutant concentrations associated with offshore and onshore emission sources are expected to remain well within applicable State and Federal standards over the life of the Program. Therefore, the overall cumulative impacts on air quality in the Beaufort and Chukchi Sea Planning Areas are expected to be minor to moderate, and the incremental contribution of routine Program activities to air quality impacts would be small (see Section 4.4.4.3).

The number of expected accidental oil spills in Arctic waters associated with the Program would represent only a small increase over the number of expected spills from ongoing non-OCS program activities (mainly oil and gas production in State waters). The incremental increase in adverse air quality impacts from these spills (and *in situ* burning of spilled crude or diesel) would be localized and temporary (due to the spreading of oil and action by winds, waves, and currents that disperse volatile compounds to extremely low levels over a relatively large area); therefore, the incremental contribution of expected oil spills to cumulative air quality impacts could range from small to medium. Air quality impacts associated with an unexpected, low-probability CDE (and *in situ* burning) would also be reduced by these factors, and could be moderate if it were to occur. Spill response and cleanup activities (e.g., *in situ* burning and use of chemical dispersants) could contribute to air quality impacts regardless of the size of spill. A more detailed discussion of the effects of oil spills on air quality in the Arctic region is presented in Section 4.4.4.2.3.

4.6.2.3.3 Acoustic Environment. Section 4.4.5.3 discusses impacts on the acoustic environment in the Arctic region resulting from the Program. Section 4.4.7 evaluates the direct and indirect impacts of noise on marine fauna (fish, marine mammals, and birds), and Section 4.6.4 addresses the cumulative impacts of noise on marine fauna. Cumulative impacts on the acoustic environment result from the incremental impacts of the Program when added to impacts from reasonably foreseeable future OCS program activities (that are not part of the

Program) and other non-OCS program activities.[51] Table 4.6.1-3 presents the exploration and development scenario for the Beaufort Sea and Chukchi Sea Planning Areas cumulative case (encompassing the Program and other OCS program activities). Ongoing and reasonably foreseeable non-OCS program activities contributing to adverse cumulative impacts on the acoustic environment in the Arctic region include aircraft traffic, marine vessel traffic, construction of onshore and offshore facilities (e.g., related to ongoing oil and gas exploration and development in State waters), and other activities (e.g., seismic surveys) conducted as part of the existing oil and gas industry in the Beaufort and Chukchi Seas. This section addresses the quality of the acoustic environment only; the cumulative impacts of noise on marine fauna in the Beaufort and Chukchi Seas are discussed in Section 4.6.4.3.

Ambient (background) noise has numerous natural and man-made sources that vary with respect to season, location, depth of occurrence, time of day, and noise characteristics (e.g., frequency and duration).[52] Natural sources of ambient noise include wind and wave action, currents, ice, precipitation (rain and hail), lightening, and biological noise (from marine mammals and coastal birds). Marine vessels (e.g., tankers, supply ships, tugboats, barges, and fishing boats) are the greatest man-made contributors to overall marine noise in the Arctic region. Baseline acoustic conditions in the region are discussed in more detail in Section 3.6.3.

Future routine OCS program activities, including those of the Program, that generate noise include operating airgun arrays (during marine seismic surveys), drilling, pipeline trenching, and onshore and offshore construction and decommissioning of platforms (including artificial islands and causeways), and drilling rigs. Vessel and aircraft traffic (including that associated with emergency response and cleanup activities in the event of a spill), accidental releases (e.g., loss of well control events), and vessel collisions also contribute to noise. A preliminary study of the noise impacts of OCS related geophysical surveys found that marine seismic surveys have the greatest impact on marine mammals, sea turtles, fish, and commercial and recreational fisheries (MMS 2004a). Noise generated from OCS and non-OCS program activities would be transmitted through both air and water, and may be transient or more extended (occurring over the long term).

Conclusion. The quality of the acoustic environment in the Beaufort and Chukchi Seas would continue to be adversely affected by ongoing and future non-OCS program activities and by future OCS program activities (currently there are no existing OCS activities, although seismic studies and exploratory drilling have been conducted in the past). The magnitude of cumulative impacts due to noise in the Beaufort and Chukchi Seas from all OCS and non-OCS activities taking place in the Arctic region over the next 40 to 50 years is time- and location-specific and could range from minor to major, depending on the ambient acoustic conditions and the nature of activities taking place. The incremental contribution due to noise generated by

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51 Currently, there are no existing OCS program activities in the Beaufort Sea and Chukchi Sea Planning Areas, but it is assumed that exploration and development activities as a result of Sale 193 (Chukchi Sea) will have occurred before the Program (Section 4.4.1.3).

52 Higher frequencies are attenuated with distance from the source more rapidly than lower frequencies. Traffic noise generated in deep water contributes to background noise levels at greater distances than traffic noise generated in shallow water.

routine Program activities could range from small to medium, depending on the timing of the disturbance and the location and characteristics of noise sources present (e.g., their frequency and duration). The cumulative impacts of noise on marine fauna (fish, marine mammals, and birds) are discussed in Section 4.6.4.

The number of expected accidental oil spills in Arctic waters associated with the Program would represent only a small increase over the number of expected spills from ongoing non-OCS program activities. The incremental increase in adverse acoustic environment impacts from these spills (mainly due to noise sources associated with response and cleanup activities) would be localized and temporary; therefore, the incremental contribution of expected oil spills due to noise could range from small to medium. Impacts associated with an unexpected, low-probability CDE could be minor to moderate if it were to occur. Most of the impacts to the acoustic environment are due to noise sources (e.g., mechanical equipment, skimmers, support vessel traffic, and aircraft traffic) associated with spill response and cleanup activities. A more detailed discussion of the effects of oil spills on the acoustic environment in the Arctic region is presented in Section 4.4.5.3.

4.6.2.4 Summary for the Gulf of Mexico Region

4.6.2.4.1 Water Quality. There are many factors affecting the water quality in the GOM currently. In general, these include marine vessel traffic, wastewater discharge, dredging and marine disposal, oil and gas production (in State waters and on the OCS), military operations, LNG terminal operations, LOOP operations, and natural oil seepage along the continental slope. Coastal waters are also affected by numerous other factors, including river inflows, urbanization, agricultural practices, municipal waste discharges, and coastal industry. Climate change is also expected to affect water quality in the coming decades, especially in terms of surface temperature, salinity, vertical stratification, and pH. Another issue of importance to water quality in the GOM concerns an area known as the hypoxic zone, a zone of oxygen depletion (due to high nutrient loads) which is located at the bottom of the continental shelf of Louisiana and Texas. Cumulative impacts on water quality are attributed to a combination of all these factors and, overall, are considered to be moderate. The incremental contribution of the Program to cumulative impacts on water quality in the GOM would be small to medium.

Routine operations under the Program could result in localized and short-term minor to moderate impacts as a result of structure placement and construction (pipelines and platforms), operational discharges (produced water, bilge water, and drill cuttings), bottom disturbance, and waste discharges. Compliance with NPDES permits and USCG regulations would reduce the magnitude of most of these impacts. The effects of expected accidental oil spills (most of which are less than 1,000 bbl) would depend upon weather and sea conditions at the spill site, the type of oil spilled, the depth of the spill event, and the volume and rate of spillage; therefore, the incremental contribution of expected oil spills to cumulative water quality impacts could range from small to large. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from moderate to major if it were to occur. Spill response and cleanup activities could also contribute to water quality impacts. While small spills (less than 1,000 bbl) would result in short-term, localized impacts, the impacts associated with larger spills (1,000 bbl or greater) or a CDE could persist for an extended period (especially in wetlands and low-energy environments).

4.6.2.4.2 Air Quality. In general, the ambient air quality in coastal counties along the GOM is relatively good. Coastal counties are in attainment for all criteria pollutants except 8-hr ozone (in some areas of Texas and Louisiana). Visibility in the coastal region is about 48 to 64 km (30 to 40 mi). Most of the human-caused visibility degradation is attributed to sulfate particles, but also to organic or elemental carbon particles and nitrate particles. The effects of various USEPA regulations and standards are expected to result in a steady, downward trend in future air emissions in the coming decades. Cumulative impacts on air quality in the GOM region are attributed to both offshore and onshore activities. Offshore activities in the GOM are mainly associated with the oil and gas industry, but also include various marine vessel traffic (shipping, fishing, cruise ships), tanker lightering, and military operations. Onshore emission sources include power generation, industrial processing, manufacturing, refineries, commercial and home heating, on-road vehicles, and non-road engines (e.g., aircraft, locomotives, and construction equipment). Overall, cumulative impacts on air quality in the GOM over the next 40 to 50 years are expected to be minor to moderate.

The incremental contribution of routine operations under the Program would be small, because they would not cause exceedance of the NAAQS in public access areas or affect visibility. Small accidental oil spills (less than 1,000 bbl) would have localized and temporary effects and are considered minor from an air quality standpoint. The effects of expected accidental oil spills (most of which are less than 1,000 bbl) would be localized and temporary due to dispersion; therefore, the incremental contribution of expected oil spills to cumulative air impacts could range from small to medium. Air quality impacts associated with an unexpected, low-probability would also be reduced by these factors, and would be moderate if it were to occur. Spill response and cleanup activities could also contribute to air quality impacts.

4.6.2.4.3 Acoustic Environment. Sources of ambient noise in the GOM include wind and wave activity, precipitation (rain and hail), lightning, biological noise, and distant marine vessel traffic. The main sources of anthropogenic noise are numerous in the GOM and include marine vessel traffic, dredging, construction, oil and gas activities (such as seismic surveys), marine mineral mining, sonar, explosions, and ocean science studies. The quality of the acoustic environment in the GOM would continue to be adversely affected by ongoing and future OCS and non-OCS activities. The magnitude of cumulative impacts in the GOM is time- and location-specific and could range from minor to major, depending on the ambient acoustic conditions and the nature and combination of noise sources from all OCS and non-OCS activities.

Routine operations under the Program would result in minor impacts to ambient noise levels mainly associated with seismic surveys, drilling and production, infrastructure placement and removal, and marine vessel traffic. Depending on the source, changes in ambient noise levels could be short-term and localized (e.g., from vessel traffic), long-term and localized (e.g., from production), or short-term and less localized (e.g., seismic surveys), and some may extend well beyond the survey boundary. The contribution of the Program to cumulative impacts could be small to medium, depending on the timing of the disturbance and the location and characteristics of noise sources present (e.g., their frequency and duration). The incremental increase in adverse acoustic environmental impacts from expected accidental oil spills in GOM waters (most of which are less than 1,000 bbl) would be localized and temporary; therefore, the incremental contribution of expected oil spills to cumulative noise-related impacts would be small. Impacts associated with an unexpected, low-probability CDE could range from minor to moderate if it were to occur. Most of the impacts to the acoustic environment would be due to noise sources associated with response and cleanup activities.

4.6.2.5 Summary for Alaska – Cook Inlet

4.6.2.5.1 Water Quality. Factors affecting the water quality in Cook Inlet include marine vessel traffic, wastewater discharge, dredging and marine disposal, oil and gas production (currently only in State waters), and military operations. Water quality is also affected by numerous other factors, including river inflows, urbanization, forest practices, mining, municipal waste discharges, and agriculture. Natural seepage of oil along the west part of the inlet may also be significant. Cumulative impacts on water quality are attributed to a combination of all these factors and, overall, are considered to be minor to moderate. These impacts may lessen with time since oil and gas production in Cook Inlet is currently in decline. The incremental contribution of the Program to cumulative impacts on water quality in Cook Inlet would be small to medium.

Routine operations under the Program could result in localized and short-term minor to moderate impacts as a result of structure placement and construction (pipelines and platforms), operational discharges (produced water, bilge water, and drill cuttings), bottom disturbance, and waste discharges. Compliance with NPDES permits and USCG regulations would reduce the magnitude of most impacts. The effects of expected accidental oil spills (most of which are less than 1,000 bbl) would depend upon weather and sea conditions at the spill site, the type of oil spilled, the depth of the spill event, and the volume and rate of spillage; therefore, the incremental contribution of expected oil spills to cumulative water quality impacts could range from small to large. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from moderate to major if it were to occur. Spill response and cleanup activities could also contribute to water quality impacts. While small spills (less than 1,000 bbl) would result in short-term, localized impacts, impacts associated with larger spills (1,000 bbl or greater) or a CDE could persist for an extended period (especially in wetlands and low-energy environments).

4.6.2.5.2 Air Quality. Except for a few population centers such as Anchorage, the existing air quality in Alaska is relatively pristine with pollutant levels that are well within the ambient standards. Cumulative impacts on air quality in Cook Inlet are attributed to both offshore and onshore activities. Offshore activities in the region are mainly associated with the oil and gas industry, but also include various marine vessel traffic (shipping, fishing, cruise ships). Onshore emission sources include power generation, industrial plants, mining, commercial and home heating, on-road vehicles, and non-road engines (e.g., aircraft, locomotives, and construction equipment). Overall, cumulative impacts on air quality in Cook Inlet over the next 40 to 50 years are expected to be minor to moderate.

The incremental contribution of routine operations under the Program would be small, because they would not cause exceedance of the NAAQS in public access areas or affect visibility. Small accidental oil spills (less than 1,000 bbl) would have localized and temporary effects and are considered minor from an air quality standpoint. The effects of expected accidental oil spills would be localized and temporary due to dispersion; therefore, the incremental contribution of expected oil spills to cumulative air impacts could range from small to medium. Air quality impacts associated with an unexpected, low-probability CDE would also be reduced by these factors, and could be moderate if it were to occur. Spill response and cleanup activities could also contribute to air quality impacts.

4.6.2.5.3 Acoustic Environment. Ice, strong tidal fluctuations, and currents all play an important role in the ambient noise levels in Cook Inlet. The main sources of anthropogenic noise are aircraft overflights, marine vessel traffic, oil and gas activities (including seismic surveys and production operations), and other operations such as dredging and pile driving (for new docks). The quality of the acoustic environment in Cook Inlet would continue to be adversely affected by ongoing and future non-OCS program activities and by future OCS program activities (currently there are no existing OCS activities, although seismic studies and exploratory drilling have been conducted in the past). The magnitude of cumulative impacts in the inlet is time- and location-specific and could range from minor to major, depending on the ambient acoustic conditions and the nature and combination of noise sources from all OCS and non-OCS activities.

Routine operations under the Program would result in minor impacts to ambient noise levels mainly associated with seismic surveys, drilling and production, infrastructure placement and removal, and marine vessel traffic. Depending on the source, changes in ambient noise levels could be short-term and localized (e.g., from vessel traffic), long-term and localized (e.g., from production), or short-term and less localized (e.g., seismic surveys), and some may extend well beyond the survey boundary. The contribution of the Program to cumulative impacts could range from small to medium, depending on the timing of the disturbance and the location and characteristics of noise sources present (e.g., their frequency and duration). The incremental increase in adverse acoustic environmental impacts from expected accidental oil spills in Cook Inlet waters (mainly due to noise sources associated with response and cleanup) would be localized and temporary; therefore, the incremental contribution of expected oil spills to cumulative noise-related impacts would be small. Impacts associated with an unexpected, low-probability CDE could range from minor to moderate if it were to occur. Most of the impacts to the acoustic environment would be due to noise sources associated with response and cleanup activities.

4.6.2.6 Summary for Alaska – Arctic

4.6.2.6.1 Water Quality. Factors affecting the water quality in the Beaufort and Chukchi Seas include marine vessel traffic, wastewater discharge, oil and gas production (currently only in State waters), and military operations. Water quality is also affected by numerous other factors, including river inflows, mining, and municipal waste discharges. Cumulative impacts on water quality are attributed to a combination of all these factors and, overall, are considered to be moderate. Impacts related to marine vessel traffic in the Beaufort and Chukchi Seas (especially shipping and research vessels, icebreakers, and cruise ships) would likely increase in the coming decades as the open-water season begins earlier and ends later (an effect of climate change). The incremental contribution of the Program to cumulative impacts on water quality in Arctic waters would be small to medium.

Routine operations under the Program could result in localized and short-term minor to moderate impacts as a result of structure placement and construction (pipelines and platforms), operational discharges (produced water, bilge water, and drill cuttings), bottom disturbance, and waste discharges. Compliance with NPDES permits and USCG regulations would reduce the magnitude of most of these impacts. The effects of expected accidental oil spills (most of which are less than 1,000 bbl) would depend upon weather and sea conditions at the spill site, the type of oil spilled, the depth of the spill event, and the volume and rate of spillage; therefore, the incremental contribution of expected oil spills to cumulative water quality impacts could range from small to large. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from moderate to major if it were to occur. Spill response and cleanup activities could also contribute to water quality impacts. While small spills (less than 1,000 bbl) would result in short-term, localized impacts, impacts associated with larger spills (1,000 bbl or greater) or a CDE could persist for an extended period (especially in wetlands and low-energy environments).

4.6.2.6.2 Air Quality. The Arctic region has a low population. Barrow is the largest city in the North Slope Borough, with a population (in 2010) of just 4,600. The primary industrial emissions in the region are associated with the oil and gas industry, power generation, small refineries, paper mills, and mining. Currently, North Slope Borough is designated as an unclassified/attainment area for all criteria pollutants. The region does experience air pollution problems (e.g., Arctic haze), however, due to long-range transport of air pollutants from industrial parts of northern Eurasia and North America. Overall, cumulative impacts on air quality in the Arctic region over the next 40 to 50 years are expected to be minor to moderate. The incremental contribution of the Program would be small.

The incremental contribution of routine operations under the Program would be small, because they would not significantly increase onshore airborne pollutants or affect visibility. Small accidental oil spills (less than 1,000 bbl) would have localized and temporary effects and are considered minor from an air quality standpoint. The effects of expected accidental oil spills (most of which are less than 1,000 bbl) would be localized and temporary due to dispersion; therefore, the incremental contribution of expected oil spills to cumulative air impacts could range from small to medium. Air quality impacts associated with an unexpected, low-probability CDE would also be reduced by these factors (depending on the season), and could be moderate if it were to occur. Spill response and cleanup activities could also contribute to air quality impacts.

4.6.2.6.3 Acoustic Environment. Arctic waters are a unique acoustic environment, mainly because of the presence of ice, which can contribute significantly to ambient sound levels (e.g., ice cracking generates noise; ice deformation generates low-frequency noise). Ambient levels of natural sound can vary dramatically between and within seasons. During open-water season, wind and waves (and biological sounds) are important sources of ambient sounds. The main sources of anthropogenic noise are aircraft overflights, marine vessel traffic, oil and gas activities (including seismic surveys and production operations), human settlements, and military activities. The quality of the acoustic environment in the Beaufort and Chukchi Seas would continue to be adversely affected by ongoing and future non-OCS program activities and by future OCS program activities (currently there are no existing OCS activities, although seismic studies and exploratory drilling have been conducted in the past). The magnitude of cumulative impacts in the Beaufort and Chukchi Seas is time- and location-specific and could range from minor to major, depending on the ambient acoustic conditions and the nature and combination of noise sources from all OCS and non-OCS activities.

Routine operations under the Program would result in minor impacts to ambient noise levels mainly associated with seismic surveys, drilling and production, infrastructure placement and removal, and marine vessel traffic. Depending on the source, changes in ambient noise levels could be short-term and localized (e.g., from vessel traffic), long-term and localized (e.g., from production), or short-term and less localized (e.g., seismic surveys), and some may extend well beyond the survey boundary. The contribution of the Program to cumulative impacts could range from small to medium, depending on the timing of the disturbance and the location and characteristics of noise sources present (e.g., their frequency and duration). The incremental increase in adverse acoustic environmental impacts from expected accidental oil spills in Arctic waters (most of which are less than 1,000 bbl) would be localized and temporary; therefore, the incremental contribution of expected oil spills to cumulative noise-related impacts would be small. Impacts associated with an unexpected, low-probability CDE could range from minor to moderate if it were to occur. Most of the impacts to the acoustic environment would be due to noise sources associated with response and cleanup activities.

4.6.3 Marine and Coastal Habitats

4.6.3.1 Gulf of Mexico Region

4.6.3.1.1 Coastal and Estuarine Habitats. Section 4.4.6.1.1 discusses direct and indirect impacts on coastal and estuarine habitats in the GOM resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on these resources result from the incremental impacts of the Program (described in Section 4.4.6.1.1) when added to impacts from ongoing and reasonably foreseeable future actions, including those of ongoing and future OCS programs and other non-OCS activities. Table 4.6.1-2 presents the exploration and development scenario for the GOM cumulative case, which takes into account activities associated with the Program in combination with those from ongoing and future OCS programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in the GOM are summarized in Table 4.6.1-5 and discussed below, as applicable.

A number of activities associated with the Program could result in impacts on coastal and estuarine habitats in the GOM (Section 4.4.6.1.1). These activities include construction of pipelines and shoreline facilities, maintenance dredging of inlets and channels, and vessel traffic. Impacts associated with these activities could include (1) losses of beach and dune habitat and indirect effects that contribute to reductions in beach habitat in areas of ongoing shoreline degradation; and (2) elimination of wetland habitat and indirect effects that contribute to reductions in wetland habitat. Similar activities would occur from previous and future sales during the life of the Program (see Table 4.6.1-2). Excluding the estimated number of offshore pipelines installed, which is not relevant to this analysis, the activities associated with the Program will be about 15–30% of the total amount of OCS program activity that will occur during the life of the Program.

Barrier Beaches and Dunes. Impacts on barrier beaches and dunes primarily result from factors that reduce sediment input to downdrift areas or that directly contribute to increased erosion of beaches and dunes. Construction projects may reduce the sediment contribution to the GOM barrier landforms from inflowing rivers, or they may restrict the movement of sediments to downdrift areas and natural replenishment of barrier beaches. Other activities may disturb barrier dune vegetation, thereby promoting dune erosion, or directly disturb beach and dune substrates, resulting in increased erosion of beaches and dunes. Increases in wave action can also contribute to beach erosion.

Ongoing non-OCS activities that could affect barrier beaches and dunes include those related to State oil and gas development, commercial shipping (and other marine vessel traffic), coastal development, and recreation (Table 4.6.1-5). These activities can be reasonably expected to continue into the future. A number of activities reduce the sediment supply to barrier beaches and dunes. Past activities that have contributed to sediment deprivation and submergence of coastal lands have contributed to erosion and land losses, particularly along the Louisiana coast, and are expected to continue into the foreseeable future. Channelization and diversion of Mississippi River flows, as well as the construction of Mississippi River dams and reservoirs, and subsequent reductions in sediment supply to deltaic areas to the west have resulted in the continued extensive erosion of coastal habitats. Past construction of dams on other rivers discharging to the western GOM has also resulted in a reduction in sediments delivered to the coast, which, along with natural causes of sediment supply reductions, have resulted in ongoing land loss along the Texas coast. The emplacement of groins, jetties, and seawalls for beach stabilization in much of the GOM contributes to the reduction of sediment inputs and the acceleration of coastal erosion in downdrift areas. Maintenance dredging of barrier inlets and bar channels, in combination with channel jetties, has resulted in impacts on adjacent barrier beaches down-current due to sediment deprivation, especially on the sediment-starved coastal areas of Louisiana. Maintenance dredging is an ongoing practice and is expected to continue to be an impact-producing factor into the future; this includes, for example, efforts to accommodate larger cargo vessels. The past construction of canals for pipelines and navigation has resulted in losses of coastal barrier habitat. Although new navigation canals from the GOM to inland areas are unlikely to be needed and current pipeline construction methods result in little, if any, impacts on barrier landforms, existing pipeline canals are expected to continue to be sediment sinks and to promote the reduction of adjacent barrier island dunes and beaches. However, the replenishment of barrier beaches with sand obtained from OCS sources and the beneficial use of dredged material are expected to continue to aid in the restoration of barrier islands.

The presence of pipelines, even after decommissioning, in some areas of the GOM may potentially result in the reduction or elimination of suitable sediment sources used for beach renourishment and restoration projects, due to the necessity of pipeline avoidance. Loss of sediment sources could potentially restrict restoration activities in some areas. In addition, at restoration sites, pipeline safety buffers can reduce areas available for restoration, and pipeline surveys divert funds otherwise available. However, as noted above, fewer than 12 new pipeline landfalls would be constructed under the Program. Pipeline disturbance widths are generally small with modern placement methods, and the rights-of-way would be less than 200 m (656 ft) in width. Operators are interested in protecting pipelines from coastal erosion, so a synergy could be developed with coastal restoration projects. Because of demand for OCS material for coastal restoration, BOEM is trying to cluster pipelines and to keep pipelines away from known marine mineral resources (BOEM 2012a; USDOI 2009). The impacts on barrier beaches and dunes from sediment removal activities associated with maintenance dredging under the Program would represent a very small contribution to the past, ongoing, and expected future degradation of barrier beaches and dunes from non-OCS activities.

Although coastal barrier islands in most of the Central Planning Area generally receive minimal recreational use, most barrier beaches in Texas, Alabama, and Florida are accessible and extensively used for recreation. Pedestrian and vehicular traffic on beaches and dunes can destabilize substrates, either by reducing vegetation density — and thus increasing erosion by wind, waves, and traffic — or by directly disturbing or displacing substrates. In addition, considerable private and commercial development has occurred on many barrier islands in the GOM, resulting in losses of beach and dune habitat. The impacts on barrier beaches and dunes from substrate-disturbance activities associated with pipeline construction under the Program are expected to be greatly minimized by non-intrusive construction techniques and would not be expected to appreciably add to the cumulative effects of other substrate-disturbing activities.

Activities that increase wave action along barrier beaches and dunes can contribute to their erosion. The construction of seawalls, groins, and jetties in Texas and Louisiana has contributed to coastal erosion in part by increasing or redirecting the erosional energy of waves. Vessel traffic related to shipping and transportation can result in wake erosion of channels between barrier islands. A large number of vessels use the navigation channels near the GOM coast. A portion of the impacts related to vessel traffic would be associated with the Program; however, activities conducted under the Program would contribute a relatively small number of vessel trips to the total.

Barrier beaches and dunes could be affected by accidental spills of oil or petroleum products resulting from ongoing and future activities in the GOM (Section 4.6.1.1). Although the majority of these spills would be small (less than 50 bbl), catastrophic releases can impact extensive areas of shoreline. Oil released into coastal waters as a result of the DWH event, April–July 2010, affected more than 1,046 km (650 mi) of the GOM coastal habitat, from the Mississippi River delta to the Florida panhandle, with the Louisiana, Mississippi, Alabama, and Florida coasts all affected (OSAT-2 2011; National Commission 2011). The greatest impacts were in Louisiana. More than 209 km (130 mi) of coastal habitat were moderately to heavily oiled, with only 32 km (20 mi) occurring outside of Louisiana (National Commission 2011). Little or no oil affected Texas coastal habitats. Heavy to moderate oiling occurred along a substantial number of Louisiana beaches, with the heaviest oiling on the Mississippi Delta, in Barataria Bay, and on the Chandeleur Islands (OSAT-2 2011). The majority of Mississippi barrier islands had light oiling to trace oil, although heavy to moderate oiling occurred in some areas. Some heavy to moderate oiling also occurred on beaches in Alabama and Florida, with the heaviest stretch of oiling extending from Dauphin Island, Alabama, to near Gulf Breeze, Florida (OSAT-2 2011). Light to trace oiling occurred from Gulf Breeze to Panama City, Florida. Deposition of oil occurred in the supratidal zone (above the high tide mark), deposited and buried during storm events; intertidal zone; and subtidal zone, there remaining as submerged oil mats (OSAT-2 2011). On Grand Isle, Louisiana, and Bon Secour, Alabama, oil was found up to 105 cm (41 in.) below the surface (OSAT-2 2011). Low-molecular-weight and volatile compounds were mostly depleted from oil that reached shorelines, due to weathering at sea (OSAT-2 2011). Although much of the oil remaining after cleanup is highly weathered, several constituents have the potential to cause toxicological effects (OSAT-2 2011).

Non-OCS activities, such as the domestic transportation of oil, foreign crude oil imports, and State oil and gas development may also result in accidental spills that could potentially affect coastal barrier beaches and dunes. The amount of oil contacting barrier islands from a spill would depend on a number of factors such as the location and size of the spill, waves and water currents, and containment actions. Naturally occurring seeps may also be a source of crude oil introduced into GOM waters (NRC 2003b; Kvenvolden and Cooper 2003). The magnitude of resulting impacts and the persistence of oil would depend on factors such as the amount of oil deposited, remediation efforts, substrate grain size, and localized erosion and deposition patterns. In areas of barrier beach erosion, such as Louisiana, remediation would likely include the minimization of sand removal or replacement of removed sand. The impacts of potential oil spills associated with the Program would be expected to add a small contribution to the impacts of other sources of oil.

Indirect effects on coastal barrier beaches and dunes could result from global climate change. Factors associated with global climate change include changes in temperature and rainfall, alteration in stream flow and river discharge, sea level rise, changes in hurricane frequency and strength, sediment yield, mass movement frequencies and coastal erosion, and subsidence (Yanez-Arancibia and Day 2004). Potential thermal expansion of ocean water and melting of glaciers and ice caps could result in a global rise in mean sea level (Section 4.6.1.6). Recent rates of sea level rise have been approximately 3 mm/yr (0.12 in./yr), but this rate may increase to 4 mm/yr (0.16 in./yr) by 2100 (Blum and Roberts 2009). Sea-level rise could result in increased inundation of barrier beaches and increases in losses of beach habitat. Effects of sea level rise include damage from inundation, floods and storms; and erosion (Nicholls et al. 2007). Effects of increased storm intensity include increases in extreme water levels and wave heights; increases in episodic erosion, storm damage, risk of flooding, and defense failure (Nicholls et al. 2007). Patterns of erosion and accretion can also be altered along coastlines (Nicholls et al. 2007). The small tidal range of the GOM coast increases the vulnerability of coastal habitats to the effects of climate change.

Hurricanes and other severe storm events can affect coastal barrier beaches and dunes. Increased wave action and intensity on barrier habitats may result in increased erosion and changes in beach and dune topography or losses of habitat. Hurricanes and tropical storms are inherent components of the GOM ecosystem that have long influenced coastal habitats and are expected to continue to be sources of impacts. Anthropogenic impacts on barrier beaches and dunes may be greatly exacerbated by severe storm events such as hurricanes. In 2005, Hurricanes Katrina and Rita caused extensive erosion of barrier landforms in the central and western GOM. Extreme storms such as these can result in relatively permanent change to these habitats, particularly in areas that are already experiencing erosion and retreat as a result of sediment deprivation, sea level rise, and coastal development.

Wetlands. Factors that affect coastal wetlands include the direct elimination of wetland habitat by excavation or filling, the reduction of sediment inputs, the erosion of wetland substrates, and the degradation of wetland communities by reduced water quality or hydrologic changes. Construction projects may fill wetlands for facility siting or excavate wetlands for the construction of canals or pipelines. Other projects may reduce the sediment delivered to coastal wetlands from inflowing rivers. A number of activities may degrade wetlands or promote wetland losses indirectly by causing changes to wetland hydrology or introducing contaminants. Routine OCS operations could have direct impacts on wetlands as a result of direct losses of habitat from construction activities, pipeline landfalls and channel dredging, and indirect impacts as a result of altered hydrology caused by channel dredging.

Ongoing non-OCS activities that could affect coastal wetlands include those related to State oil and gas development, commercial shipping (and other marine vessel traffic), coastal development, dredging operations, discharge of municipal wastes and other effluents, domestic transportation of oil and gas, and foreign crude oil imports (Table 4.6.1-5). These activities can be reasonably expected to continue into the future. A number of these activities result in the localized destruction of wetlands. The construction of pipelines and navigation channels would result in direct losses of wetlands that are crossed, due to excavation. In addition, the creation of spoil banks along canals would bury wetland habitat. Large areas of coastal wetlands are also lost by drainage and filling, due to urban development and agricultural use (Gosselink et al. 1979; Bahr and Wascom 1984). Although activities that affect wetlands are regulated by State and Federal agencies, construction of industrial facilities, commercial sites, and residential developments would be expected to result in continued wetland losses. Pipeline installation and vessel traffic outside of established traffic routes could have short-term impacts on seagrass communities, which are primarily located in the eastern GOM. The direct impacts on coastal wetlands from pipeline, navigation canal, or facility construction under the Program would represent a small contribution to the past, ongoing, and expected future losses of wetlands from non-OCS activities.

Indirect impacts on wetlands from non-OCS activities are expected to continue to contribute to wetland degradation and conversion of wetlands to open water. A major factor that has contributed to the ongoing loss of coastal wetlands, particularly in the Mississippi River Delta region of Louisiana, is the reduction in sediments provided to coastal marshes. Reductions in sediment supply, in combination with natural subsidence, have contributed significantly to the conversion of coastal marsh to open water. The construction of dams and levees and channelization along the Mississippi River restrict the sediment supply and overbank flow of floodwaters, limiting the release of sediments and fresh water to coastal marshes (LCWCRTF 1998, 2003; USACE 2004).

Coastal wetlands are also lost due to the effects of large storm events, and the continuing erosion of barrier islands reduces their capacity to act as buffers for coastal wetlands (LCWCRTF 2001). Construction of canals for pipelines and navigation would result in future continuing progressive losses from canal widening and failure of mitigation structures, which would contribute to the conversion of wetlands to open water. Canal construction and maintenance dredging of navigation canals result in hydrologic changes, primarily high levels of tidal and storm flushing and draining potential of interior wetland areas. Such alterations of water movement can result in erosion of marsh substrates and increase inundation levels, and can result in substantial impacts on the hydrologic basin. Construction and maintenance of canals through coastal wetlands can increase the impacts of coastal storms, such as hurricanes, in the conversion of wetlands to open water. Saltwater intrusion results from canal construction and reduced freshwater inputs due to river channelization, and causes considerable deterioration of coastal wetlands. Wetland losses due to subsidence have also been attributed to extraction of oil in some portions of the Mississippi River Delta, or the withdrawal of groundwater along the Texas coast. Changes in wetland hydrology, as well as increases in turbidity and sedimentation, as a result of construction projects, can affect wetlands.

Degradation of wetlands can result from water quality impacts due to stormwater discharges and discharges of waste water from vessels, municipal treatment plants, and industrial facilities. Water quality may also be affected by waste storage and disposal sites. The direct and indirect impacts on coastal wetlands under the Program would represent a small contribution to the past, ongoing, and expected future impacts on wetlands from non-OCS activities.

Accidental spills of oil or petroleum products from OCS activities (Section 4.4.6.1) could impact coastal wetlands. The majority of these spills would be small (less than 50 bbl). Should spills occur in shallow water from marine vessel accidents and pipelines, they could contact and affect coastal wetlands. Most spills that occur in deep water would be unlikely to contact and impact wetlands. Catastrophic releases in deep water, however, can impact extensive areas of shoreline. Oil released into coastal waters as a result of the DWH event, April–July 2010, affected more than 1,046 km (650 mi) of the GOM coastal habitat, from the Mississippi River delta to the Florida panhandle, with the Louisiana, Mississippi, Alabama, and Florida coasts all affected (OSAT-2 2011; National Commission 2011). Non-OCS activities, such as State oil and gas development, the domestic transportation of oil, and foreign crude oil imports, may also result in accidental spills that could potentially impact coastal wetlands. Naturally occurring seeps may also be a source of crude oil that could potentially affect coastal wetlands. The amount of oil contacting wetlands, the magnitude of resulting impacts, and the length of time for recovery would depend on a number of factors such as the location and size of the spill, containment actions, waves and water currents, type of oil, types of remediation efforts, amount of oil deposition, duration of exposure, season, substrate type, and extent of oil penetration. Impacts from oil spills would be expected to range from short-term effects on vegetation growth to permanent loss of wetlands and conversion to open water. The impacts of potential oil spills associated with the Program are expected to constitute a small addition to the impacts of all other sources of oil in the GOM.

Global climate change could result in indirect effects on coastal wetlands. Factors associated with global climate change include changes in temperature and rainfall, alteration in stream flow and river discharge, wetland loss, salinity, sea level rise, changes in hurricane frequency and strength, sediment yield, mass movement frequencies and coastal erosion, and subsidence (Yanez-Arancibia and Day 2004). Effects of sea level rise include damage from inundation, floods and storms; erosion; saltwater intrusion; rising water tables/impeded drainage; and wetland loss and change (Nicholls et al. 2007). Effects of increased storm intensity include increases in extreme water levels and wave heights; increases in episodic erosion, storm damage, risk of flooding, and defense failure (Nicholls et al. 2007). Patterns of erosion and accretion can also be altered along coastlines (Nicholls et al. 2007). The small tidal range of the GOM coast increases the vulnerability of coastal habitats to the effects of climate change. A study of coastal vulnerability along the entire U.S. GOM coast found that 42% of the shoreline mapped was classified as being at very high risk of coastal change due to factors associated with future sea level rise (Thieler and Hammar-Klose 2000). A revised coastal vulnerability index study of the coast from Galveston, Texas, to Panama City, Florida, indicated that 61% of that mapped coastline was classified as being at very high vulnerability, with coastal Louisiana being the most vulnerable area of this coastline (Pendleton et al. 2010). Potential thermal expansion of ocean water and melting of glaciers and ice caps could result in a global rise in mean sea level (Section 4.6.1.6). Sea level rise would result in greater inundation of coastal wetlands and likely result in an acceleration of coastal wetland losses, particularly in Louisiana, as wetlands are converted to open water. In addition, large changes in river flows into the GOM could affect salinity and water circulation in estuaries, which, in turn, could impact estuarine wetland communities.

Hurricanes and other severe storm events impact coastal wetlands through increased wave action and intensity, resulting in increased erosion of wetland substrates and conversion of coastal wetlands to open water. Hurricanes and tropical storms are inherent components of the GOM ecosystem that have long influenced coastal habitats and are expected to be continuing sources of impacts. However, impacts on wetlands as a result of human activities, such as those that create marsh openings that enhance tidal and storm-driven water movements, may be amplified by severe storm events such as hurricanes. In 2005, Hurricanes Katrina and Rita caused extensive impacts on wetlands in the Central and Western GOM. For example, up to 259 km^2 (100 mi^2) of coastal wetlands in Louisiana may have been converted to open water as a result of the storms, and up to 60,700 ha (150,000 ac) of coastal wetlands and bottomland forests were damaged in national wildlife refuges along the GOM coast (USFWS 2006). It is possible that extreme storms such as these could result in relatively permanent change to these habitats, particularly in areas that are already experiencing erosion and conversion of wetlands to open water as a result of sediment deprivation, sea-level rise, channelization, and coastal development.

Seagrass Beds. As identified in Section 4.4.6.1, the principal OCS activities under the Program that could potentially affect seagrass beds include placement of structures (e.g., pipelines) and vessel traffic within the vicinity of the beds. In addition, coastal development associated with OCS oil and gas activities could contribute to cumulative impacts on submerged seagrass beds. Most of the seagrass beds in the GOM are in the Eastern Planning Area, where no OCS activities are proposed during the Program.

Ongoing and future non-OCS activities that may contribute to cumulative effects on seagrass habitats include anchoring, fishing/trawling, offshore shipping (and other marine vessel traffic), diving, and continued onshore development (Table 4.6.1-5). The extensive seagrass beds located in the eastern GOM may be susceptible to impacts from non-OCS activities such as dredging and onshore development that contribute to increased sedimentation, turbidity, nutrient input, and various types of point and non-point source contamination.

As noted in Section 4.4.6.1, oil spills reaching coastal areas could affect submerged seagrass beds. The majority of these spills would be small (less than 50 bbl). Should spills occur in shallow water from vessel accidents and pipelines, they could contact and affect seagrass beds. Most spills that occur in deep water would be very unlikely to contact and impact seagrasses; however, catastrophic releases can impact extensive areas of shoreline. As identified in Table 4.6.1-4, it is assumed that up to 40 large oil spills (1,000 bbl or greater), up to 330 small-sized spills 50 to 999 bbl, and up to 1,950 small oil spills of less than 50 bbl could occur as a result of ongoing and future OCS activities. A catastrophic spill event would have an assumed spill size of 4 Bbbl. As discussed previously, non-OCS activities and oil seeps could also contribute substantially to releases of oil in the GOM. Oil spills in shallow water in the GOM from OCS and non-OCS activities could have significant effects on submerged seagrass beds. The magnitude and severity of potential effects on seagrass beds from oil spills would be a function of the location, timing, duration, and size of the spill; the proximity of the spill to seagrass beds; and the timing and nature of spill containment and cleanup activities. Releases that occur in the shallow portions of the eastern GOM have the potential to be of greatest significance, due to the more extensive growth of seagrasses along that coastline. It is unlikely that OCS spills would contact the extensive seagrass areas offshore Florida and along its coast because of the great distance between these resources and locations in the Central and Western Planning Areas where leasing will occur.

Conclusion. Ongoing OCS and non-OCS program activities in combination with naturally occurring events have resulted in considerable losses of coastal and estuarine habitats in the GOM; cumulative impacts on these resources, therefore, are considered to be moderate to major. Routine operations under the Program would result in minor localized impacts, primarily due to facility construction, pipeline landfalls, channel dredging, and vessel traffic; therefore, the incremental contribution of routine Program activities to cumulative impacts is expected to be small to medium (see Section 4.4.6.1.1).

The cumulative impacts of past, present, and future oil spills and natural seeps on submerged seagrass beds would be moderate to major. The incremental impacts of expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program on these resources would be negligible to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to seagrass beds; and the timing and nature of spill containment and cleanup activities (see Section 4.4.6.1.1). The majority of these spills would be small (less than 50 bbl) and most of them would not likely contact and affect coastal and estuarine habitats. Large oil spills (1,000 bbl or greater) or an unexpected, low-probability CDE that occur in or reach shallower nearshore areas have the greatest potential to affect extensive areas of shoreline and coastal and estuarine habitats. Although these are rare events, the impacts of such releases on coastal and estuarine habitats could range from moderate to major if they were to occur.

4.6.3.1.2 Marine Benthic and Pelagic Habitats. Sections 4.4.6.2.1 and 4.4.6.3.1 discuss direct and indirect impacts, respectively, on marine benthic and pelagic habitats in the GOM resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on these resources result from the incremental impacts of the Program (described in Sections 4.4.6.2.1 and 4.4.6.3.1) when added to impacts from ongoing and reasonably foreseeable future actions, including those of ongoing and future OCS programs and other non-OCS activities. Table 4.6.1-2 presents the exploration and development scenario for the GOM cumulative case, which takes into account activities associated with the Program in combination with those from ongoing and future OCS programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in the GOM are summarized in Table 4.6.1-5 and discussed below, as applicable.

Cumulative impacts on marine benthic and pelagic habitats could result from a number of activities associated with ongoing and future OCS and non-OCS activities in the GOM, including those of the Program. Activities with the potential to affect these resources include vessel traffic, seismic surveys, and construction (all noise-producing activities), well drilling, pipeline placement (trenching, landfalls, and construction), platform placement (anchoring, mooring, and removal, except in deep waters), and routine discharges (drilling, production, platform, and vessel). Accidental oil spills are also counted among OCS and non-OCS activities.

Up to 12,000 development and production wells and 2,000 oil platforms are anticipated to be built in the GOM under the cumulative scenario (Table 4.6.1-2). In addition, the construction of platforms and pipelines would disturb as much as 81,000 ha (200,200 ac) of bottom surface over the next 40 to 50 years (Table 4.6.1-2). Bottom disturbance resulting from the Program may degrade water quality by increasing water turbidity in the vicinity of the operations and adding contaminants to the water column. It also changes sediment composition as suspended sediments (and contaminants, if present) are entrained in currents and deposited in new locations. The increased amount of drilling anticipated under the Program will result in OCS discharges of drill muds, cuttings, and produced waters. Impacts of OCS routine operations (exploration, production and decommissioning activities) on marine benthic and pelagic habitat are discussed in detail in Sections 4.4.6.2.1 and 4.4.6.3.1. Overall, routine operations represent a negligible to moderate long-term disturbance, with the severity of the impacts generally decreasing dramatically with distance from the well site.

Ongoing and future non-OCS activities with the potential to affect marine benthic and pelagic habitats in the GOM include sediment dredging and disposal, sand mining, anchoring, fishing/trawling, and tankering of imported oil. Anchoring by non-OCS marine vessels could cause significant chronic disturbance the benthic habitat and biota and temporarily reduce water quality by generating turbidity in the water column. Anchoring could involve boats used for recreational and commercial fishing or scuba diving, and commercial ship traffic. The amount of damage that could result from anchoring activity would depend upon vessel size, the size of the anchor and chain, sea conditions at the time of anchoring, and the location or position of the anchor on the feature. Areas damaged by anchors may take more than 10 years to recover, depending upon the severity of the damage. Due to a lack of regulation of non-OCS activities on these features, there is a likelihood of damages increasing due to heavier usage of the resources in the future. Sand mining and dredging operations in conjunction with ship channel maintenance and construction, pipeline placement and burial, and support facility access occur throughout the GOM as part of non-OCS activities. Sediments dredged and sidecast or transported to approved dredged material disposal sites would alter bottom habitat and communities and remove, injure, or kill local biotic communities in addition to generating turbidity over the length of the water column. Similarly, bottom trawling degrades benthic habitats and temporarily increases the turbidity of the water (Jones 1992). Benthic habitat disturbances from OCS activities (e.g., pipeline trenching and placement and platform placement) would add to the existing impacts to benthic habitat from these non-OCS sediment-disturbing activities.

Other ongoing and future non-OCS activities with the potential to affect marine benthic and pelagic habitats include offshore marine transportation, and pollutant inputs from point and non-point sources. Vessel traffic is a source of chronic noise that could temporarily and episodically reduce local habitat quality by disturbing pelagic and shallow water benthic organisms. Multiple contaminant sources exist from nearshore point sources and contaminants can also be delivered to the continental shelf during storms and high river discharge. A primary example is the cultural eutrophication of the GOM, which has resulted in a large seasonal hypoxic zone off the coasts of Louisiana and Texas (see Figure 4.6.1-5) and restricts the use of benthic and bottom water habitat by marine biota over a wide area. In addition to non-point source pollution, LNG terminal operations (biocide-laden, cooled water), and activities related to the oil and gas industry, which operates hundreds of platforms in State and Federal waters, discharges large volumes of drilling wastes, produced water, and other industrial waste streams to GOM waters. Pollutant inputs into the GOM and their impact on water quality are discussed in Section 4.6.2.1. The impacts of these activities on marine pelagic habitat can be temporary or long term and could result in reduced habitat quality for marine biota.

In the benthic and pelagic habitats of the GOM, climate change may cause the temporal variability of key chemical and physical parameters — particularly hydrology, dissolved oxygen, salinity, and temperature — to change or increase, which could significantly alter the existing structure of the benthic and phytoplankton communities (Rabalais et al. 2010). For example, freshwater discharge into the GOM has been increasing and is expected to continue to increase as a result of the increased rainfall in the Mississippi River Basin (Dai et al. 2009). Such changes could result in severe long-term or short-term fluctuations in temperature and salinity that could reduce or eliminate sensitive species. Such changes are most likely to occur in the Mississippi Estuarine Ecoregion, where freshwater inputs are highest. In addition, greater rainfall may increase inputs of nutrients into the GOM, potentially resulting in more intense phytoplankton blooms that could promote benthic hypoxia (Rabalais et al. 2010). Hypoxic or anoxic conditions can reduce or eliminate the suitability of benthic habitat for marine organisms. The increased storm severity predicted to result from climate change may also increase disturbance to benthic habitats that are already stressed by trawling, anchoring, and dredging operations, as well as OCS-related pipeline trenching. See Sections 3.7.2.1 and 3.7.3.1 for a complete discussion of how climate change may affect marine benthic and pelagic habitat.

Marine benthic and pelagic habitat and biota could be affected by oil spills from both OCS and non-OCS activities, including the domestic transportation of oil, the import of foreign crude oil, and State development of oil. Storms, operator error, and mechanical failures may result in accidental oil releases from a variety of non-OCS related activities. Assumptions for oil spills for the GOM cumulative case are provided in Table 4.6.1-4; Table 4.4.2-2 presents assumptions for catastrophic spills. Large and potentially catastrophic spills could result from pipeline ruptures, tanker spills associated with an FPSO system, or loss of well control. In addition, crude oil enters the environment of the GOM from naturally occurring seeps. At least 63 seeps have been identified in the GOM (mostly off the coast of Louisiana) (MacDonald et al. 1996), and more than 350 naturally occurring and constant oil seeps that produce perennial slicks of oil at consistent locations may be present in the GOM (MacDonald et al. 2002, as cited in Kvenvolden and Cooper 2003). Seeps in the northern GOM have been estimated to discharge 0.4–1.1 × 10^8 L (252,000 to 692,000 bbl) per year of crude oil annually to overlying GOM waters (MacDonald et al. 2002).

For both OCS and non-OCS program-related oil spills, it is assumed that the magnitude and severity of the potential effects on benthic and pelagic habitat would be a function of the location, timing, duration, and size of the spill and the timing and nature of spill containment and cleanup activities. Detailed discussion of the impacts of OCS accidental hydrocarbon releases on marine benthic and pelagic habitat can be found in Sections 4.4.6.2.1 and 4.4.6.3.1.

Coral Reefs and Hard-Bottom Habitat. Sensitive coral reef and hard-bottom benthic habitats in the GOM may be more susceptible to OCS program-related impacts and take longer to recover if impacts were to occur. Consequently, these habitats receive special protection. Four coral reef and hard-bottom habitats are designated for the various protections: (1) banks offshore of Texas and Louisiana (including the FGBNMS), (2) the Pinnacle Trend off the Louisiana-Alabama coast, (3) seagrass and low-relief live-bottom areas primarily located in the Central and Eastern Planning Areas, and (4) potentially sensitive biological features of moderate to high relief that are not protected by (1) and (2). As identified in Section 4.4.6.2.1, NTL No. 2009-G39 has several protections in place to minimize and mitigate the adverse effects of oil and gas exploration and development on coral reefs and hard-bottom habitat.

Cumulative impacts on coral reef and hard-bottom habitat could result from a number of activities associated with ongoing and future activities in the GOM, including those of the Program. Activities with the potential to affect these resources include vessel traffic, seismic surveys, and construction (all noise-producing activities), as well as well drilling, pipeline placement (trenching, landfalls, and construction), chemical releases (drilling discharges, operation discharges, and sanitary wastes), and platforms placement (anchoring, mooring, and removal, except in deep waters). Impacts of OCS exploration, production and decommissioning activities on marine benthic and pelagic habitat are discussed in detail in Section 4.4.6.2.1. Overall, impacts on coral reef and live-bottom habitat from routine activities would be minimized by the protection stipulated by NTL 2009-G39. However, low-relief or small, isolated, unmapped live-bottom could be affected by direct mechanical damage and turbidity and sedimentation.

Ongoing and future non-OCS activities with the potential to affect these habitats include anchoring by non-OCS activity vessels, fishing/trawling, discharges by non-OCS offshore marine transportation, and tankering of imported oil. Anchoring could involve boats used for recreational and commercial fishing or scuba diving, and commercial ship traffic. The amount of damage that could result from anchoring activity would depend upon vessel size, the size of the anchor and chain, sea conditions at the time of anchoring, and the location or position of the anchor on the feature. Recovery of areas damaged by anchors may be long term, depending upon the severity of the damage. Due to a lack of regulation of non-OCS activities on these features, there is a likelihood of damages increasing due to heavier usage of the resources in the future.

Trawling activities are another source of damage to coral and hard-bottom habitat. Because anchoring and collection activities by scuba divers on the living reef areas of the Flower Garden Banks are prohibited, biota associated with the Flower Garden Banks are unlikely to be significantly affected by these activities. Similarly, use of spiny lobster and stone crab traps may also damage bottom substrate such as seagrasses and corals. Strings of traps deployed without buoys are sometimes retrieved by dragging 18-kg (40-lb) grapnels and chains across the bottom until the trap string is hooked, potentially damaging bottom habitats in the process.

Impacts could also occur due to discharges from other non-OCS activities, including tankers or other marine traffic passing in the vicinity of coral reef and hard-bottom habitat. Because water depths are typically greater than 20 m (66 ft) at the tops of most of the banks, dilution of discharges would greatly reduce concentrations of potentially toxic components before they could come in contact with these features; consequently, it is assumed that discharges from such activities would not be concentrated enough to reduce habitat quality.

Climate change has the potential to profoundly affect coral communities on coral and hard-bottom features in several ways including (Section 3.7.1.1.4):

- Increased frequency of bleaching as a stress response to warming water temperatures (Hoegh-Guldberg et al. 2007);

- Excessive algal growth on reefs and an increase in bacterial, fungal, and viral agents (Boesch et al. 2000; Twilley et al. 2001);

- Greater frequency of mechanical damage to corals from greater severity of tropical storms and hurricanes (Janetos et al. 2008);

- Decreases in the oceanic pH and carbonate concentration are expected to reduce the reef formation rate, weaken the existing reef structure, and alter the composition of coral communities (Janetos et al. 2008); and

- Climate change may allow the range expansion of non-native species.

Potential interactions between climate change and OCS activities could affect hard-bottom habitat. For example, ocean acidification and increases in water temperature may slow the recovery of corals exposed to drilling muds or oil from an accidental spill. Another potential interaction could occur between oil and gas platforms and climate change, in which new hard-bottom–associated species are able to expand northward due to warming and the availability of hard substrate in the form of active or decommissioned oil platforms. By acting as stepping stones across the GOM, oil platforms have been implicated in the introduction of a non-native coral species (*Tubastraea coccinea*) and fishes such as sergeant majors (*Abudefduf saxatilis*) and yellowtail snapper (*Ocyurus chrysurus*) into the FGB (Hickerson et al. 2008).

Oil spills from both OCS and non-OCS activities could affect coral reef and hard-bottom habitat and biota. Detailed discussion of the impacts of OCS accidental hydrocarbon releases on hard-bottom and coral reef habitat can be found in Section 4.4.6.2.1. It is assumed that accidental oil releases from most non-OCS activities would be at the surface or located sufficiently far from coral reef and hard-bottom habitat and biota that they would be unlikely to greatly affect these habitats. The magnitude and severity of potential effects on coral reef and hard-bottom habitat and biota from such exposure would be a function of the location, timing, duration, and size of the spill; the proximity of the spill to the features; and the timing and nature of spill containment and cleanup activities. Depending upon location, spills from non-OCS sources and releases from natural seeps could contribute to the overall exposure of communities associated with topographic features in the GOM OCS planning areas to oil, with corresponding lethal or sublethal effects.

High Density Deepwater Communities (HDDC). High density deepwater communities (HDDCs) include coldwater corals and chemosynthetic communities. Cumulative impact factors for HDDCs include both OCS and non-OCS cumulative activities. Potential impacts on HDDCs resulting from ongoing and future routine OCS program activities, including those of the Program, could result from noise, well drilling, pipeline placement (trenching, landfalls, and construction), chemical releases (drilling discharges, operation discharges, and sanitary wastes), and platform placement (anchoring, mooring, and removal, except in deep waters). Mitigation measures instituted to protect these HDDCs include Notice to Lessee (NTL) 2009-G40, which requires the avoidance of HDDCs or areas that have a high potential for supporting these community types, as interpreted from geophysical records. Impacts of OCS exploration, production, and decommissioning activities on HDDCs are discussed in detail in Section 4.4.6.2.1. Overall, impacts on HDDCs from exploration and site development activities are expected to be minor because of the provisions in NTL 2009-G40 that protect HDDCs from oil and gas development activities. However, small and unmapped HDDCs may be completely or partially destroyed by bottom-disturbing activities. In such cases, recovery would likely be long term, although permanent loss of the affected feature is also possible. For these HDDCs, impacts could be major.

Ongoing and future non-OCS activities that have the potential to adversely affect HDDCs include fishing/trawling, anchoring, and offshore marine transportation. Due to the water depths of these areas and the widely scattered nature of these habitats, such activities are unlikely to greatly affect HDDCs in the GOM. However, deepwater trawling could destroy HDDCs and recover could be long term or may not occur at all. Generally, commercially important deepwater fish species use *Lophelia* reefs as juveniles (SAFMC 1998).[53]

As climate change has the potential to affect warm water corals, it could affect coldwater *Lophelia* reefs (Section 3.7.2.1.7). The saturation depth of aragonite (the primary carbonate formed used by hard corals) appears to be a primary determinant of deepwater coral distribution, with reefs forming in areas of high aragonite solubility (Orr et al. 2005). The depth at which the water is saturated with aragonite is projected to become shallower over the coming century, and most coldwater corals may be in undersaturated waters by 2100 (Orr et al. 2005). Consequently, the spatial extent, density, and growth of deepwater corals may decrease, diminishing their associated ecosystem functions (Orr et al. 2005). There are potential interactions between climate change and OCS activities that could affect HDDC. For example, ocean acidification may slow the recovery of deepwater corals exposed to drilling muds or oil from an accidental spill.

Oil spills from both OCS and non-OCS activities could affect HDDCs. Detailed discussion of the impacts of OCS accidental hydrocarbon releases can be found in Section 4.4.6.2.1. The magnitude and severity of potential effects on biota associated with topographic features from such exposure would be a function of the location, timing, duration, and size of the spill, the proximity of the spill to the features, and the timing and nature of spill containment and cleanup activities. It is assumed that most accidental oil releases would be at the surface or located sufficiently far from HDDCs that they would be unlikely to greatly affect communities associated with the topographic features.

Conclusion. Impact-producing factors for marine benthic and pelagic habitats include those from both OCS and non-OCS activities. For OCS activities, planning and permitting procedures and stipulations that promote identification and avoidance of sensitive habitats would minimize the potential for direct impacts on sensitive seafloor areas during routine OCS activities. In the GOM, stipulations that are currently in place restrict OCS activities in the immediate vicinity of seafloor areas containing important topographic features, live bottom habitat, and HDDC, and there is relatively little likelihood that OCS activities would affect overall viability of ecological resources in such areas. Non-OCS activities with a potential to impact marine benthic and pelagic habitats in the GOM include oil and gas production in State waters, sediment dredging and disposal, sand mining, anchoring, fishing/trawling, and tankering of imported oil. Disturbances from these activities such as noise, marine vessel discharges, and bottom disturbance would occur in addition to similar impacts from OCS Program activities.

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53 There is evidence that oil and gas extraction reduces the natural release of hydrocarbons that support deep-sea chemosynthetic communities (Quigley et al. 1999). However, *Lophelia* corals do not depend on hydrocarbon seepage to meet their metabolic requirements (Becker et al. 2009), and presumably would not be affected by a reduction in natural hydrocarbon release to marine waters.

Overall, the cumulative impacts on marine habitat would be moderate to major, considering OCS routine operations and the significant impacts to marine habitat from past, present, and future human activities. The incremental contribution of routine Program activities to cumulative impacts on marine habitat would range from negligible to medium (see Section 4.4.6.2.1).

Accidental oil spills could result from both OCS and non-OCS activities. Overall, the cumulative impacts on marine habitats from oil spills would range from minor to moderate. The incremental impacts of expected oil spills, most of which would be small (less than 1,000 bbl), would range from negligible to small, depending on the location, timing, duration, and size of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities (Section 4.4.6.2.1). Spills in deeper water, whether from OCS or non-OCS sources, are unlikely to have overall community-level effects on seafloor habitats because of the relatively small proportion of seafloor area that would come in contact with released oil at concentrations great enough to elicit toxic effects. Impacts associated with an unexpected, low-probability CDE affecting shallow and intertidal habitats could range from minor to moderate, depending on the habitats affected. Although pelagic habitat is likely to recover following a CDE, the recovery time for intertidal and shallow subtidal benthic habitat directly affected by such oil spills could be long term.

4.6.3.1.3 Essential Fish Habitat. Section 4.4.6.4.1 discusses direct and indirect impacts on EFH in the GOM resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on these resources result from the incremental impacts of the Program (described in Section 4.4.6.4.1) when added to impacts from ongoing and reasonably foreseeable future actions, including those of ongoing and future OCS programs and other non-OCS activities. Table 4.6.1-2 presents the exploration and development scenario for the GOM cumulative case, which takes into account activities associated with the Program in combination with those from ongoing and future OCS programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in the GOM are summarized in Table 4.6.1-5 and discussed below, as applicable.

Cumulative impacts on EFH could result from ongoing and future OCS and non-OCS activities that have the potential to directly kill managed fish species, disturb ocean bottom habitats, increase sediment suspension, degrade water quality, or affect the food supply for fishery resources. Activities include seismic surveys (noise), well drilling, pipeline placement (trenching, landfalls, and construction), platform placement (anchoring, mooring, and removal, except in deep waters) and routine discharges (drilling, production, platform, and vessel). Accidental oil spills are also counted among OCS and non-OCS activities.

Routine OCS activities could disturb bottom areas due to the installation of platforms and pipelines and the anchoring of vessels and structures. Up to 12,000 development and production wells and 2,000 oil platforms are anticipated to be built in the GOM under the cumulative scenario (Table 4.6.1-2). In addition, the construction of platforms and pipelines over the period of the Program would disturb as much as 81,000 ha (200,200 ac) of bottom surface over the next 40 to 50 years (Table 4.6.1-2). Under the cumulative scenario, it is anticipated that less than 40 new pipeline landfalls could occur in the GOM (Table 4.6.1-2) with up to 12 of these resulting from the Program. As discussed in Section 4.4.6.4, deposition of drilling muds and cuttings could potentially affect EFH by altering grain-size distributions and chemical characteristics of sediments such that benthic prey of some managed fish species would be affected in the immediate area surrounding drill sites. Produced water will also be released into the GOM during the production phase.

Platform removals using explosives will likely kill some fish and shellfish, including managed species for which EFH has been established, and would remove platform-associated fouling communities that serve as prey for managed species. Up to 280 platforms may be removed under the Program compared with up to 1,200 platforms removed using explosives as a result of cumulative OCS activities during the life of the Program. If large numbers of fish are killed as the result of removal of platforms using explosives, there could be effects on managed species and their prey in the immediate vicinity of the removed platforms. Once a platform is removed, the fouling community that serves as a food source for some managed and prey fish species in the vicinity would no longer be available, and the associated fishes would be forced to relocate to other foraging areas. However, given the relatively small area that would be affected by such removals, GOM-wide effects on managed species are not anticipated.

See Section 4.4.6.4.1 for a detailed discussion of the impacts of routine operations on EFH and managed species in the GOM. Overall, it is expected that the incremental impacts of exploration and site development activities on marine EFH would be medium, and impacts are not expected to permanently reduce the EFH available to managed species or result in population-level impacts to managed species. The most sensitive benthic habitats, such as those associated with hard bottoms and topographic features, are not expected to be affected by routine operations, and effects would be minimized or eliminated by existing lease stipulations.[54]

There are also State oil and gas activities that can affect EFH. Louisiana and Texas have experienced substantial oil and gas development within their coastal areas including exploratory drilling, production platform installation, and pipeline installation. Factors that could affect EFH from these activities would be similar to those described above for OCS activities. However, the effects from non-OCS oil and gas activities could possibly be more severe than the effects from routine OCS activities because the activities are closer to shore and in shallower environments. As a consequence, more benthic EFH may be damaged, and resulting changes in sedimentation and turbidity could affect a greater proportion of the water column.

Other non-OCS activities that influence EFH may include commercial fishing, commercial shipping (and other marine vessel traffic), land development, water quality degradation, dredge and fill and dredge disposal operation, and construction of channel stabilization structures such as jetties could affect EFH (GMFMC 1998). As discussed below, these non-OCS activities when combined with OCS activities could result in cumulative impacts

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[54] There is evidence that oil and gas extraction reduces the natural release of hydrocarbons that support deep-sea chemosynthetic communities (Quigley et al. 1999). However, *Lophelia* corals do not depend on hydrocarbon seepage to meet their metabolic requirements (Becker et al. 2009), and presumably would not be affected by a reduction in natural hydrocarbon release to marine waters.

on EFH over time, especially if these impacts occur frequently or are of sufficient magnitude that habitat recovery times are prolonged.

Barges carrying cargo arrive and depart through ports and travel through the GOM Intracoastal Water Way, which serves as a major route for needed goods and supplies. Discharges of treated wastes or hazardous chemicals could negatively affect water quality (Section 4.6.2.1.1), a component of EFH, as well as aquatic vegetation. Pollutants generated from boat maintenance activities on land and water could also negatively impact water quality. Oil and grease are commonly found in bilge water, especially in vessels with inboard engines, and these products may be discharged during vessel pump out (USEPA 1993).

Sand mining and routine dredging operations for channel construction and maintenance, pipeline emplacement, and creation of harbor and docking areas can affect EFH in the GOM by suspending sediments and affecting water quality. As suspended sediments settle to the bottom, the benthic prey of some managed fish species could be smothered. In most cases, benthic organisms would recolonize such areas unless maintenance dredging operations are repeated frequently. Dumping sites for dredge spoils in the GOM, most of which are located within State waters, could also alter water quality and affect benthic organisms that serve as prey for some managed fish species. Pipeline and platform placement that would occur as part of OCS activities would also add to the existing disturbance of benthic habitat from sand mining and dredging activities.

Commercial and recreational fisheries in the GOM also impact EFH. For example, most of the wild shrimp caught are harvested using bottom trawls. The nets are held open with bottom sled devices made from wood or steel. In addition to capturing and killing some nontarget fish and invertebrate species, the sleds, or “doors,” drag along the bottom, potentially digging up sediments and hard substrate. Such activities could disrupt the benthic community and increase the turbidity of the water (Jones 1992). Similarly, use of spiny lobster and stone crab traps may also damage bottom substrate such as seagrasses and corals. Pipeline and platform emplacement add to the disturbance of benthic habitat by temporarily increasing turbidity in disturbed regions.

Other potential interactions between fishing and OCS activities result from the presence of platforms, around which reef-associated fish species tend to congregate. Recreational fishing targeting platform areas increase fishing pressure on overfished species such as snapper and grouper. Explosive removal of platforms also likely results in higher proportional mortality of reef-associated fish.

Other events, including hurricanes, turbidity plumes, and hypoxia, could also affect various managed fish or their habitat, although the GOM fish community as a whole should be adapted to such events. For example, a hurricane or a series of hurricanes could temporarily degrade the quality of large areas of wetlands that serve as nursery and feeding areas for a variety of managed fish and invertebrate species.

Climate change could affect EFH in several ways. Climate change may cause the temporal variability of key chemical and physical parameters — particularly hydrology, dissolved oxygen, salinity, and temperature — to change or increase, which could significantly alter the existing structure of the benthic and phytoplankton communities (Rabalais et al. 2010). For example, freshwater discharge into the GOM has been increasing and is expected to continue to increase as a result of the increased rainfall in the Mississippi River Basin (Dai et al. 2009). Such changes could result in severe long-term or short-term fluctuations in temperature and salinity that could reduce or eliminate sensitive species. Such changes are most likely to occur in the Mississippi Estuarine Ecoregion, where freshwater inputs are highest. In addition, greater rainfall may increase inputs of nutrients into the GOM, potentially resulting in more intense phytoplankton blooms that could promote benthic hypoxia (Rabalais et al. 2010). Hypoxic or anoxic conditions can reduce or eliminate the suitability of benthic EFH for marine organisms. The increased storm severity predicted to result from climate change may also increase disturbance to benthic habitats that are already stressed by trawling, anchoring, and dredging operations and OCS-related pipeline trenching. See Sections 3.7.2.1 and 3.7.3.1 for a complete discussion of how climate change may affect marine benthic and pelagic habitat.

Climate change has the potential to profoundly affect coral and hard bottom EFH in several ways, including the following (Section 3.7.1.1.4):

- Increased frequency of bleaching as a stress response to warming water temperatures (Hoegh-Guldberg et al. 2007);
- Excessive algal growth on reefs and an increase in bacterial, fungal, and viral agents (Boesch et al. 2000; Twilley et al. 2001);
- Greater frequency of mechanical damage to corals from greater severity of tropical storms and hurricanes (Janetos et al. 2008);
- Decreases in the oceanic pH and carbonate concentration are expected to reduce the reef formation rate, weaken the existing reef structure, and alter the composition of coral communities (Janetos et al. 2008); and
- Range expansion of non-native species into the northern GOM.

Another primary impact expected to result from climate change is the loss of wetland habitat, which is an important EFH for many larval and juvenile stages of managed species. Wetland loss could be caused by several factors including erosion, sea level rise, discharging nutrient-laden waters to the environment, reduced sediment load of the Mississippi River, and human-induced subsidence from groundwater withdrawals, among others. Cumulative effects on wetlands are discussed in Section 4.6.3.1.1.

As climate change has the potential to affect warm water corals, it could affect coldwater *Lophelia* reefs (Section 3.7.2.1.7). The saturation depth of aragonite (the primary carbonate formed used by hard corals) appears to be a primary determinant of deepwater coral distribution, with reefs forming in areas of high aragonite solubility (Orr et al. 2005). The depth at which the water is saturated with aragonite is projected to become shallower over the coming century, and most coldwater corals may be in undersaturated waters by 2100 (Orr et al. 2005). Consequently, the spatial extent, density, and growth of deepwater corals may decrease, diminishing their associated ecosystem functions (Orr et al. 2005).

There are potential interactions between climate change and OCS activities that could affect EFH and managed species. For example, ocean acidification and increases in water temperature may slow the recovery of corals exposed to drilling muds or oil from an accidental spill. Another potential interaction could occur between oil and gas platforms and climate change in which new hard-bottom–associated species are able to expand northward due to warming and the availability of hard substrate in the form of active or decommissioned oil platforms. By acting as stepping stones across the GOM, oil platforms have been implicated in the introduction of a non-native coral species (*Tubastraea coccinea*) and fishes such as sergeant majors (*Abudefduf saxatilis*) and yellowtail snapper (*Ocyurus chrysurus*) into the FGB (Hickerson et al. 2008).

Oil spills from OCS and non-OCS activities may cumulatively affect several resources that contribute to EFH, including sediments, water quality, fish resources, coastal habitats, and seafloor habitats and benthic communities (see Sections 4.6.2 and 4.6.3). Large, potentially catastrophic spills could result from pipeline ruptures, tanker spills associated with an FPSO system, or loss of well control. Other potential sources of oil spills that could affect EFH include non-OCS oil and gas development activities and non-OCS tankering activities. Spills from import tankers could occur offshore in shipping lanes or in coastal waters as tankers prepare to make landfall.

Oil from shallow-water spills could impact life stages of managed fish species that use surface waters as part of their lifecycle, especially those that release pelagic eggs and have pelagic larvae. Unlike adult fish that can move away from oiled waters, pelagic eggs and larvae are largely transported by wind and water currents. Those that come into contact with surface oil could be injured or killed through smothering or an accumulation of oil on the gills. Thus, oiled surface waters would temporarily reduce the amount of EFH available for these life stages. Detailed discussion of the impacts of oil spills on fish can be found in Section 4.4.7.3.1.

In marine waters, several individual reefs and banks located offshore of the Louisiana-Texas border have been designated HAPCs by the GMFMC (NMFS 2010a). As identified in Section 4.4.6.2.1, NTL No. 2009-G39 has several protections in place to minimize and mitigate the adverse effects of oil and gas exploration and development on these banks. However, large or catastrophic spills could adversely affect hard-bottom HAPC by causing lethal or sublethal impacts to corals (Section 4.4.6.2.1). The HAPC for bluefin tuna extends from the 100 m (328 ft) isobath seaward to the EEZ. The HAPC could also be affected by oil spills, and population-level impacts to bluefin tuna could result from catastrophic spills. Habitat areas of particular concern in nearshore areas include intertidal and estuarine habitats with emergent and submerged vegetation, sand and mud flats, and shell and oyster reefs that may provide food and rearing for managed juvenile fish and shellfish. Shallow-water spills may reach these coastal EFH areas and have negative impacts. Shallow-water wave action could increase entrainment of oil and tar balls in the water column. This could temporarily diminish the quality and quantity of benthic EFH. Settled tar balls may be ingested by bottom-feeding fishes and may harm or prove fatal to them. During a spill, aquatic vegetation, which provides habitat for juveniles and for prey of some managed species, could become coated with oil. In such cases, organisms that are sessile or that have limited ability to avoid spills could be killed. These areas represent important nursery areas for fishes and invertebrates that contribute to estuarine, coastal, and shelf food webs. Loss of such habitat by oil spills would be compounded by the existing high natural loss of wetlands.

The actual locations of the spills will determine the degree to which EFH would be affected. The HAPC in the Eastern Planning Area that could be affected by oil spills from the Central or Western Planning Areas include the Florida Middle Grounds, the Madison-Swanson Marine Reserve. Pulley Ridge, and Tortugas North and South Ecological Reserve are also located in the southern tip of Florida, and are unlikely to be contacted by oil. Spills have the greatest potential to harm EFH resources if they occur in shallow waters, where benthic habitats or wetlands can be affected, or if they occur when large numbers of pelagic eggs and larvae of managed species are present. If the location of a spill coincided with the location of eggs and larvae, large numbers of these organisms would be injured or killed. Oil reaching the surface from deepwater pipeline spills and deepwater tanker spills could affect EFH for the eggs and larvae of federally managed pelagic fish species, neuston prey species, and *Sargassum* and its associated fauna. Pelagic eggs and larvae contacting the spilled oil would be smothered, and *Sargassum* within affected areas would be fouled and potentially killed.

Conclusion. Impact-producing factors for EFH include those from both OCS and non-OCS activities. Non-OCS activities with the potential to impact EFH in the GOM include oil and gas production in State waters, sediment dredging and disposal, and vessel traffic. Impacts from OCS activities would be limited by specific lease stipulations. Overall, the cumulative impacts on EFH would be moderate to major. The incremental contribution of routine Program activities to these impacts would range from negligible to medium (see Section 4.4.6.3.1).

Accidental oil spills could result from both OCS and non-OCS activities. Overall, the cumulative impacts on EFH from oil spills would range from moderate to major. The incremental impacts of expected oil spills would range from negligible to medium, depending on the location, timing, duration, and size of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities (Section 4.4.6.3.1). While most accidents related to OCS activities assumed under the cumulative scenario would be small (less than 50 bbl) and would have relatively small incremental impacts on EFH, spills that reach coastal wetlands could have more persistent impacts and could require remediation. Spills in deeper water, whether from OCS or non-OCS sources, are unlikely to have overall population-level effects on fish resources because of the relatively small proportion of similar available fish habitats that would come in contact with released oil at concentrations great enough to elicit toxic effects. Oil spills that have the greatest potential to impact EFH and managed species are those that occur in shallower subtidal and intertidal areas and spills that reach areas at the same time where substantial numbers of eggs or larvae of managed species are present. Impacts associated with an unexpected, low-probability CDE affecting shallow and intertidal habitats could be moderate to major, depending on the size, duration, timing, and location of the spill.

4.6.3.2 Alaska – Cook Inlet

4.6.3.2.1 Coastal and Estuarine Habitats. Section 4.4.6.1.2 discusses direct and indirect impacts on coastal and estuarine habitats in Cook Inlet resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on these resources result from the incremental impacts of the Program (described in Section 4.4.6.1.2), when added to impacts from ongoing and reasonably foreseeable future actions, including those of future OCS programs[55] and other non-OCS activities. Table 4.6.1-3 presents the exploration and development scenario for the Cook Inlet cumulative case, which takes into account activities associated with the Program in combination with those from future OCS programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in Cook Inlet are summarized in Table 4.6.1-6 and discussed below, as applicable.

A number of activities associated with the Program could result in impacts on coastal and estuarine habitats in the Cook Inlet Planning Area (Section 4.4.6.1.2). These activities include construction of pipelines and pipeline landfalls and operation of service vessels and existing facilities. Impacts could include losses of beach and wetland habitat and indirect effects that contribute to reductions in these habitats or impacts on biota. There are no past or ongoing OCS activities in the Cook Inlet Planning Area.

Pipeline landfalls could directly disturb tidal marshes, beaches, rocky shores, or other coastal habitats, depending on the location of the landfalls. Sedimentation from physical disturbance of substrates may affect biota in intertidal or shallow subtidal habitats. In addition, accidental spills may impact shoreline habitat.

Ongoing non-OCS activities that could affect coastal and estuarine habitats include those related to State oil and gas development, commercial shipping (and other marine vessel traffic), coastal development, discharge of municipal wastes and other effluents, domestic transportation of oil and gas, and logging (Table 4.6.1-6). These activities can be reasonably expected to continue into the future.

Factors that impact coastal wetlands include the direct elimination of wetland habitat by excavation or filling and the degradation of wetland communities by reduced water quality or hydrologic changes. The construction of pipelines, docks, or shore bases associated with State oil and gas exploration and development could result in direct losses of habitat. Habitats and associated biota within the Cook Inlet Planning Area could also be affected by routine discharges from marine vessels, discharges of municipal and industrial wastewater, or sedimentation from upland areas, including erosion from logging operations within the Cook Inlet watershed. Activities that increase wave action along beaches could contribute to their erosion. Barge and service vessel traffic supporting State oil and gas development may result in wake erosion. The direct and indirect impacts on wetlands from pipeline construction, service vessel operation, and operation of existing facilities under the Program would represent a very small contribution to

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55 Currently, there are no ongoing OCS activities within Cook Inlet.

the past, ongoing, and expected future impacts on coastal and estuarine habitats from non-OCS activities.

Accidental spills of oil or other liquid hydrocarbons, resulting from activities conducted under the Program, could impact shoreline habitats. The majority of these spills are assumed to be small (less than 50 bbl) for the cumulative case (Table 4.6.1-4). Spills from onshore pipelines and facilities could impact freshwater wetlands, or tidal wetlands if carried to coastal habitats by streams. Non-OCS activities, such as State oil and gas development, domestic transportation of oil or refined petroleum products, including LNG from Cook Inlet and the Alaska Peninsula, the production and storage of petroleum products and LNG, and commercial shipping (and other marine vessel traffic), may also result in accidental spills that could potentially impact shoreline habitats. Oil spills have resulted in past impacts on beaches and other intertidal habitats, as in the case of the *Exxon Valdez* oil spill. Spills can result in short- or long-term effects on vegetation growth and changes in the composition of intertidal or shallow subtidal communities, or extensive mortality of biota associated with shoreline habitats, and may persist in substrates for decades. The amount of oil contacting shoreline habitats from a spill depends on a number of factors such as the location and size of the spill, waves and water currents, and containment actions. Naturally occurring seeps may also be a source of crude oil introduced into nearshore waters (Kvenvolden and Cooper 2003). The magnitude of resulting impacts and the persistence of oil would depend on factors such as the amount of oil deposited, remediation efforts, substrate grain size, and localized erosion and deposition patterns. Recovery of affected wetlands could require several decades. The impacts of potential spills associated with the Program would be expected to add a small contribution to the impacts of other sources of oil in the planning area.

Indirect effects on coastal and estuarine habitats could result from global climate change. Potential thermal expansion of ocean water and melting of glaciers and ice caps could result in a global rise in mean sea level (Section 4.6.1.6). Sea-level rise could result in increased inundation of shorelines and erosion of beach habitat and conversion of wetlands to open water. In addition, large changes in river flows into nearshore marine waters could affect salinity and water circulation in estuaries, which, in turn, could impact estuarine wetland communities.

Conclusion. Future OCS program and ongoing and future non-OCS program activities in combination with naturally occurring events have resulted in losses of coastal habitats in Cook Inlet; cumulative impacts on these resources, therefore, are considered to be moderate to major. Operations under the Program would result in minor localized impacts, primarily due to facility construction, pipeline landfalls, channel dredging, and vessel traffic; therefore, the incremental contribution of routine Program activities to cumulative impacts would range from small to medium (see Section 4.4.6.2.2).

The cumulative impacts of past, present, and future oil spills on coastal and estuarine habitats would be moderate. The incremental impacts of expected accidental oil spills associated with the Program on these resources would be negligible to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to particular habitats; and the timing and nature of spill containment and cleanup activities (see Section 4.4.6.2.2). The majority of these spills would be small (less than 50 bbl). Impacts associated with large oil spills (1,000 bbl or greater) or an unexpected, low-probability CDE that occur in or reach shallower nearshore areas have the greatest potential to affect extensive areas of shoreline and coastal habitats. Although these are rare events, the impacts of such releases on coastal habitats could range from moderate to major if they were to occur.

4.6.3.2.2 Marine Benthic and Pelagic Habitats. Sections 4.4.6.2.2 and 4.4.6.3.2 discuss direct and indirect impacts, respectively, on marine benthic and pelagic habitats in Cook Inlet resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on these resources result from the incremental impacts of the Program (described in Sections 4.4.6.2.2 and 4.4.6.3.2), when added to impacts from ongoing and reasonably foreseeable future actions, including those of future OCS programs and other non-OCS activities.[56] Table 4.6.1-3 presents the exploration and development scenario for the Cook Inlet cumulative case, which takes into account activities associated with the Program in combination with those from future OCS programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in Cook Inlet are summarized in Table 4.6.1-6 and discussed below, as applicable.

Cumulative impact-producing factors for marine benthic and pelagic habitats in Cook Inlet Planning Area include both OCS and non-OCS activities. Potential impacts on marine benthic and pelagic habitat resulting from ongoing and future routine OCS program activities, including those of the Program, could result from noise (vessel, seismic surveys, construction, operations), well drilling, pipeline placement (trenching, landfalls, and construction), platform placement (anchoring, mooring, and removal), and discharges (drilling, vessel and platform). All these activities have the potential to adversely affect marine benthic habitats in the Cook Inlet Planning Area. Accidental oil spills are also counted among OCS program-related activities; assumptions for oil spills under the cumulative case scenario are provided in Table 4.6.1-4, and catastrophic spill assumptions are provided in Table 4.4.2-2.

Because there is no ongoing OCS activity in Cook Inlet Planning Area, the new OCS activities under the Program represent a 100% increase in all associated OCS activities in Cook Inlet. Over the life of the Program, up to 110 production wells and up to three oil platforms are anticipated. In addition, up to 241 km (150 mi) of new offshore pipeline is anticipated. Bottom disturbance resulting from OCS program activities degrades water quality by increasing water turbidity in the vicinity of the operations and adding contaminants to the water column. It also changes sediment composition as suspended sediments (and contaminants, if present) are entrained in currents and deposited in new locations. Construction of platforms in areas previously lacking hard substrate could have localized effects on the biodiversity and distribution of benthic communities by favoring organisms that prefer a hard substrate. Impacts of OCS routine operations (exploration, production and decommissioning activities) on marine benthic and pelagic habitat in the Cook Inlet Planning Area are discussed in detail in Sections 4.4.6.2.2 and 4.4.6.3.2. Overall, routine operations represent a negligible to moderate long-term disturbance, with the severity of the impacts generally decreasing dramatically with distance from the well site.

[56] Currently, there are no ongoing OCS activities within Cook Inlet.

The increased amount of drilling in Cook Inlet anticipated under the Program will result in OCS discharges of drill muds and cuttings from exploration and delineation wells. Drilling muds and cuttings from production wells as well as all produced waters will be disposed of in the well rather than discharged into Cook Inlet. The OCS discharges of drill muds, cuttings, and produced waters could potentially affect benthic and pelagic habitat by increasing turbidity and altering grain size distributions and chemical characteristics of sediments. The impacts of drilling discharges on benthic and pelagic habitats are discussed in detail in Sections 4.4.6.2.3 and 4.4.6.3.3.

Various non-OCS activities in Cook Inlet, including State oil and gas programs, dredging and disposal of dredging spoils in OCS waters, anchoring, and commercial or sportfishing activities, and commercial shipping (including imported oil) could contribute to cumulative effects on pelagic and seafloor habitats, along with OCS activities. Drilling of wells in State waters could also require construction of platforms and pipelines in waters of Alaska. Effects on seafloor and pelagic habitat and biota would be similar to those described above for OCS oil and gas programs (Sections 4.4.6.2.2 and 4.4.6.3.2). Dredging operations in conjunction with ship channel maintenance and construction, pipeline placement and burial, and support facility access occur throughout the Cook Inlet Planning Area as part of non-OCS activities. Non-OCS dredging and marine disposal activities would involve excavation of nearshore sediments and subsequent disposal in offshore or nearshore areas, thereby disturbing seafloor habitats and generating temporary turbidity in the water column. Sediments dredged and sidecast or transported to approved dredged material disposal sites could cause smothering and some mortality of sessile animals in the vicinity of the activity. Anchoring of non-OCS activity vessels on these features could cause significant chronic disturbance to benthic and bottom water habitat and biota. Anchoring could involve boats used for recreational and commercial fishing and commercial ship traffic. The amount of damage that could result from anchoring activity would depend upon vessel size, the size of the anchor and chain, sea conditions at the time of anchoring, and the location or position of the anchor on the feature. Similarly, some fishing methods, such as trawling and shellfish dredging, could damage seafloor habitats and increase the turbidity of the water column (Jones 1992). The effects of dredging, anchoring, and trawling activities on marine benthic and pelagic habitats are expected to be similar to those described for OCS bottom disturbing activities (Sections 4.4.6.2.2 and 4.4.6.3.2). Impacts on pelagic habitat would be localized and temporary, while benthic habitat damaged by anchors may take more than 10 years to recover, depending upon the nature of the habitat and severity of the damage. Benthic habitat disturbances from OCS activities (e.g., pipeline trenching and placement and platform placement) would add to the existing impacts to benthic habitat from these non-OCS sediment-disturbing activities.

Cook Inlet is a heavily river-influenced system. Therefore, climate change relating to the temporal variability of key chemical and physical parameters could have important effects in the Cook Inlet Planning Area — particularly to hydrology, dissolved oxygen, salinity, and temperature. These changes could significantly alter the existing benthic and pelagic habitat and biota. A predicted increase in river discharge could change the salinity, temperature, and turbidity regimes in nearshore areas and alter the composition of existing phytoplankton and benthic communities. Other changes could result from:

- Ocean acidification from increasing CO_2 inputs into the ocean that may reduce the availability of calcite and aragonite to calcifying marine organisms.

- Reduction in landfast ice extent and duration expected as a result of rising temperatures which may reduce the scouring of intertidal and shallow subtidal habitats on the western side of Cook Inlet.

- Increases or decreases in phytoplankton productivity. Studies in the Gulf of Alaska suggest phytoplankton productivity is controlled by a number of factors, especially light, microzooplankton consumption, nutrients, and water column stratification, all of which could be affected by climate change (Strom et al. 2010). Therefore, climate change could increase or decrease phytoplankton productivity, potentially resulting in greater or lesser food inputs to benthic habitats and a subsequent increase or decrease in the productivity of benthic biota.

Oil spills from both OCS and non-OCS activities could affect benthic and pelagic habitat in Cook Inlet. The total number of oil spills and the extent of affected seafloor habitat would likely increase under the cumulative scenario, in conjunction with increased levels of petroleum exploration and production. Accidental hydrocarbon releases can occur at the surface from tankers or platforms or at the seafloor from the wellhead or pipelines. Non-OCS activities, such as oil and gas development in State waters, domestic transportation of oil or refined petroleum products, and commercial shipping (and other marine vessel traffic), may also result in accidental spills that could affect benthic and pelagic habitats within the Cook Inlet Planning Area.

For both OCS and non-OCS oil spills, it is assumed the magnitude and severity of potential impacts on benthic and pelagic habitat would be a function of the location (including habitats affected), timing, duration, and size of the spill and containment and cleanup activities. It is anticipated that most small to medium spills would have limited effects because of the relatively small areas likely to be exposed to high concentrations of hydrocarbons and the short period of time during which potentially toxic concentrations would be present. Oil spills would likely have the greatest impacts on benthic habitat and communities in shallow subtidal waters and in intertidal areas. Although pelagic habitat is likely to recover following an oil spill, the recovery time for intertidal and shallow subtidal benthic habitat directly affected by oil spills could be long term (Section 4.4.6.2.2). Multiple spills would further contribute to cumulative effects. Detailed discussion of the impacts of OCS accidental hydrocarbon releases on marine benthic and pelagic habitat can be found in Sections 4.4.6.2.2 and 4.4.6.3.2.

Impact-producing factors for marine benthic and pelagic habitats in Cook Inlet include those from both OCS and non-OCS activities. Non-OCS activities with the potential to impact these resources include oil and gas development in State waters, commercial fishing and sportfishing, sediment dredging and disposal, anchoring, and tankering of imported oil. Disturbances from these activities including noise, marine vessel discharges, and bottom disturbance would add to similar impacts from OCS activities. Overall, cumulative impacts on marine benthic and pelagic habitats, as a result of OCS and non-OCS program activities, would be moderate to major. The incremental contribution of routine Program activities to these impacts would range from negligible to medium (see Section 4.4.6.2.2).

Accidental oil spills could result from both OCS and non-OCS activities. Overall, the cumulative impacts on marine habitats from oil spills would range from minor to moderate. The incremental impacts of expected oil spills, most of which would be small (less than 1,000 bbl), would range from negligible to small, depending on the location, timing, duration, and size of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities (Section 4.4.6.2.2). Spills in deeper water, whether from OCS or non-OCS sources, are unlikely to have overall community-level effects on seafloor habitats because of the relatively small proportion of seafloor area that would come in contact with released oil at concentrations great enough to elicit toxic effects. Impacts associated with an unexpected, low-probability CDE affecting shallow and intertidal habitats could be minor to moderate, depending on the habitats affected. Although pelagic habitat is likely to recover following a CDE, the recovery time for intertidal and shallow subtidal benthic habitat directly affected by such oil spills could be long term.

4.6.3.2.3 Essential Fish Habitat. Section 4.4.6.4.2 discusses direct and indirect impacts on EFH in Cook Inlet resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on these resources result from the incremental impacts of the Program (described in Section 4.4.6.4.2) when added to impacts from ongoing and reasonably foreseeable future actions, including those of future OCS programs and other non-OCS activities.[57] Table 4.6.1-3 presents the exploration and development scenario for the GOM cumulative case, which takes into account activities associated with the Program in combination with those from future OCS programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in Cook Inlet are summarized in Table 4.6.1-6 and discussed below, as applicable.

Cumulative impacts on EFH could result from future OCS and ongoing and future non-OCS activities that have a potential to directly kill managed fish species, disturb ocean bottom habitats, increase sediment suspension, degrade water quality, or affect the food supply for fishery resources (there are no ongoing OCS programs in Cook Inlet). Future OCS activities (resulting from the Program) include seismic surveys (noise), well drilling, pipeline placement (trenching, landfalls, and construction), platform placement (anchoring, mooring, and removal), and routine discharges (drilling, platform, and vessel). Accidental oil spills are also counted among OCS and non-OCS activities.

Because there is no ongoing OCS activity in Cook Inlet Planning Area, the new OCS activities under the Program represent a 100% increase in all associated OCS activities in Cook Inlet. Over the life of the Program, up to 110 production wells and up to three oil platforms are anticipated. In addition, up to 241 km (150 mi) of new offshore pipeline are anticipated, as is one pipeline landfall. Implementation of the Program would also result in seismic survey activity and the release of drilling muds and cuttings to offshore areas (Table 4.6.1-3).

[57] Currently, there are no ongoing OCS activities within Cook Inlet.

Although there are is no oil and gas development in OCS waters, oil and gas operations have existed in State waters of Cook Inlet for decades. Impact-producing factors from OCS and non-OCS oil and gas activities would be similar. Overall, it is expected that the cumulative impacts of exploration and site development activities on marine EFH would be moderate, and impacts are not expected to permanently reduce the EFH available to managed species or result in population-level impacts on managed species. The most sensitive benthic habitats, such as those associated with hard-bottoms and kelp communities, are not expected to be affected by routine operations, and effects would be minimized or eliminated by existing protections. The construction of all platforms and pipelines would disturb bottom habitats to some degree. Deposition of drilling fluids and cuttings could potentially affect EFH by altering grain size distributions and chemical characteristics of sediments such that benthic prey of some managed fish species or water quality in offshore areas would be affected in the immediate area surrounding drill sites. Although muds and cuttings from exploration and delineation wells could be discharged to surrounding waters, it is assumed that muds, cuttings, and produced waters from production wells would be discharged into wells and not released to open waters. See Section 4.4.6.4.2 for a detailed discussion of the impacts of routine operations on EFH and managed species in Cook Inlet Planning Area.

Freshwater areas used by salmon and other anadromous fish are considered to be EFH and could be affected by nearshore OCS and non-OCS oil and gas activity such as pipeline dredging or by onshore pipelines that cross bodies of water, especially streams. The primary effects of pipeline crossings would be increasing turbidity and sedimentation of the benthic environment during construction and blocking migration of anadromous fish following construction. As a consequence, crossings of anadromous fish streams would be minimized and consolidated with other utility and road crossings of such streams. In addition, onshore pipelines would be designed, constructed, and maintained to reduce risks to fish habitats from a spill, pipeline break, or construction activities. Other non-OCS activities, such as logging, road construction, and development in general could also contribute to water quality degradation and blockage of fish passage in anadromous fish streams.

Other ongoing and future non-OCS activities that could impact fish communities include land use practices, point and non-point source pollution, logging, dredging, and disposal of dredging spoils in OCS waters, anchoring, and commercial or sportfishing activities, and commercial shipping (including imported oil). Many of these activities would result in bottom disturbance that would affect bottom dwelling fishes as well as their food sources in a manner similar to those described for OCS activities (Section 4.4.7.3.2). These non-OCS activities when combined with OCS activities could over time result in cumulative impacts on EFH and managed species especially if these impacts occur frequently or are of sufficient magnitude that habitat recovery times are prolonged. See Section 4.6.3.2.1 and Section 4.6.3.2.2 for a discussion of impacts of these non-OCS activities on benthic and pelagic EFH.

Logging could also degrade riverine habitats that are important reproductive and juvenile habitat for managed migratory fish species. Erosion from areas undergoing commercial logging could increase the silt load in streams and rivers, which could reduce levels of invertebrate prey species and adversely affect spawning success and egg survival. The introduction of fine sediments into spawning gravels may render these habitats unsuitable for salmon spawning.

Logging could also remove riparian canopies along some streams, which could increase solar heating of freshwater habitats. Downed timber could physically block salmon migrations. Because of past damage inflicted by commercial logging, improved forestry practices have been initiated, and timber harvests have been curtailed. Continued implementation of effective forest management techniques would help mitigate the adverse effects of logging in the future. Cumulative impacts on migratory species could also occur as a result of activities that obstruct fish movement in marine environments during migration periods.

Commercial fishing practices that are indiscriminate, such as trawling and pots, are responsible for significant amounts of bycatch that can injure or kill juveniles of many fish species. These types of fishing practices could damage future year classes, reduce available prey species, and damage benthic habitat for many Cook Inlet fish resources. A wide variety of methods are used to target numerous species of fishes and shellfishes, including longlines, seines, setnets, trawls, and traps. Some fisheries target particular fish species returning to their natal stream or river, while other fisheries take place in pelagic waters and target mixed stocks of fishes or shellfishes.

As a consequence of the pressure commercial fishing places on fishery resources, appropriate management is required to reduce the potential for depletion of stocks due to overharvesting. Fisheries in Alaskan waters and in adjacent offshore areas are managed by the Alaska Department of Fish and Game and the North Pacific Fishery Management Council of the National Marine Fisheries Service through implementation of fishing regulations such as fishing seasons and harvest limits and through hatchery production of some fishery resources (primarily salmon). Even with management, the possibility of overfishing still exists. Occasionally fisheries are closed when stocks are considered insufficient to support harvesting, and will sometimes remain closed for multiple seasons before stocks are deemed sufficient. While occasional or sustained declines in fishery stocks may not be fully attributable to commercial fishing, it appears that commercial fishing is an important factor in the abundance, or lack thereof, of fishery resources.

Although the magnitude of harvests is considerably smaller than for commercial fisheries (Fall et al. 2009), sportfishing also contributes to cumulative effects on the abundance of some fishery resources. Recreational fisheries are managed to prevent overharvesting, but recreational harvests can be a substantial portion of fisheries landings. Consequently, recreational fishing activities have a potential to result in overharvest of managed species over the life of the Program. However, recreational fishing methods are less destructive of EFH compared to commercial fisheries.

Subsistence fishing may also contribute to the cumulative effects on the abundance of some fishery resources. Alaska State law defines subsistence as the “noncommercial customary and traditional uses” of fish and wildlife. The Alaska Department of Fish and Game defines subsistence fishing to include “the taking of, fishing for, or possession of fish, shellfish, or other fisheries resources by a resident of the State for subsistence uses with gill net, seine, fish wheel, long line, or other means defined by the Board of Fisheries.” These fishing methods have more limited impacts on EFH compared to commercial fishing methods. Subsistence fishing is subject to harvest limits that reduce the potential for overfishing and much of Cook Inlet is defined as a nonsubsistence area, and subsistence fishing is therefore not authorized. Consequently, subsistence fishing makes a relatively minor contribution to the reduction in fish stocks compared to commercial fishing (Fall et al. 2009).

Another source of cumulative impacts to fishery resources are personal use fisheries which are a legally defined as "the taking, fishing for, or possession of finfish, shellfish, or other fishery resources, by Alaska residents for personal use and not for sale or barter, with gill or dip net, seine, fish wheel, long line, or other means defined by the Board of Fisheries." In the Cook Inlet Planning Area, there are areas designated for personal use fisheries for salmon, tanner crab, herring, and eulachon, all of which are managed species. All personal use fisheries are subject to harvest limits that reduce the potential for overfishing. Personal use fishing makes a relatively minor contribution to the reduction in fish stocks compared to commercial fishing.

See individual sections on water quality, coastal habitats, and marine and pelagic habitats for a discussion of the effects of climate change on EFH in the Cook Inlet Planning Area. As a heavily river-influenced system, climate change may cause the temporal variability of key chemical and physical parameters, which could significantly alter the existing benthic and pelagic habitat and biota. A predicted increase in river discharge could change the salinity, temperature, and turbidity regimes in nearshore areas and alter the composition of existing phytoplankton and benthic communities. Other changes could result from ocean acidification, reduction in landfast ice extent and duration, and increase phytoplankton productivity.

The total number of oil spills and the extent of affected EFH areas would likely increase under the Program in conjunction with increased levels of petroleum exploration and production. The Program would contribute 100% of the OCS spills in the Cook Inlet Planning Areas. See Table 4.6.1-4 for oil spill assumptions for Alaska. Catastrophic spills assumptions are provided in Table 4.4.2-2. Non-OCS activities, such as oil and gas development in State waters, domestic transportation of oil or refined petroleum products, and commercial shipping (and other marine vessel traffic), may also result in accidental spills that could potentially impact fish resources within the Cook Inlet Planning Area. While effects on EFH resources would depend on the timing, location, and magnitude of specific oil spills, it is anticipated that most small to medium spills that occur in OCS waters would have limited effects on EFH, due to the relatively small areas likely to be exposed to high concentrations of hydrocarbons and the short period of time during which potentially toxic concentrations would be present. See Section 4.4.6.4 for a detailed discussion of the impact of oil spills on EFH.

Because of the high concentrations of individuals likely to be present, EFH for anadromous salmon are at higher risk from an OCS oil spill in the Cook Inlet Planning Areas. The greatest potential for damage to salmon stocks would be if a spill were to occur along migration routes. However, because of the limited area affected by even large oil spills relative to the wide pelagic distribution and migratory patterns of salmonids, it is anticipated that most impacts would be limited to small fractions of exposed salmon populations. Oil spills occurring at constrictions in migration routes would have an increased potential for adversely affecting salmon. Adverse effects of oil spills on EFH for groundfishes of southern Alaska would also be a function of spill magnitude, location, and timing. Adult groundfishes are primarily demersal and would generally be subjected only to the insoluble oil and water-soluble fractions of oil that reach deeper strata. Insoluble oil fractions would sink to the bottom and be distributed diffusely as tar balls over a wide area, and would be unlikely to produce a reduction in the population of adult fishes. Egg and larval stages would be at greater risk of exposure to oil spills because spawning aggregations of many groundfish species produce pelagic eggs that could come into contact with surface oil slicks. Herring are also potentially susceptible to oil spills because they spawn in nearshore waters for protracted periods of time.

Managed shellfish stocks (such as tanner, snow, and red king crab) are unlikely to be exposed to surface oil. However, oil reaching shallow subtidal and intertidal shellfish or crab habitat could measurably reduce crab populations. Pelagic crab larvae could also be affected if a large surface oil spill occurred during the spring spawning season. However, because the area affected by most spills would be expected to be small relative to overall distributions of crab larvae, overall population levels are unlikely to be noticeably affected.

Conclusion. Impact-producing factors for EFH include those from both OCS and non-OCS activities. Non-OCS activities with the potential to impact EFH in the Cook Inlet Planning Area include oil and gas production in State waters, coastline development, commercial and recreational fishing, sediment dredging and disposal, and vessel traffic. Impacts from OCS activities would be limited by specific lease stipulations. Overall, the cumulative impacts on EFH would be minor to moderate, considering ongoing and future OCS and non-OCS activities. The incremental contribution of routine Program activities to these impacts would be negligible to medium (see Section 4.4.6.3.2).

Accidental oil spills could result from both OCS and non-OCS activities. Overall, the cumulative impacts on EFH from oil spills would range from minor to moderate. The incremental impacts of expected oil spills would range from negligible to medium, depending on the location, timing, duration, and size of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities (Section 4.4.6.3.2). While most accidents related to OCS activities assumed under the cumulative scenario would be small (less than 50 bbl) and would have relatively small incremental impacts on EFH, spills that reach coastal wetlands could have more persistent impacts and could require remediation. Spills in deeper water, whether from OCS or non-OCS sources, are unlikely to have overall population-level effects on fish resources because of the relatively small proportion of similar available fish habitats that would come in contact with released oil at concentrations great enough to elicit toxic effects. Oil spills that have the greatest potential to impact EFH and managed species are those that occur in shallower subtidal and intertidal areas and spills that reach areas at the same time where substantial numbers of eggs or larvae of managed species are present. Impacts associated with an unexpected, low-probability CDE affecting shallow and intertidal habitats could be moderate to major, depending on the size, duration, timing, and location of the spill.

4.6.3.3 Alaska Region – Arctic

4.6.3.3.1 Coastal and Estuarine Habitats. Section 4.4.6.1.3 discusses direct and indirect impacts on coastal and estuarine habitats in the Arctic region resulting from the

2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on these resources result from the incremental impacts of the Program (described in Section 4.4.6.1.3), when added to impacts from ongoing and reasonably foreseeable future actions, including those of ongoing and future OCS programs and other non-OCS activities. Table 4.6.1-3 presents the exploration and development scenario for the Arctic region cumulative case, which takes into account activities associated with the Program in combination with those from ongoing and future OCS programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in the Arctic are summarized in Table 4.6.1-7 and discussed below.

Coastal Barrier Beach and Dunes. Vessel traffic associated with the Program could result in indirect impacts on coastal barrier beaches and dunes in the Arctic region (Section 4.4.6.1.3). Onshore pipeline construction may impact sand beaches and dunes on the margins of lakes and rivers on the Arctic Coastal Plain (ACP). Similar activities are associated with current and planned OCS sales in the Alaska region and would occur during the life of the Program (see Table 4.6.1-5). In the Beaufort Sea and Chukchi Sea Planning Areas, vessel traffic associated with the Program would represent approximately 25–35% of such OCS activities, and onshore pipelines associated with the Program would represent approximately 30% for the Beaufort Sea Planning Area.

Impacts on barrier beaches and dunes primarily result from factors that contribute to increased erosion of beaches and dunes. Activities may disturb dune vegetation, thereby promoting dune erosion, or directly disturb beach and dune substrates, resulting in increased erosion of beaches and dunes. Increases in wave action could also contribute to the erosion of beaches. Sedimentation from physical disturbance of substrates or erosion may affect biota in intertidal or shallow subtidal habitats. In addition, accidental spills may impact beach or dune habitat.

Ongoing non-OCS activities that could affect barrier beaches and dunes include those related to State oil and gas development, commercial shipping (and other marine vessel traffic), and coastal development. These activities can be reasonably expected to continue into the future.

The construction of pipelines, docks, causeways, or shorebases associated with State oil and gas exploration and development could result in direct losses of beach or dune habitat. Construction of facilities on barrier islands could impact beach, dune, or tundra habitat. Erosion of beach or dune substrates adjacent to these constructions may result in additional habitat losses. Intertidal and shallow subtidal organisms in nearby areas may be buried by excavated materials or indirectly affected by turbidity and sedimentation. Sand beaches and dunes along lagoon shorelines and on the margins of lakes and rivers on the ACP may also be affected by pipeline construction. The impacts on barrier beaches and dunes from substrate-disturbance activities associated with construction under the Program would represent a small contribution to the past, ongoing, and expected future impacts on barrier beaches and dunes from non-OCS activities. Vegetated dunes in the Arctic region may be affected by vehicles associated with seismic activities (ADNR 2009d). Beaches and associated biota within the Beaufort Sea and Chukchi Sea Planning Areas could also be affected by routine discharges from marine vessels, discharges of municipal and industrial wastewater, or sedimentation from upland areas.

Activities that increase wave action along barrier beaches and dunes could contribute to their erosion. Barge and service vessel traffic supporting State oil and gas development may result in wake erosion along barrier islands in the Beaufort Sea and Chukchi Sea Planning Areas. A portion of the impacts related to vessel traffic would be associated with the Program; however, activities conducted under the proposed action would contribute a relatively small number of vessel trips to the total.

Accidental spills of oil or other liquid hydrocarbons, resulting from activities conducted under the proposed action, could impact beaches and dunes. Such spills would represent approximately 20–40% of the spills resulting from ongoing OCS activities and planned future sales in the Beaufort Sea and Chukchi Sea Planning Areas (Table 4.6.1-4). As under the Program, the majority of these spills would be small (less than 50 bbl). Non-OCS activities, such as State oil and gas development, domestic transportation of oil or refined petroleum products, and commercial shipping (and other marine vessel traffic), may also result in accidental spills that could potentially impact coastal barrier beaches and dunes. Spills can result in short- or long-term changes in the composition of intertidal or shallow subtidal communities, or extensive mortality of biota associated with coastal habitats, and may persist in substrates for decades. The amount of oil contacting beaches from a spill depends on a number of factors such as the location and size of the spill, waves and water currents, and containment actions. Naturally occurring seeps may also be a source of crude oil introduced into nearshore waters (Kvenvolden and Cooper 2003). The magnitude of resulting impacts and the persistence of oil would depend on factors such as the amount of oil deposited, remediation efforts, substrate grain size, and localized erosion and deposition patterns. The impacts of potential spills associated with the Program would be expected to add a small contribution to the impacts of other sources of beach degradation in the Arctic region.

Indirect effects on coastal barrier beaches and dunes could result from global climate change. Potential thermal expansion of ocean water and melting of glaciers and ice caps could result in a global rise in mean sea level (Section 4.6.1.6). Sea-level rise could result in increased inundation of barrier landforms and erosion of beach habitat. In the Arctic, greater wave activity during storms due to decreases in sea-ice cover, as well as changes in permafrost due to temperature increases, could result in increased coastal erosion.

Wetlands. A number of activities associated with the Program could result in impacts on coastal wetlands in the Alaska region (Section 4.4.6.1.3). These activities include construction of pipelines, road construction, and facility maintenance, and activities that result in poorer water and air quality and altered hydrology. Impacts associated with these activities could include elimination of wetland habitat and indirect effects that contribute to reductions in wetland habitat. Similar activities are associated with current and planned OCS lease sales in the Beaufort Sea and Chukchi Sea Planning Areas, and would occur during the life of the Program (see Table 4.6.1-3). In the Beaufort Sea Planning Area, the activities associated with the Program would represent approximately 30% of such OCS activities; the Program does not include new onshore pipelines in the Chukchi Sea Planning Area.

Factors that impact coastal wetlands include the direct elimination of wetland habitat by excavation or filling and the degradation of wetland communities by reduced water or air quality or hydrologic changes. Construction projects may fill wetlands for facility siting or excavate wetlands for the construction of pipelines, causeways, or shore bases or for gravel mining. A number of activities may degrade wetlands or promote wetland losses indirectly by causing changes to wetland hydrology or introducing contaminants.

Ongoing non-OCS activities that could affect coastal wetlands include those related to State oil and gas development, commercial shipping and other marine traffic, coastal development, discharge of municipal wastes and other effluents, and domestic transportation of oil and gas. These activities can reasonably be expected to continue into the future.

A number of these activities result in the localized destruction of wetlands. The construction of pipeline landfalls, docks, or shorebases associated with State oil and gas exploration and development could result in direct losses of tidal wetlands. The construction of onshore facilities to support State oil and gas development and the exploration of oil reserves on the NPR-A on the ACP have affected freshwater wetlands, and future impacts associated with oil and gas development are expected to continue. The construction of buried pipelines results in direct impacts on wetlands due to excavation, and the construction of gravel pads and gravel roads eliminates wetland habitat by filling. Current technology allows for smaller and fewer drilling pads, and some new developments in the Arctic region would not include interconnecting roads. On the ACP, gravel has been used in support of oil and gas development to construct pads for camps, drilling sites, operations and maintenance facilities, airports, and roads for facility access as well as the Dalton Highway/haul road, offshore islands, and causeways (MMS 2003a). Gravel mining operations often result in the excavation of wetland habitat in and near rivers and other water bodies. Over 730 ha (1,800 ac) of tundra have been removed by gravel mining on the ACP (MMS 2003a). The construction of vertical support members for elevated pipelines also contributes to small localized wetland losses. Although activities that impact wetlands are regulated by State and Federal agencies, construction of industrial facilities, commercial sites, and residential developments would be expected to result in continued wetland losses. On the ACP, over 3,900 ha (9,600 ac) of tundra habitat, most of which is wetland, have been affected by oil and gas development activities (MMS 2002b, 2003a). The direct impacts on coastal wetlands from pipeline construction under the Program would represent a very small contribution to the past, ongoing, and expected future losses of wetlands from non-OCS activities.

Indirect impacts of many activities have also resulted in wetland losses. The construction of gravel roads and pads has resulted in altered hydrology in some areas, by blocking natural drainage patterns, converting vegetated wetlands to open water, or drying wetlands by restricting water inflow. Snow accumulations adjacent to pads and roads can result in vegetation changes and thermokarst. Windblown dust near gravel pads and roads causes changes in plant communities, reduction of vegetation, and thermokarst, leading to wetland losses. Sedimentation from gravel pads, roads, gravel mining operations, and vehicular impacts on streambanks adversely affect wetlands and may result in losses of vegetation or other associated biota. Ice roads in the Arctic could result in compression of vegetation, microtopography, and tundra soils, altering wetland communities. Vehicles used for seismic surveys could compress microtopography and cause changes in the vegetation community. Organisms in wetland areas near construction activities may be buried by excavated materials or indirectly affected by turbidity and sedimentation. Degradation of wetlands could result from water quality impacts due to discharges of waste water from vessels, municipal treatment plants, and industrial facilities, and stormwater discharges. Water quality may also be affected by waste storage and disposal sites. Spills of produced water could kill vegetation and other biota in freshwater wetlands. Impacts on air quality near construction sites or industrial facilities could result in local effects on wetland vegetation, and may include sources such as fugitive dust, off-gassing from processing facilities, or exhaust emissions. Indirect impacts on wetlands from non-OCS activities are expected to continue to contribute to wetland degradation and losses in the Arctic region. The indirect impacts on wetlands from pipeline construction under the Program would represent a very small contribution to the past, ongoing, and expected future impacts on wetlands from non-OCS activities.

Accidental spills of oil or petroleum products as a result of activities conducted under the Program could impact tidal or freshwater wetlands (see Section 4.4.6.1.3). Such spills would represent approximately 20–40% of the spills resulting from ongoing OCS activities and planned future sales in the Beaufort Sea and Chukchi Sea Planning Areas (Table 4.6.1-4). Most of these spills (1,350–1,950) would be small (less than 50 bbl), as under the Program. Spills in shallow water, primarily those from vessel accidents and pipelines, would be most likely to affect coastal wetlands, whereas deepwater spills, such as those from platforms, would be less likely to impact wetlands. Spills from onshore pipelines and facilities could impact freshwater wetlands or tidal wetlands if carried to coastal habitats by streams. Non-OCS activities such as State oil and gas development, the domestic transportation of oil or refined petroleum products, the production and storage of petroleum products, and commercial shipping (and other marine vessel traffic) may also result in accidental spills that could potentially impact wetlands. Naturally occurring seeps may also be a source of crude oil that could potentially affect coastal wetlands. The amount of oil contacting wetlands, the magnitude of resulting impacts, and the length of time for recovery would depend on a number of factors such as the location and size of the spill, containment actions, waves and water currents, type of oil, types of remediation efforts, amount of oil deposition, duration of exposure, season, substrate type, and extent of substrate penetration. Impacts from oil spills would be expected to range from short-term effects on vegetation growth to extensive mortality. Recovery of affected wetlands could require several decades. The impacts of potential oil spills associated with the Program would be expected to constitute a small addition to the impacts of all other sources of oil in the Arctic region.

Global climate change could result in indirect effects on coastal wetlands. Potential thermal expansion of ocean water and melting of glaciers could result in a global rise in mean sea level (Section 4.6.1.6). Sea-level rise would result in greater inundation of coastal wetlands, and likely result in conversion of wetlands to open water. In addition, large changes in river flows into nearshore marine waters could affect salinity and water circulation in estuaries, which, in turn, could impact estuarine wetland communities.

Conclusion. Future OCS program and ongoing and future non-OCS program activities in combination with naturally occurring events have resulted in losses of coastal habitats in the Arctic region; cumulative impacts on these resources, therefore, are considered to be moderate to major. Operations under the Program would result in small localized impacts, primarily due to facility construction, pipeline landfalls, channel dredging, and vessel traffic; however, the incremental contribution of routine Program activities to cumulative impacts would be small to medium (see Section 4.4.6.1.3).

The cumulative impacts of past, present, and future oil spills on coastal and estuarine habitats would be moderate. The incremental impacts of expected accidental oil spills associated with the Program on these resources would be negligible to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to particular habitats; and the timing and nature of spill containment and cleanup activities (see Section 4.4.6.1.3). The majority of these spills would be small (less than 50 bbl) and most of them would not likely contact and affect coastal and estuarine habitats. Impacts associated with large oil spills (1,000 bbl or greater) or an unexpected, low-probability CDE have the greatest potential to affect extensive areas of shoreline and coastal habitats. Although these are rare events, the impacts of such releases on coastal habitats could range from moderate to major if they were to occur.

4.6.3.3.2 Marine Benthic and Pelagic Habitats. Sections 4.4.6.2.3 and 4.4.6.3.3 discuss direct and indirect impacts on marine benthic and pelagic habitats in the Arctic region resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on these resources result from the incremental impacts of the Program (described in Sections 4.4.6.2.3 and 4.4.6.3.3), when added to impacts from ongoing and reasonably foreseeable future actions, including those of ongoing and future OCS programs and other non-OCS activities. Table 4.6.1-3 presents the exploration and development scenario for the Arctic region cumulative case, which takes into account activities associated with the Program in combination with those from ongoing and future OCS programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in the Arctic are summarized in Table 4.6.1-7 and discussed below.

Cumulative impact-producing factors for marine benthic and pelagic habitats in Beaufort Sea and Chukchi Sea Planning Areas include those from both OCS and non-OCS activities. Potential impacts on marine benthic and pelagic habitat resulting from future routine OCS program activities, including those of the Program, could result from noise (vessel, seismic surveys, construction, operations), well drilling, pipeline placement (trenching, landfalls, and construction), discharges (drilling, vessel and platform), and platform placement (anchoring, mooring, and removal). All these activities have the potential to adversely affect marine benthic and pelagic habitats in the Beaufort Sea and Chukchi Sea Planning Areas. Accidental oil spills are also counted among OCS program-related activities; assumptions for oil spills under the cumulative case scenario are provided in Table 4.6.1-4, and catastrophic spill assumptions are provided in Table 4.4.2-2.

Potential environmental impacts associated with the building and operation of OCS facilities such as platforms, subsea wells, artificial islands, and pipelines would increase in conjunction with the increased number of wells (approximately 9 ha [22 ac] for artificial islands versus less than 1.5 ha [3.7 ac] for platforms) and complete burial of existing substrates during construction. Under the cumulative scenario, it is anticipated that up to 1,450 production wells, up to 26 oil platforms, and up to 922 km (573 mi) of new offshore pipeline would be constructed in the Beaufort Sea and Chukchi Sea Planning Areas. Bottom substrates would be significantly altered by the construction of artificial islands. Marine benthic and pelagic habitats would be affected by bottom disturbance, by temporary increases in turbidity, and by deposition of disturbed sediment. Construction of artificial islands would result in a more complete loss of benthic habitat, due to larger footprints. Bottom disturbance degrades water quality by increasing water turbidity in the vicinity of the operations and adding contaminants to the water column. It also changes sediment composition as suspended sediments (and contaminants, if present) are entrained in currents and deposited in new locations. Construction of platforms and artificial islands in areas previously lacking hard substrate could have localized effects on the biodiversity and distribution of benthic communities by favoring organisms that prefer a hard substrate. Impacts of OCS routine operations (exploration, production and decommissioning activities) on marine benthic and pelagic habitat in the Beaufort Sea and Chukchi Sea Planning Areas are discussed in detail in Sections 4.4.6.2.3 and 4.4.6.3.3. Regulations and mitigating measures would preclude construction of platforms or artificial islands and placements of pipelines or wells in environmentally sensitive areas, such as the Stefansson Sound Boulder Patch in the Beaufort Sea (Section 4.4.6.2.3). Overall, routine operations represent a negligible to moderate long-term disturbance, with the severity of the impacts generally decreasing dramatically with distance from the well site.

The increased amount of drilling anticipated under the Program will result in OCS discharges of drill muds and cuttings from exploration and delineation wells. Deposition of drilling fluids and cuttings could potentially affect benthic and pelagic habitat by increasing turbidity and altering grain size distributions and chemical characteristics of sediments. The impacts of drilling discharges on benthic and pelagic habitats are discussed in detail in Sections 4.4.6.2.3 and 4.4.6.3.3.

Along with future OCS activities, various ongoing and future non-OCS activities, including oil and gas activities in State waters, commercial shipping (including tankers), dredging and disposal of dredging spoils in OCS waters, and anchoring could contribute to cumulative effects on pelagic and seafloor habitats in the Beaufort Sea and Chukchi Sea Planning Areas. Drilling of wells and oil and gas activities in State waters could also require construction of artificial islands, platforms, and pipelines in waters of Alaska. Effects on seafloor and pelagic habitat and biota would be similar to those described above for OCS oil and gas programs (Sections 4.4.6.2.3 and 4.4.6.3.3). Dredging operations in conjunction with ship channel maintenance and construction, pipeline placement and burial, and support facility access occur throughout the Beaufort Sea and Chukchi Sea Planning Areas as part of non-OCS activities. Dredging and marine disposal activities would involve excavation of nearshore sediments and subsequent disposal in offshore or nearshore areas and could cause temporary turbidity in the water column and smothering of sessile animals in the vicinity of the activity. Anchoring of non-OCS activity vessels on these features could cause significant chronic disturbance to benthic and bottom water habitat and biota. The amount of damage that could result from anchoring activity would depend upon vessel size, the size of the anchor and chain, sea conditions at the time of anchoring, and the location or position of the anchor on the feature. Benthic habitat disturbances from OCS activities (e.g., pipeline trenching and placement and platform placement) would add to the existing impacts to benthic habitat from these non-OCS sediment-disturbing activities. The effects of dredging, anchoring, and trawling activities on marine benthic and pelagic habitats are expected to be similar to those described for the installation of pipelines (Sections 4.4.6.2.2 and 4.4.6.3.2). Impacts on pelagic habitat would be localized and temporary, with recovery time depending upon the nature of the habitat and severity of the damage.

Climate change is expected to have multiple effects on the Beaufort Sea and Chukchi Sea Planning Areas that could impact benthic and pelagic habitat. Increased river discharge could alter the salinity, temperature, and turbidity regimes in nearshore areas (Hopcroft et al. 2008). Several rivers flow into the Beaufort shelf, and this region may be more heavily affected than the western Chukchi shelf. The increase in total suspended solids due to coastal erosion and the greater riverine sediment loading could increase turbidity in the water column and consequently decrease the penetration of photosynthetically active radiation available for kelp production (Hopcroft et al. 2008).

Climate change is expected to decrease the spatial extent and temporal duration of sea ice and make the ice thinner. Several possible consequences could result, including:

- Reduction in the spatial and temporal extent of subtidal and intertidal benthic scouring, but an increase in wave generated subtidal and intertidal disturbance;

- An increase in the sloughing of sediments from shoreline during storms, adding to the sediment loads and changing water chemistry in nearshore areas;

- An overall increase in biological productivity in the open water with increasing temperature and ice retreat and a shift to a pelagic-based rather than a benthic-based food web (Hopcroft et al. 2008); and

- Reduction in the amount and seasonal availability of sea ice algae.

In addition, ocean acidification from increasing CO_2 inputs into the ocean is also predicted to continue in Arctic waters, which may reduce the availability of calcite and aragonite to calcifying marine organisms in the sediment and water column.

Oil spills from both OCS and non-OCS activities could affect benthic and pelagic habitat in the Beaufort Sea and Chukchi Sea Planning Areas. The total number of oil spills and the extent of affected seafloor habitat would likely increase under the cumulative scenario, in conjunction with increased levels of petroleum exploration and production. Accidental hydrocarbon releases can occur at the surface from tankers or platforms or at the seafloor from the wellhead or pipelines. The total number of oil spills and the extent of affected seafloor habitat would likely increase under the cumulative scenario, in conjunction with increased levels of petroleum exploration and production. Non-OCS activities, such as oil and gas development in State waters and domestic transportation of oil, may also result in accidental spills that could affect benthic and pelagic habitats within the Beaufort Sea and Chukchi Sea Planning Areas.

For both OCS and non-OCS oil spills, it is assumed the magnitude and severity of potential impacts on benthic and pelagic habitat would be a function of the location (including habitats affected), timing, duration, and size of the spill and containment and cleanup activities. It is anticipated that most small to medium spills would have limited effects because of the relatively small areas likely to be exposed to high concentrations of hydrocarbons and the short period of time during which potentially toxic concentrations would be present. However, oil spilled during periods of ice cover could persist months or years trapped in or under the ice until the ice melted. Oil could also be transported within the ice to areas far from the spill. Oil spills would likely have the greatest impacts on benthic habitat and communities in shallow subtidal waters and in intertidal areas. Although pelagic habitat is likely to recover following an oil spill, the recovery time for intertidal and shallow subtidal benthic habitat directly affected by oil spills could be long term. If a large amount of oil from a spill were to sink and inundate sensitive boulder communities, the recovery of sensitive species could be long term (Section 4.4.6.2.3). Detailed discussion of the impacts of accidental hydrocarbon releases on marine benthic and pelagic habitat potentially resulting from the Program in the Beaufort Sea and Chukchi Sea Planning Areas can be found in Sections 4.4.6.2.3 and 4.4.6.3.3.

Conclusion. Impact-producing factors for marine benthic and pelagic habitats include those from both OCS and non-OCS activities. Ongoing and future non-OCS activities with the potential to impact marine benthic and pelagic habitats in the Beaufort Sea and Chukchi Sea Planning Areas include oil and gas production in State waters, sediment dredging and disposal, and vessel traffic. Disturbances from these activities including noise, vessel discharges, and bottom disturbance would occur in addition to similar impacts from OCS activities. For OCS activities, planning and permitting procedures would minimize the potential for direct impacts on sensitive boulder habitats during routine OCS activities. Overall, the cumulative impacts on benthic and marine habitats would be moderate to major, considering ongoing and future OCS and non-OCS activities. The incremental contribution of routine Program activities to these impacts would be negligible to medium (see Section 4.4.6.2.3).

Accidental oil spills could result from both OCS and non-OCS activities. Overall, the cumulative impacts on marine habitats from oil spills would range from minor to moderate. The incremental impacts of expected oil spills, most of which would be small (less than 1,000 bbl), would range from negligible to small, depending on the location, timing, duration, and size of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities (Section 4.4.6.3.2). Spills in deeper water, whether from OCS or non-OCS sources, are unlikely to have overall community-level effects on seafloor habitats because of the relatively small proportion of seafloor area that would come in contact with released oil at concentrations great enough to elicit toxic effects. Impacts associated with an unexpected, low-probability CDEs affecting shallow and intertidal habitats could be minor to moderate, depending on the habitats affected. Although pelagic habitat is likely to recover following a CDE, the recovery time for intertidal and shallow subtidal benthic habitat directly affected by such oil spills could be long term.

Oil spills could result from both OCS and non-OCS activities. The impacts of accidental oil spills associated with the Program on these resources would be negligible to moderate, depending on the location, timing, duration, and size of spills; the proximity of spills to particular seafloor habitats; and the timing and nature of spill containment and cleanup activities (see Section 4.4.6.2.3). Spills in deeper water, whether from OCS or non-OCS sources, are unlikely to have overall community-level effects on seafloor habitats because of the relatively small proportion of seafloor area that would come in contact with released oil at concentrations great enough to elicit toxic effects. Catastrophic oil releases that affect shallow and intertidal habitats have the potential to be of greatest significance. Although pelagic habitat is likely to recover following an oil spill, the recovery time for intertidal and shallow subtidal benthic habitat directly affected by oil spills could be long term. The incremental contribution of accidental oil spills associated with the Program would range from small to medium.

4.6.3.3.3 Essential Fish Habitat. Section 4.4.6.4.3 discusses direct and indirect impacts on EFH in the Arctic region resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on these resources result from the incremental impacts of the Program (described in Section 4.4.6.4.3) when added to impacts from ongoing and reasonably foreseeable future actions, including those of ongoing and future OCS programs and other non-OCS activities. Table 4.6.1-2 presents the exploration and development scenario for the Arctic region cumulative case, which takes into account activities associated with the Program in combination with those from ongoing and future OCS programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in the Arctic are summarized in Table 4.6.2-7 and discussed below.

Cumulative impacts on EFH could result from future OCS and ongoing and future non-OCS activities that have the potential to directly kill managed fish species, disturb ocean bottom habitats, increase sediment suspension, degrade water quality, or affect the food supply for fishery resources (there are only offshore exploratory drilling and seismic studies in Beaufort and Chukchi Seas). Future OCS activities (resulting from the Program) include seismic surveys (noise), well drilling, pipeline placement (trenching, landfalls, and construction), subsea production well and platform placement (anchoring, mooring, and removal), and routine discharges (drilling, platform, and vessel). Accidental oil spills are also counted among OCS and non-OCS activities.

Under the cumulative scenario it is anticipated that up to 1,450 production wells, up to 26 oil platforms, and up to 922 km (573 mi) of new offshore pipeline would be constructed in the Beaufort Sea and Chukchi Sea Planning Areas over the period of the Program. Drilling muds and cuttings from exploration wells would also be released in to OCS waters.

Overall, it is expected that the impacts of exploration and site development activities on marine EFH would be moderate, and impacts are not expected to permanently reduce the EFH available to managed species or result in population-level impacts on managed species. The most sensitive benthic habitats, such as those associated with hard-bottoms and kelp communities, are not expected to be affected by routine operations since impacts would be minimized or eliminated by existing protections. Although construction of platforms, artificial islands, and pipelines would all disturb bottom habitats to some degree, artificial islands (Beaufort and Chukchi Seas only) would result in a more complete loss of benthic habitat due to larger footprints (approximately 9 ha [22 ac] for artificial islands versus less than 1.5 ha [3.7 ac] for platforms) and complete burial of existing substrate. Deposition of drilling muds and cuttings could potentially affect EFH by altering sediment characteristics such that benthic prey of some managed fish species, certain stages of the managed species themselves, or water quality in offshore areas would be affected in the immediate area surrounding drill sites. See Section 4.4.6.4.3 for a detailed discussion of the impacts of routine operations on EFH and managed species in the Arctic.

Ongoing and future non-OCS activities, such as subsistence fishing, commercial shipping (including tankers and other marine vessels), coastal modifications, hardrock mining, dredging and disposal of dredging spoils in OCS waters, and anchoring could contribute to cumulative effects on pelagic and seafloor EFH in the Beaufort Sea and Chukchi Sea Planning Areas. Commercial fishing does not occur in the Beaufort Sea and Chukchi Sea Planning Areas and sportfishing is minor in the Arctic region, but could increase if regulations change and if warming temperatures allow an increase in vessel traffic. Impacts from these non-OCS activities including noise, vessel discharges, and bottom disturbance would occur in addition to similar impacts from OCS activities. Many of these activities would result in bottom disturbance that would affect bottom dwelling fishes as well as their food sources in a manner similar to those described for OCS activities (MMS 2008b; ADEC 2007a; Section 4.4.7.3.3).

EFH and managed species in the Beaufort and Chukchi Seas fall in the Kotzebue Sound and Northern Subsistence fishing areas (http://www.adfg.alaska.gov/index.cfm?adfg=subsistence.main). Subsistence fishing may contribute to the cumulative effects on the abundance of some fishery resources. Alaska State law defines subsistence as the "noncommercial customary and traditional uses" of fish and wildlife. The Alaska Department of Fish and Game defines subsistence fishing to include "the taking of, fishing for, or possession of fish, shellfish, or other fisheries resources by a resident of the State for subsistence uses with gill net, seine, fish wheel, long line, or other means defined by the Board of Fisheries." These fishing methods have more limited impacts on EFH compared to commercial fishing methods. In addition, subsistence fishing is subject to harvest limits that reduce the potential for overfishing. Consequently, subsistence fishing makes a relatively minor contribution to the reduction in fish stocks.

Cumulative impacts on anadromous or diadromous managed species could also occur as a result of activities that obstruct fish movement in marine environments during migration periods. For example, some structures along the Beaufort Sea mainland (e.g., the West Dock) have been shown to block the movements of diadromous fishes, particularly juveniles, under certain meteorological conditions (Fechhelm 1999; Fechelm et al. 1999). Causeways such as the 40 m (131 ft) wide and 60 m (197 ft) long structure associated with the Red Dog Mine may impede coastal movement either by directly blocking fish or by modifying nearshore water conditions to the point where they might become too cold and saline for some species (Fechhelm et al. 1999). Although the presence of causeways has been an issue associated with oil and gas development activities in the Beaufort Sea, the small size of the Red Dog causeway would likely have little effect on the coastal movements and distributions of Chukchi Sea fishes and shellfishes. However, it is anticipated that proper placement and design considerations for future causeway construction along the North Slope would alleviate the potential for such effects on fish movement.

There are several contaminant sources in the Beaufort Sea and Chukchi Sea Planning Areas. The Red Dog Mine in Alaska is the largest lead and zinc mine in the world, and is presently the only base-metal lode mine operating in northwest Alaska. A study for the National Park Service (Hasselbach et al. 2004) showed extensive airborne transport of cadmium and lead from Red Dog Mine; although the study was focused only on the limits of the Cape Krusenstern National Monument, these contaminants are probably carried out into the Chukchi Sea. There are also natural sources of metals and hydrocarbons. Sediments, peats, and soils from the Sagavanirktok, Kuparuk, and Colville Rivers are the largest source of dissolved and particulate metals and saturated and polycyclic aromatic hydrocarbons in the development area. However, concentrations of these contaminants in fish sampled in the Arctic planning areas are typically at background levels (Neff & Associates, LLC 2010).

There are also State oil and gas activities that can affect EFH in the Beaufort and Chukchi Seas. Factors that could affect EFH from these activities would be similar to those described above for OCS activities including underwater noise, habitat loss and disturbance, seismic survey and exploratory drilling, as well as other ancillary activities. However, the effects from non-OCS oil and gas activities could possibly be more severe than the effects from routine OCS activities because the activities are closer to shore and in shallower environments. As a consequence, more benthic EFH may be damaged, and resulting changes in sedimentation and turbidity could affect a greater proportion of the water column.

Freshwater areas used by salmon and other anadromous fish are considered to be EFH and could be affected by nearshore OCS and non-OCS oil and gas activities such as pipeline dredging or by onshore pipelines that cross bodies of water, especially streams. The primary effects of pipeline crossings would be increasing turbidity and sedimentation of the benthic environment during construction and blocking migration of anadromous fish following construction. Any pipeline route would be required to comply with various Alaska Coastal Management Program policies. As a consequence, crossings of anadromous fish streams would be minimized and consolidated with other utility and road crossings of such streams. In addition, onshore pipelines would be designed, constructed, and maintained to reduce risks to fish habitats from a spill, pipeline break, or construction activities.

See individual sections on water quality, coastal habitats, and marine and pelagic habitats for a discussion of the effects of climate change on EFH in the Beaufort Sea and Chukchi Sea Planning Areas. As a heavily river-influenced system, increased river discharge could alter the salinity, temperature, and turbidity regimes in nearshore areas (Hopcroft et al. 2008). Climate change is also expected to decrease the spatial extent and temporal duration of sea ice as well as make the ice thinner, an overall increase in biological productivity in the open water, and a shift to a pelagic-based rather than a benthic-based food web (Hopcroft et al. 2008). In addition, ocean acidification may reduce the availability of calcite and aragonite to marine organisms.

The total number of oil spills and the extent of affected EFH areas would likely increase under the Program in conjunction with increased levels of petroleum exploration and production. See Table 4.6.1-4 for oil spill assumptions for Alaska. Non-OCS activities, such as oil and gas development in State waters, domestic transportation of oil, and commercial shipping (and other marine vessel traffic), may also result in accidental spills that could potentially impact fish resources within the Arctic. While effects on EFH resources would depend on the timing, location, and magnitude of specific oil spills, it is anticipated that most small to medium spills that occur in OCS waters would have limited effects on EFH, due to the relatively small areas likely to be exposed to high concentrations of hydrocarbons and the short period of time during which potentially toxic concentrations would be present. Large or catastrophic spills could result in long-term impacts to EFH habitat quality and managed species populations. See Section 4.4.6.4 for a detailed discussion of the impact of oil spills on EFH.

Arctic fishes could also be susceptible to adverse effects of oil spills (see Section 4.4.6.4.2). Most offshore spills would be small and likely have little effect on overall populations, since the areas with significant hydrocarbon concentrations would be localized relative to the broad distributions of most marine and anadromous fishes of the Beaufort and Chukchi Seas. However, population level effect could occur if large amounts of oil from a catastrophic spill were to reach shallow subtidal and intertidal sediments. Some anadromous species of the Alaskan North Slope could be at greater risk because of their unique life-history cycles. Juveniles of some species of whitefish (including broad whitefish, humpback whitefish, and least cisco) are intolerant of highly saline marine conditions. During their summer feeding dispersals in the Beaufort Sea, these species tend to remain within a narrow band of warm, low-salinity water along the coast. Offshore barrier islands offer additional protection by helping to maintain low-salinity corridors. Thus, unlike most subarctic fishes, whitefish along the North Slope have a reduced capacity to bypass localized disruptions to their migration corridor by moving offshore and around the impasse. An oil spill, even one of limited area, could block the narrow nearshore corridor and prevent fishes from either dispersing along the coast to feed or returning to their overwintering grounds in rivers of the North Slope. If a spill were localized in the sensitive nearshore zone, its location would also make it more amenable to cleanup by environmental response teams. There is no tanker traffic on the North Slope, which eliminates the possibility of a collision spill in that area.

Oil from spills occurring under the ice in the Beaufort and Chukchi Seas could remain trapped there throughout the winter unless removed, which, while difficult, could be done. Water quality would be negatively affected, and overwintering eggs, larvae, and invertebrate prey would likely be killed in affected areas. Surface spills occurring in the summer months would temporarily reduce EFH for surface-dwelling eggs, larvae, and pelagic prey species. Oil reaching nearshore areas could travel short distances upriver in anadromous fish streams as a result of tidal water movements, and some oil could become trapped in the interstitial spaces of the sediments. In such cases, EFH for salmon eggs and larvae could be affected. See Section 4.4.3.3 for a detailed discussion of accidental oil spills in ice and ice-free conditions.

Conclusion. Impact-producing factors for EFH include those from both OCS and non-OCS activities. Non-OCS activities with a potential to impact EFH in the Beaufort Sea and Chukchi Sea Planning Areas include oil and gas production in State waters, sediment dredging and disposal, and vessel traffic. Impacts from OCS activities would be limited by specific lease stipulations. Overall, the cumulative impacts on EFH would be moderate to major, considering ongoing and future OCS and non-OCS activities. The incremental contribution of routine Program activities to these impacts would be negligible to medium (see Section 4.4.6.3.3).

Accidental releases of oil and gas from OCS and non-OCS activities could also have effects on EFH. The incremental contribution of accidental spills associated with the Program on EFH would be negligible to medium, depending on the location, timing, duration, and size of spills; the proximity of spills to particular fish habitats; and the timing and nature of spill containment and cleanup activities (see Section 4.4.6.3.2). While most accidents related to OCS activities assumed under the cumulative spill scenario would be small and would have relatively minor incremental impacts on EFH, oil that reaches coastal wetlands could have more persistent impacts and could require remediation. Spills in deeper water, whether from OCS or non-OCS sources, are unlikely to have overall population-level effects on fish resources because of the relatively small proportion of similar available fish habitats that would come in contact with released oil at concentrations great enough to elicit toxic effects. Oil spills that have the greatest potential to impact EFH and managed species are those that occur in shallower subtidal and intertidal areas and spills that reach areas at the same time substantial numbers of eggs or larvae of managed species are present. Impacts associated with an unexpected, low-probability CDE affecting shallow and intertidal habitats could be moderate to major, depending on the size, duration, timing, and location of the spill.

4.6.3.4 Summary for Gulf of Mexico Region

4.6.3.4.1 Coastal and Estuarine Habitats. Cumulative impacts on barrier beaches and dunes result from factors that reduce sediment input to downdrift areas and increase erosion of beach and dune sands. Past actions such as channelization and diversion of Mississippi River flows (through dams and reservoirs) and beach stabilization projects (using groins, jetties, and seawalls) have contributed to sediment deprivation and submergence of coastal lands, particularly along the Louisiana coast, and are expected to continue into the foreseeable future. Ongoing and future actions/trends that affect barrier beaches and dunes include those related to oil and gas development in State and OCS waters, coastal development (onshore industry and wastewater discharge), vessel traffic, recreation, and climate change. Cumulative impacts on barrier beaches and dunes in the GOM are considered to be moderate to major.

Cumulative impacts on wetlands result from direct elimination of wetland habitat by excavation or filling, reduction of sediment inputs, erosion of wetland substrates, and degradation of wetland communities (by reduced water quality or hydrologic changes). Construction of canals or pipelines may require filling or excavating of wetlands. Other projects may reduce the sediment delivered to coastal wetlands from inflowing rivers. Losses of coastal wetlands have been occurring along the GOM coast for decades (especially in Louisiana) and are expected to continue into the foreseeable future. Many factors contribute to coastal land loss, including the effects of large storm events, subsidence, sea level rise, saltwater intrusion, drainage and development, canal construction, and reduced flooding. Upstream alterations of the Mississippi River drainage system are also important factors because construction of dams on upstream tributaries has reduced the sediment loads to the GOM by as much as 50%. Ongoing and future actions/trends that affect wetlands include those related to oil and gas development in State and OCS waters, coastal development (onshore industry and wastewater discharge), vessel traffic, dredging operations, and climate change. In addition, a number of coastal habitat protection and restoration projects have been initiated along the GOM coast to address erosion and land loss. Cumulative impacts on coastal wetlands in the GOM are considered to be moderate to major.

Seagrass beds grow in shallow, relatively clear and protected waters with predominantly sand bottoms; they are uncommon where freshwater inflow is high and salinities average less than 20 ppt. Most seagrass beds are in the Eastern GOM, where there are no past or present OCS activities and none proposed as part of the Program. Seagrass beds are found only within a few scattered, protected locations in the Western and Central GOM, although seagrass meadows occur in nearly all bay systems along the Texas coast. The distribution of seagrass beds in coastal waters of Western and Central GOM has diminished in recent decades, possibly due to high turbidity caused by increased marine vessel traffic. Ongoing and future actions/trends that affect seagrass habitats include onshore development, commercial and recreational fishing (trawling and anchoring), vessel traffic (anchoring), recreation (diving), and climate change. Cumulative impacts on seagrass beds in the GOM are considered to be moderate to major.

Routine operations under the Program in the GOM would result in minor localized impacts primarily due to facility construction, pipeline trenching and landfalls, channel dredging, and marine vessel traffic. The contribution of the Program to cumulative impacts therefore would generally be small to medium. The effects of expected accidental oil spills on coastal and estuarine habitats could be negligible to large, depending on the location, timing, duration, and size of the spill, and the timing and nature of spill containment and cleanup activities. Most expected oil spills are small (less than 50 bbl) and would not likely contact and affect coastal and estuarine habitats. Impacts associated with large oil spills (1,000 bbl or greater) or an unexpected, low-probability CDE that occur in or reach shallower nearshore areas have the greatest potential to affect extensive areas of shoreline and coastal and estuarine habitats. Although these are rare events, the impacts of such releases on coastal and estuarine habitats could range from moderate to major if they were to occur.

4.6.3.4.2 Marine Benthic and Pelagic Habitats. Cumulative impacts on marine benthic and pelagic habitats in the GOM result from any activities that disturb ocean bottom or marine habitats, increase sediment suspension (turbidity), degrade water quality, or affect the food supply of biota living in these habitats. Ongoing and future actions/trends that affect these resources include oil and gas activities in State waters, commercial shipping (including tankers), dredging and disposal of dredging spoils in OCS waters, and anchoring. Ongoing and future State and OCS oil and gas activities could also affect seafloor and pelagic habitats; these activities include marine vessel traffic, seismic surveys, and construction (all noise-producing activities), well drilling, pipeline placement (trenching, landfalls, and construction), platform placement (anchoring, mooring, and removal, except in deep waters), and routine discharges (drilling, production, platform, and vessel). Accidental oil spills are included among these actions. Cumulative impacts on benthic and pelagic habitats in the GOM are considered to be moderate to major.

Routine operations under the Program in the GOM could result in mainly temporary and localized impacts from ground disturbance during drilling and pipeline and platform placement, as well as the discharge of drilling muds and cuttings and produced water (sensitive habitats could have long term affects depending on their proximity to these activities). The incremental contribution to cumulative impacts on marine benthic habitats could range from negligible to medium and would be limited by existing mitigation measures. The incremental impacts of expected accidental oil spills on benthic habitats (most of which are less than 1,000 bbl) could range from negligible to small, depending on the size, duration, timing, and location of the spill, and the nature (i.e., sensitivity) of the benthic habitat contacted by oil. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and could result in minor to moderate impacts if they were to occur. Major impacts to coral reef habitats could occur if the Flower Gardens Banks are heavily oiled and high mortality occurs.

4.6.3.4.3 Essential Fish Habitat. Cumulative impacts on EFH in the GOM result from any activities that kill managed fish species, disturb ocean bottom habitats, increase sediment suspension (turbidity), degrade water quality, or affect the food supply for fishery resources. Ongoing and future actions/trends that affect these resources include commercial fishing, commercial shipping (and other marine vessel traffic), land development, water quality degradation, dredge/fill and disposal operations, the construction of channel stabilization structures such as jetties, and climate change. Ongoing and future State and OCS oil and gas activities affect EFH; these include the generation of noise, well drilling, pipeline placement, subsea production well and platform placement, and routine discharges. Accidental oil spills are also among these actions. Cumulative impacts on EFH in the GOM are considered to be moderate to major.

Routine operations under the Program in the GOM could result in moderate short- and long-term impacts to EFH and managed species, mainly as a result of bottom disturbance and the creation of artificial reefs by production platforms. The incremental contribution to cumulative impacts on EFH could be negligible to medium and would be limited by specific lease stipulations. The incremental impacts of expected accidental oil spills on EFH (most of which are less than 1,000 bbl) would range from negligible to small, depending on the size of the spill, its location, environmental factors, and the uniqueness of the affected EFH. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and could result in minor to moderate impacts if they were to occur.

4.6.3.5 Summary for Alaska – Cook Inlet

4.6.3.5.1 Coastal and Estuarine Habitats. Sensitive shoreline habitats in the lower Cook Inlet include marshes, sheltered tidal flats, sheltered rocky shores, and exposed tidal flats. Coastal habitats along Cook Inlet are influenced by dynamic tidal currents. Cumulative impacts on coastal and estuarine habitats result from the loss of beach and wetland habitat in Cook Inlet. While there are no past or ongoing OCS activities in the Cook Inlet Planning Area, other ongoing and future actions/trends that affect these resources include those related to State oil and gas development, commercial shipping (and other marine vessel traffic), coastal development, discharge of municipal wastes and other effluents, domestic transportation of oil and gas, logging, and climate change. These activities can be reasonably expected to continue into the future. Cumulative impacts on coastal and estuarine habitats in Cook Inlet are considered to be moderate.

Routine operations under the Program in Cook Inlet would result in minor localized impacts, primarily due to pipeline, road, and onshore facility construction, and marine vessel traffic. The contribution of the Program to cumulative impacts therefore would generally be negligible to medium. The effects of accidental oil spills on coastal and estuarine habitats could be negligible to medium, and depending on the location, timing, duration, and size of the spill, and the timing and nature of spill containment and cleanup activities. Most expected oil spills are small (less than 50 bbl) and would not likely contact and affect coastal and estuarine habitats. Impacts associated with large oil spills (1,000 bbl or greater) or an unexpected, low-probability CDE that occur in or reach shallower nearshore areas have the greatest potential to affect extensive areas of shoreline and coastal and estuarine habitats. Although these are rare events, the impacts of such releases on coastal and estuarine habitats could range from moderate to major if they were to occur.

4.6.3.5.2 Marine Benthic and Pelagic Habitats. Cumulative impacts on marine benthic and pelagic habitats in Cook Inlet result from any activities that disturb ocean bottom or marine habitats, increase sediment suspension (turbidity), degrade water quality, or affect the food supply of biota living in these habitats. Ongoing and future actions/trends that affect these resources include oil and gas activities in State waters, commercial shipping (including tankers), dredging and disposal of dredging spoils in OCS waters, and anchoring. State oil and gas activities (in upper Cook Inlet) and future OCS activities could affect seafloor and pelagic habitats; these include the generation of noise, well drilling, pipeline placement, subsea production well and platform placement, and routine discharges. Accidental oil spills are also among these actions. Cumulative impacts on benthic and pelagic habitats in Cook Inlet are considered to be moderate to major.

Routine operations under the Program in Cook Inlet could result in negligible to moderate impacts from ground disturbance during drilling and pipeline and platform placement, as well as the discharge of drilling muds and cuttings and produced water. The incremental contribution to cumulative impacts on marine benthic habitats could range from negligible to medium and would be limited by existing mitigation measures. The incremental contribution to cumulative impacts on marine benthic habitats could range from negligible to medium and would be limited by existing mitigation measures. The incremental impacts of expected accidental oil spills on benthic habitats (most of which are less than 1,000 bbl) could range from negligible to small, depending on the size, duration, timing, and location of the spill, and the nature (i.e., sensitivity) of the benthic habitat contacted by oil. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and could result in minor to moderate impacts if they were to occur.

4.6.3.5.3 Essential Fish Habitat. Cumulative impacts on EFH in Cook Inlet result from any activities that kill managed fish species, disturb ocean bottom habitats, increase sediment suspension (turbidity), degrade water quality, or affect the food supply for fishery resources. Ongoing and future actions/trends that affect these resources include land use practices (e.g., logging), point and non-point source pollution, dredging and disposal operations, anchoring, fishing (commercial, subsistence, personal use, and sportfishing), and commercial shipping (including imported oil). Subsistence fishing is subject to harvest limits that reduce the potential for overfishing, and much of Cook Inlet is defined as a nonsubsistence area where subsistence fishing is not authorized. For this reason, the impacts related to subsistence are considered minor. State oil and gas activities (in upper Cook Inlet) and future OCS activities could affect EFH (there are no ongoing OCS activities in the inlet); these include the generation of noise, well drilling, pipeline placement, subsea production well and platform placement, and routine discharges. Accidental oil spills are also among these actions. Cumulative impacts on EFH in the Cook Inlet are considered to be minor to moderate.

Routine operations under the Program in Cook Inlet could result in moderate short- and long-term impacts to EFH and managed species, mainly as a result of bottom disturbance during the placement of pipelines and production platforms. The incremental contribution to cumulative impacts on EFH could be negligible to medium and would be limited by specific lease stipulations. The incremental impacts of expected accidental oil spills on EFH (most of which are less than 1,000 bbl) would range from negligible to small, depending on the size of the spill, its location, environmental factors, and the uniqueness of the affected EFH. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and could result in moderate to major impacts if they were to occur.

4.6.3.6 Summary for Alaska – Arctic

4.6.3.6.1 Coastal and Estuarine Habitats. Arctic coastal habitats are greatly influenced by a short growing season and extremely cold winters; onshore sediments are underlain by permanently frozen soil (permafrost). They are also greatly affected by the dynamics of sea ice, which dominates coastal habitats during most of the year. The Arctic coastline is highly disturbed due to the movement of sea ice that frequently is pushed onshore, scouring and scraping the coastline. The effects of climate change on Arctic habitats are also significant. These include decreases in sea ice cover, warming of permafrost, a longer growing season, and changes in precipitation. Portions of the coast have experienced considerable erosive losses (up to 457 m [1,500 ft]) over the past few decades; the erosion rate in areas of the Beaufort Sea coast more than doubled between 1955 and 2005. Projections for future climate change indicate that these changes are expected to continue.

Cumulative impacts on barrier beaches and dunes result from factors that increase erosion of beach and dunes, such as disturbance of dune vegetation or beach and dune substrates. Increases in wave action also contribute to the erosion of beaches. Accidental oil spills may also affect these resources. While there are no past or ongoing OCS activities in the Beaufort Sea and Chukchi Sea Planning Areas (other than exploratory drilling), other ongoing and future actions/trends that affect beaches and sand dunes include those related to State oil and gas development, commercial shipping (and other marine vessel traffic), coastal development, and climate change. These activities can be reasonably expected to continue into the future. Cumulative impacts on coastal and estuarine habitats in the Arctic region are considered to be moderate.

Routine operations under the Program in the Arctic region would result in minor localized impacts primarily due to pipeline, road, and onshore facility construction, and marine vessel traffic. The contribution of the Program to cumulative impacts therefore would generally be small to medium. The effects of expected accidental oil spills on coastal and estuarine habitats could be negligible to large, depending on the location, timing, duration, and size of the spill, and the timing and nature of spill containment and cleanup activities. Most expected oil spills are small (less than 50 bbl) and would not likely contact and affect coastal and estuarine habitats. Impacts associated with large oil spills (1,000 bbl or greater) or an unexpected, low-probability CDE, however, can affect extensive areas of shoreline and coastal and estuarine habitats. Although these are rare events, the impacts of such releases on coastal habitats could range from moderate to major if they were to occur.

4.6.3.6.2 Marine Benthic and Pelagic Habitats. Cumulative impacts on marine benthic and pelagic habitats in the Arctic region result from any activities that disturb ocean bottom or marine habitats, increase sediment suspension (turbidity), degrade water quality, or affect the food supply of biota living in these habitats. Ongoing and future actions/trends that affect these resources include oil and gas activities in State waters, commercial shipping (including tankers), dredging and disposal of dredging spoils in OCS waters, and anchoring. State oil and gas activities (especially along the Beaufort Sea coastline) and future OCS activities could affect seafloor and pelagic habitats; these activities include the generation of noise, well drilling, pipeline placement, subsea production well and platform placement, and routine discharges. Accidental oil spills are also among these actions. Cumulative impacts on benthic and pelagic habitats in the Arctic region are considered to be moderate to major.

Routine operations under the Program in the Arctic region could result in impacts from ground disturbance during drilling and pipeline and platform placement, as well as the discharge of drilling muds and cuttings and produced water (sensitive habitats could have long term affects depending on their proximity to these activities). The incremental contribution to cumulative impacts on marine benthic habitats could range from negligible to medium and would be limited by existing mitigation measures. The incremental impacts of expected accidental oil spills on benthic habitats (most of which are less than 1,000 bbl) would range from negligible to small, depending on the size, duration, timing, and location of the spill, and the nature (i.e., sensitivity) of the benthic habitat contacted by oil. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and could result in minor to moderate impacts if they were to occur.

4.6.3.6.3 Essential Fish Habitat. Cumulative impacts on EFH in the Arctic region result from any activities that kill managed fish species, disturb ocean bottom habitats, increase sediment suspension (turbidity), degrade water quality, or affect the food supply for fishery resources. Ongoing and future actions/trends that affect these resources include subsistence fishing, commercial shipping (including tankers and other marine vessels), coastal modifications, hardrock mining, dredging and disposal operations, anchoring, and climate change. Commercial fishing does not occur in the Beaufort Sea and Chukchi Sea Planning Areas. Sportfishing in the Arctic region is currently a minor activity, but could increase if regulations change and warming temperatures allow an increase in marine vessel traffic. State oil and gas activities (especially along the Beaufort Sea coastline) and future OCS activities could affect EFH; these activities include the generation of noise, well drilling, pipeline placement, subsea production well and platform placement, and routine discharges. Accidental oil spills are also among these actions. Cumulative impacts on EFH in the Arctic region are considered to be moderate to major.

Routine operations under the Program in the Arctic region could result in moderate short- and long-term impacts to EFH and managed species, mainly as a result of bottom disturbance during the placement of pipelines and production platforms. The incremental contribution to cumulative impacts on EFH could be negligible to medium and would be limited by specific lease stipulations. The incremental impacts of expected accidental oil spills on EFH (most of which are less than 1,000 bbl) would range from negligible to small, depending on the size of the spill, its location, environmental factors, and the uniqueness of the affected EFH. Large spills (1,000 bbl or greater) and unexpected CDEs would also depend on these factors, and could result in minor to moderate impacts if they were to occur.

4.6.4 Marine and Coastal Fauna

Previous BOEM/MMS NEPA documents for OCS lease sales have addressed cumulative impacts on marine and coastal fauna. Unless referenced otherwise, the following cumulative impacts discussion includes information provided in those NEPA documents prepared for the GOM (see http://www.gomr.boemre.gov/homepg/regulate/environ/nepa/nepaprocess.html) and for Alaska (see http://alaska.boemre.gov/ref/eis_ea.htm).

4.6.4.1 Gulf of Mexico Region

4.6.4.1.1 Mammals. Section 4.4.7.1.1 discusses direct and indirect impacts on marine and terrestrial mammals in the GOM region resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on these resources result from the incremental impacts of the Program (described in Section 4.4.6.1.1) when added to impacts from ongoing and reasonably foreseeable future actions, including those of ongoing and future OCS programs and other non-OCS activities. Table 4.6.1-2 presents the exploration and development scenario for the GOM cumulative case, which takes into account activities associated with the Program in combination with those from other ongoing and future OCS programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in the GOM are summarized in Table 4.6.1-5 and discussed below, as applicable.

Marine Mammals. The cumulative analysis considers past, ongoing, and foreseeable future human and natural activities that may occur and adversely affect marine mammals in the same general area. These activities include effects of the OCS Program (proposed action and prior and future OCS sales), oil and gas activities in State waters, commercial shipping, commercial fishing, recreational fishing and boating activities, military operations, scientific research, and natural phenomena. Specific types of impact-producing factors considered include noise from numerous sources, pollution, ingestion and entanglement in marine debris, vessel strikes, habitat degradation, military activities, industrial development, community development, climate change, and natural catastrophes. Section 4.4.7.1.1 provides the major impact-producing factors related to the Program.

Routine Activities.

OCS Activities. Marine mammals and their habitats in the GOM could be affected by a variety of exploration, development, and production activities as a result of the proposed and future OCS leasing actions (see Section 4.4.7.1.1). These activities include seismic exploration, offshore and onshore infrastructure construction, discharge of operational wastes, vessel and aircraft traffic, and explosive removal of platforms. Impacts on marine mammals from these activities may include physical injury or death; behavioral disturbances; lethal or sublethal toxic effects; and loss of reproductive, nursery, feeding, and resting habitats.

Potential impacts (primarily behavioral disturbance) on marine mammals from OCS-related seismic activity would be short term and temporary, and not expected to result in population level impacts for any affected species with implementation of appropriate mitigation measures.

Impacts from OCS construction and operation activities could include the temporary disturbance and displacement of individuals or groups by construction equipment and long-term disturbance of some individuals from operational noise. No long-term, population-level effects are expected because individuals most affected by these impacts would be those in the immediate vicinity of the construction site or operational platform and disturbance of individuals during construction would be largely temporary.

Operational and waste discharges (e.g., produced water, drilling muds, and drill cuttings) would be disposed of through downhole injection into NPDES-permitted disposal wells, and would not be expected to result in any incremental impacts on marine mammals. Liquid wastes (such as bilge water) may also be generated by OCS support vessels and on production platforms. While these wastes may be discharged (if permitted) into surface waters, they would be rapidly diluted and dispersed, and are expected to result in minor incremental impacts on marine mammals. Drilling and production wastes may contain materials such as metals and hydrocarbons, which can bioaccumulate through the food chain into the tissues of marine mammals. Although the bioaccumulation of anthropogenic chemicals has been reported for a variety of marine mammals, adverse impacts or population-level effects resulting from such bioaccumulation have not been demonstrated (Norstrom and Muir 1994; Muir et al. 1999).

Marine mammals could be temporarily disturbed by OCS vessel traffic (all species) or incur injury or death from collisions with support vessels (primarily larger, slower moving cetaceans). The addition of up to 1,900 OCS vessel trips per week under the Program could result in minor to moderate incremental impacts to marine mammals, be largely short term, and not result in population-level effects. Noise from helicopter overflights would be transient. Impacts on marine mammals would be behavioral in nature, primarily resulting in short-term disturbance in normal activities, and would not be expected to result in population-level effects. Appropriate mitigation measures could lessen the potential for incremental impacts from vessel and helicopter traffic.

There have been no documented losses of marine mammals resulting from explosive removals of offshore oil and gas structures, but there are sporadic incidents reported of marine mammals being killed by underwater detonations (Continental Shelf Associates 2004b; MMS 2007e, 2008a). Harassment of marine mammals as a result of a non-injurious physiological response to the explosion-generated shock wave as well as to the acoustic signature of the detonation is also possible. However, explosive platform removals would comply with BOEM guidelines and would not be expected to adversely affect marine mammals in the GOM.

All of the marine mammals in the GOM are potentially exposed to OCS-industrial activities (particularly noise) due to the rapid advance into the GOM deep oceanic waters by the oil and gas industry in recent years; whereas, over two decades ago, the confinement of industry to shallower coastal and continental shelf waters generally only exposed the bottlenose dolphin, Atlantic spotted dolphin, and West Indian manatee to industry activities and their related sounds. Industry noise sources include seismic operations, fixed platforms and drilling rigs, drilling ships, helicopters, vessel traffic, and explosive operations (particularly for structure removal).

<u>Non-OCS Activities.</u> A number of non-OCS activities such as State oil and gas exploration and development, commercial and recreational fishing, marine vessel traffic, industrial and municipal discharges, climate change, and invasive species could also affect marine mammals in the GOM.

Oil and Gas Exploration and Development in State Waters. Exploration, construction, and operation activities associated with State leases would occur in nearshore and coastal areas, while OCS platforms and pipelines would be located away from coastal areas (with the exception of relatively few pipeline landfalls and onshore bases and processing facilities). Thus, State oil and gas leasing activities may be expected to have a greater potential for affecting marine mammals in coastal habitats than would the proposed OCS actions. The marine mammal species most likely affected by State leases are the bottlenose dolphin, Atlantic spotted dolphin, and the West Indian manatee.

Commercial Fisheries. Commercial fisheries are an impacting factor for marine mammals in the GOM. These fisheries employ a variety of methods, such as longlines, seines, trawls, and traps, which can result in the entanglement, injury, and death of mammal mammals. For more than a decade, however, few human-induced mortalities or serious injuries of marine mammals due to commercial fishery interactions have occurred in the GOM. The following interactions with commercial fisheries were reported by Waring et al. (2010):

- In 2008, one mortality and two serious injuries of Risso's dolphins in the GOM related to entanglement interactions with the pelagic longline fishery.

- In 2008, there was one killer whale released alive after an entanglement incident with the pelagic longline fishery.

- In 1999, there was one reported stranding of a false killer whale that was likely caused by fishery interactions or other human-related causes evidenced by its fins and flukes having been amputated.

- From 1998 through 2007, there were no reported fishing-related mortalities of short-finned pilot whales in the GOM. However, one animal was released alive after an entanglement interaction with the pelagic longline fishery.

- From 1998 through 2007, there were no reported fishing-related mortalities of beaked whales in the GOM. However, during 2007, one unidentified beaked whale was released alive after an entanglement interaction with the pelagic longline fishery.

- From 1998 through 2008, there were no reported fishing-related mortalities of sperm whales in the GOM. However, one animal was released alive with no serious injuries after an entanglement interaction with the pelagic longline fishery.

- Some bottlenose dolphins have suffered mortalities associated with the shark bottom longline fishery, pelagic longline fishery, shrimp trawl fishery, blue and stone crab trap/pot fisheries, menhaden purse seine fishery, and gillnet fishery. Strandings of bottlenose dolphins have also occurred throughout the northern GOM from both human-caused and natural events. Human-caused strandings result from gear entanglement, mutilation, gunshot wounds, vessel strikes, contaminants, and ingestion of foreign objects.

- Fishery interactions likely caused the stranding of two Atlantic spotted dolphins in 2004.

- A stranded spinner dolphin had monofilament line around its tail and abrasions around its flukes as though it had been towed. It also had possible propeller marks.

Marine Vessel Traffic. There are a number of non-OCS activities that are occurring in the GOM that could result in collisions between marine mammals and ships. These activities include dredging and marine disposal, the domestic transportation of oil and gas, State oil and gas development, foreign crude oil imports, commercial shipping and recreational boating, commercial fisheries, and military training and testing activities. Vessel traffic associated with these activities may also disturb normal behaviors with unknown long-term consequences. With all of these activities, the GOM is one of the world's most concentrated shipping areas (USACE 2010). The GOM also supports an extensive commercial fishery, as well as recreational boating. Because of the very large number of vessels typically present in the GOM, the potential for vessel-marine mammal collisions is high, and may be expected to increase for the foreseeable future. The amount of OCS-related vessel traffic anticipated as a result of the Program is provided in Table 4.4.1-1.

Contaminants. There are a number of non-OCS facilities or activities that discharge wastes to GOM waters, and thus may expose marine mammals to potentially toxic materials or solid debris that they could become entangled in or ingest. These facilities or activities include sewage treatment plants, industrial manufacturing or processing facilities, electric generating plants, cargo and tanker shipping, cruise ships, commercial fishing, and recreational pleasure craft. In addition, the Mississippi River (and to a lesser extent, other rivers and streams that discharge to the northern GOM) discharges waters containing suspended sediments, fertilizers, herbicides, and urban runoff (Rabalais et al. 2001, 2002a). While marine mammals are exposed to a variety of contaminants from these discharges, little is known about the levels of contaminants at which lethal or sublethal effects may be incurred. These discharges may also affect habitat quality in the vicinity of the discharges.

The role of exposure to toxins to marine mammal mortality is unknown. Elevated levels of chemicals such as polychlorinated biphenyls (PCBs) and pesticides have been measured in individuals sampled from waters that receive municipal, industrial, and agricultural inputs and have high concentrations of contaminants (Waring et al. 2010; see discussion on bottlenose dolphins, GOM eastern coastal stock). There is little information, however, regarding the level at which tissue concentrations of contaminants may result in lethal or sublethal effects.

Climate Change. Marine mammal populations throughout the GOM may be adversely affected by climate change and, to a lesser extent, by hurricane events. There is growing evidence that climate change is occurring, and potential effects in the GOM may include a change (i.e., rise) in sea level or a change in water temperatures. Such changes could affect the distribution, availability, and quality of feeding habitats and the abundance of food resources. It is not possible at this time to identify the likelihood, direction, or magnitude of any changes in the environment of the GOM due to changes in the climate, making it also difficult, if not impossible, to speculate on the climate change impacts on marine mammals. Such information is not, however, essential to a reasoned choice among the alternatives in this PEIS (see Section 1.4.2). Climate change is occurring independently of OCS Program activity, and choosing any alternative presented herein will likely have little or no effect on the occurrence of climate change.

Natural Catastrophes. Severe storm events such as hurricanes may result in direct or indirect mortality of manatees and have the potential to impact their nearshore habitats (Langtimm and Beck 2003). Heightened wave action and intensity could alter nearshore channels affecting the abundance and distribution of shallow-water habitats such as lagoons and bays, while sediments deposited into foraging habitats by storm waves may alter the thermal environment and affect aquatic vegetation in feeding habitats. Because hurricanes are annual events that are an inherent component of the overall GOM ecosystem, it may be assumed that marine mammals of the GOM have experienced hurricane impacts in the past and may be expected to continue to experience future hurricane events.

Other Impacting Factors**.** Marine mammals may also be impacted by other factors such as unusual mortality events (UMEs) and invasive species. A UME is an unexpected stranding that involves a significant die-off of any marine mammal population, and demands immediate response (NMFS 2011b). Since establishment of the UME program in 1991 through December 2011, there have been 55 formally recognized UMEs in the U.S., with a third of them occurring in the GOM (NMFS 2011b). Species in the GOM most commonly involved in UMEs are bottlenose dolphins and manatees. An ongoing UME in the GOM is discussed in Section 3.8.1.1.1. Causes of UMEs have been determined for 26 of the UMEs, and include infections, biotoxins (particularly domoic acid and brevetoxin), human interactions, and malnutrition. Red tides in the GOM, caused by annual blooms of the dinoflagellate Karenia brevis, are the source of UMEs caused by biotoxins in the GOM (NMFS 2011b). Invasive species could affect some marine mammals by disrupting local ecosystems and fisheries of the GOM. As examples, the Australian jellyfish (Phylloriza punctata) introduced to the northern GOM may feed heavily on juvenile fish and fish eggs (Ray 2005), while exotic shrimp viruses may affect shrimp and other crustaceans such as copepods and crabs (Batelle 2001). These could affect the prey base for some marine mammals.

Accidents**.** Marine mammals could be exposed to oil accidentally released from platforms, pipelines, and vessels (Table 4.4.2-1). Potential non-OCS sources of oil spills in the GOM include the domestic transportation of oil, State oil and gas development, and natural sources such as oil seeps. Accidental oil releases from OCS activities and other sources could expose marine mammals to oil by direct contact or through the inhalation or ingestion of oil or tar deposits. The magnitude and duration of exposure will be a function of the location, timing, duration, and size of the spill; the proximity of the spill to feeding and other important habitats; the timing and nature of spill containment; and the status of the affected animals. Depending on their location, as well as the location of non-OCS oil sources, accidental spills associated with the Program could contribute to the overall exposure of marine mammals in the northern GOM. Most expected small to medium spills (less than 1,000 bbl) would have limited effects on marine mammals due to the relatively small areas likely to incur high concentrations of hydrocarbons and the short period of time during which potentially toxic concentrations would be present. The magnitude of impact would be expected to increase should a spill occur in habitats important to marine mammals or affect a number of individuals from a population listed under the ESA. However, some spills from OCS activity may locally represent the principal source of oil exposure for some species, especially for spills contacting important coastal and island habitats.

Cumulative impacts on marine mammals in the GOM as a result of ongoing and future OCS and non-OCS activities and natural phenomena could be minor to moderate over the next 40 to 50 years. Non-OCS activities or phenomena include climate change, natural catastrophes, contaminant releases, vessel traffic, commercial fishing, and invasive species. The incremental contribution of routine Program activities to these impacts would be negligible to medium (see Section 4.4.7.1.1).

Marine mammals may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS activities as well as naturally occurring seeps. The cumulative impacts of past, present, and future oil spills on marine mammals would be minor to moderate. The incremental impacts of expected accidental spills associated with the Program on marine mammals would be small to large, depending on the location, timing, and volume of the spills; the environmental settings of the spills; and the species exposed to the spills (Section 4.4.7.1.1). Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from moderate to major if it were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to the impacts of spills regardless of size, but their incremental contribution to cumulative impacts is generally expected to be small. A more detailed discussion of the effects of oil spills on marine mammals in the GOM is presented in Section 4.4.7.1.1.

Terrestrial Mammals. Under the Program, terrestrial mammals in the GOM are not expected to be affected by routine OCS-related activities (Section 4.4.7.1.1). The terrestrial mammals considered in the impact analysis for the Program are four federally endangered GOM coast beach mouse subspecies and the federally endangered Florida salt marsh vole. Because of the listing of these species under the ESA, as well as their occurrence in protected areas, the siting and construction of any onshore facilities associated with the Program would be required to take into account these species and their habitats, and construction activities would not be allowed in the habitats of these species.

Present beach mice habitat is no longer of optimal quality because of historical beach erosion, construction, and tropical storm damage. Dredge-and-fill activities occur throughout the nearshore areas of the U.S. and disrupt beach and transport, which could affect coastal systems of dunes where beach mice live. Coastal construction and traffic can be expected to threaten beach mice populations on a continual basis. Natural catastrophes including storms, floods, droughts, and hurricanes can substantially reduce or eliminate beach mice. Storms can wash large amounts of debris into dune and marsh habitats. Trash and debris may be mistakenly consumed by beach mice or may entangle them. Cleanup efforts to remove debris could result in adverse habitat impacts. Other activities that threaten beach mice and the Florida salt marsh vole include predation and competition, artificial lighting, and coastal spills. Predation from feral and free-ranging cats and dogs, feral hogs, coyotes, and red foxes, and competition with common house mice could reduce beach mice and Florida salt marsh vole populations. Isolation of small populations of beach mice due to habitat fragmentation can preclude gene flow between populations and cause a loss of genetic diversity. Separation of frontal dune habitat from scrub habitat by a highway can make a beach mouse especially vulnerable to hurricane impacts. Global climate change and sea level rise could also impact the Florida salt marsh vole and beach mice (Bird et al. 2009; USFWS 2008, 2009; Wooten 2008).

Activities in the GOM that could result in the accidental release of oil and may affect terrestrial mammals and their habitats include oil production from prior, proposed, and future OCS sales; domestic transportation of oil; State oil development; foreign crude oil imports; and military training activities involving open-water ship refueling. If spills from these activities occur in the vicinity of, or are transported by GOM currents to, the habitats of the beach mice or the Florida salt marsh vole, potential impacts would be similar in nature to those identified for the Program. Impacts associated with an oil spill may include loss of thermoregulatory ability from oiling of fur, lethal and sublethal toxic effects from inhalation or ingestion of oil or oil-contaminated foods, a decrease in food supply due to oiled vegetation, a decrease in habitat quantity and quality due to oiling of beach sands, and the fouling of burrows and nests. In addition, spill response activities could further impact habitats due to beach cleanup activities and vehicle and pedestrian traffic.

Given the relatively small number of spills that are expected under the Program and during the life of the Program (Table 4.6.1-4), the requirement under the *Oil Pollution Act of 1990* to prevent contact of protected or sensitive habitats (such as the habitats of the beach mice and the salt marsh vole) with spilled oil, and the need of a spill to be associated with environmental conditions (such as a storm surge sufficient to transport the spilled oil over foredunes) that could favor exposure of the species and their habitats, relatively minor cumulative impacts are expected from accidental oil spills from all potential sources, and the incremental contribution of spills associated with the Program is expected to be small.

Conclusion. Cumulative impacts on terrestrial mammals in the GOM as a result of ongoing and future OCS and non-OCS program activities could be minor to moderate over the next 40 to 50 years. Non-OCS activities or phenomena that may affect populations of terrestrial mammals include climate change, natural catastrophes, contaminant releases, vehicle traffic, and invasive and feral species. The incremental contribution of routine Program activities to these impacts would be negligible to medium (see Section 4.4.7.1.1).

Terrestrial mammals may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS operations. The cumulative impacts of past, present, and future oil spills on terrestrial mammals could be minor to moderate. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on terrestrial mammals would be small to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and other important habitats; the timing and nature of spill containment; and the status of the affected animals (see Section 4.4.7.1.). It is unlikely that the Florida salt marsh vole would be affected by an oil spill because its habitat is located far from areas where oil and gas leasing and development occur. However, if their habitat is oiled, the incremental contribution to cumulative impacts on this species could be small to medium (depending on the size of the spill).

An unexpected, low-probability CDE has a greater potential to affect the habitats of beach mice and the Florida salt marsh vole; therefore, impacts would range from moderate to major if one were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to the impacts of spills regardless of size, but their incremental contribution to cumulative impacts is generally expected to be small. A more detailed discussion of the effects of oil spills on terrestrial mammals in the GOM is presented in Section 4.4.7.1.1.

4.6.4.1.2 Marine and Coastal Birds. Section 4.4.7.2.1 discusses direct and indirect impacts on marine and coastal birds in the GOM resulting from the Program (OCS program activities from 2012 to 2017). Cumulative impacts on marine and coastal birds result from the incremental impacts of the Program when added to impacts from existing and reasonably foreseeable future OCS program activities (that are not part of the Program) and other non-OCS program activities. Table 4.6.1-1 presents the exploration and development scenario for the GOM cumulative case (encompassing the Program and other OCS program activities) over the next 40 to 50 years. A number of OCS program activities could affect GOM marine or terrestrial birds or their habitats; these include offshore structure placement and pipeline trenching, offshore structure removal, operational discharges and wastes, service vessel and aircraft traffic, construction and operation of onshore infrastructure (including new pipeline landfalls), and noise. Potential impacts on marine and coastal birds from service program activities include injury or mortality of birds from collisions with platforms, vessels, and aircraft; exposure to operational discharges and ingestion of trash or debris; loss or degradation of habitat due to construction activities; and behavioral disturbance due to the presence of, and noise generated by, equipment and human activity.

Non-OCS program activities affecting marine and coastal birds include dredging and marine disposal; coastal and community development; onshore and offshore construction and operations of facilities associated with State oil and gas development and with the extraction of nonenergy minerals; commercial and recreational boating; and small aircraft traffic. Potential impacts on marine and coastal birds from these activities are similar to those under the OCS program and include injury or mortality of birds from collisions with platforms associated with State oil and gas development and other onshore and offshore structures (e.g., radio, television, cell phone towers or wind towers); non-energy mineral mines (e.g., sand and gravel and other hard minerals mined in the northern part of the GOM; onshore industrial, commercial, and residential development; exposure to discharges from permitted point sources such as sewage treatment discharges and nonpoint sources such as irrigation runoff, or accidental releases (e.g., oil spills), as described in Section 4.6.2.1.1 and summarized in Table 4.6.1-5; exposure to emissions from various onshore and offshore sources (e.g., power generating stations, refineries, and marine vessels), as described in Section 4.6.2.1.2; ingestion of trash or debris; loss or degradation of habitat due to construction and operations activities; and behavioral disturbance due to the presence of noise generated by equipment and human activity. Other trends such as sea level rise and increasing seawater temperature brought on by global climate change, as well as extreme wind conditions from storm events, are also expected to adversely affect marine and coastal birds over the next 40 to 50 years.

Injury or Mortality from Collisions. Birds are drawn to lighted platforms and often circle the platform before moving on or stopping. This behavior increases the potential for platform collision (Russell 2005). Annual bird collision mortalities under the Program (estimated at about 10,000 to 22,500) represent less than 0.01% of the hundreds of millions of birds that annually migrate across the GOM (Russell 2005). Under the cumulative scenario, annual collision mortality (estimated at 200,000 birds under current OCS activities in the GOM) could increase by about 8%. During the life of the Program from 2012 to 2017, older platforms would be decommissioned and removed as new platforms are installed, so it is likely that the estimated 200,000 collision-related deaths per year would persist throughout the life of the program. The Program would likely result in a small incremental increase of the total annual bird collision mortality in the GOM that occurs from collisions with other OCS and non-OCS structures (Klem 1990; Kerlinger 2000).

Exposure to Wastewater Discharges and Air Emissions. The discharge of operational wastes and air emissions from current OCS- and non-OCS-related marine vessel traffic and platform operations is strongly regulated and would continue to be regulated over the next 40 to 50 years. However, such wastes and emissions would still expose marine and coastal birds to potentially toxic materials or to solid debris that could be ingested or result in entanglement. In addition, the Mississippi River, and, to a lesser extent, other rivers and streams annually discharge waters containing suspended sediments, agricultural fertilizers and herbicides, and urban runoff to the northern GOM (Rabalais et al. 2001, 2002b). Birds and their habitats in the vicinity of these discharges may be exposed to lethal and sublethal levels of contaminants. Operational wastewater discharges and air emissions associated with the Program would contribute to the overall cumulative risk of toxic exposure and debris ingestion or entanglement of existing OCS and non-OCS wastewater discharges and air emissions in the GOM, but the incremental increase in impact is expected to be small relative to these other activities.

Under the Program, marine and coastal birds could be exposed to oil accidentally released from platforms, pipelines, and marine vessels, and would be most susceptible to adverse impacts from spills occurring in coastal areas and affecting feeding and nesting areas. Accidental oil releases occur in the GOM from a variety of non-OCS related activities, such as the domestic transportation of oil, import of foreign crude oil, and State development of oil. Crude oil may also enter the environment of the northern GOM from naturally occurring seeps (MacDonald et al. 1996; MacDonald 1998; NRC 2003b). Oil releases from all sources may expose marine and coastal birds via direct contact or through the inhalation or ingestion of oil or tar deposits (see Section 4.4.7.2.1).

The spills that could occur in the cumulative scenario are shown in Table 4.6.1-3. Spills from non-OCS sources could occur from import tankers, State oil and gas operations, and coastal transportation of crude and refined petroleum products. Releases from natural seeps in the northern part of the GOM have been estimated at about 73,000 tons (526,000 bbl) per year (Kvenvolden and Cooper 2003). Most spills associated with the Program would be relatively small (less than 50 bbl) (Table 4.4.2-1). Depending on their location, accidental spills associated with the Program could represent a major component of the overall exposure of marine and coastal birds in the GOM OCS Planning Areas.

The magnitude and duration of exposure, and any subsequent adverse effects, would be a function of the location, timing, duration, and size of the spill; the proximity of the spill to feeding habitats; and the timing and nature of spill containment. Spills in nearshore coastal areas have the greatest potential for impacting high concentrations of bird populations. Most activities associated with the Program would take place in deep or ultra-deep waters. Some seabirds spend a significant amount of time offshore and could be exposed to accidental oil spills that occur in these deep waters, but even marine birds that remain in coastal waters could be exposed to accidental oil spills if they were to occur closer to shore.

Loss and Degradation of Habitat. Marine and coastal birds could be affected by platform construction and removal activities, and pipeline trenching, which could disrupt behaviors of nearby birds. Platforms constructed under the Program would increase the number of offshore platforms present in open-water areas of the northern GOM; and these structures may be used by birds to rest or avoid bad weather conditions during spring and fall migrations across the GOM (see Section 4.4.7.2). The Program would increase the number of platforms to be removed by only 9% of current OCS numbers, and up to 75% of the construction of new platforms would occur in deep water (i.e., 300 m [1,000 ft] or greater), well away from coastal areas. Under the Program, there would also be construction associated with no more than 12 new pipeline landfalls and offshore pipeline placement (Table 4.4.1-1). These platform and pipeline construction activities could add to the overall disturbance level of birds and their habitats from all construction sources in the GOM.

Platform construction and removal under the Program would be localized (primarily in deep water areas) and short in duration, and would result in only a small increase in the overall level of disturbance incurred by birds and their habitats from all construction activities in the GOM OCS Planning Areas. Pipeline trenching and landfall construction that would occur under the Program would similarly be of short duration and limited in extent (associated with no more than 12 new landfalls), and would be expected to contribute little to overall levels of bird disturbance that occur in coastal areas of the GOM on a much more regular basis from existing OCS and non-OCS construction activities, such as channel construction and maintenance, creation of harbor and docking areas and facilities, State oil and gas development (including platform construction and removal), non-energy minerals extraction, and pipeline emplacement.

Marine vessel traffic potentially disturbs, feeding and nesting birds with unknown long-term consequences. The GOM is one of the world's most concentrated commercial shipping areas (COE 2003a, b), and it supports extensive commercial fishing and recreational boating. As a result, OCS and non-OCS program-related vessel traffic disturbs birds on a daily basis. This trend is expected to increase as marine traffic in the GOM increases over the next 40 to 50 years (see Table 4.6.2-1). OCS program-related marine vessel traffic in the GOM could be as high as 1,900 trips per week over the next 40 to 50 years; marine vessel traffic associated with the Program represents about 27% of this traffic (Section 4.6.2.1). Non-OCS program traffic includes that related to crude oil and natural gas imports, commercial container vessels, military and USCG vessels, cruise ships, commercial fishing, and small watercraft. In 2010, the Port of New Orleans alone handled about 7,500 vessel calls (mainly tanker and dry bulk carrier), about 140 vessel calls per week (USDOT 2011b). Impacts on water quality from marine traffic arise from regular discharges of bilge water and waste, leaching of antifouling paints, and incidental spills (MMS 2001d), although operational discharges and spillage from marine vessels have declined substantially in the past few decades (NRC 2003b). Vessel traffic associated with the Program would result in a small increase in the overall disturbance of birds in the GOM region.

Disturbance Due to Noise. Noise generated during construction activities and normal operations (e.g., helicopter overflights) may disturb marine and coastal birds, causing a short-term change in normal behavior and potentially disrupting feeding and nesting activities. Non-OCS activities that currently generate noise in the GOM include construction and/or operation of offshore structures for State oil and gas development; offshore LNG facilities and tankers; marine mineral mining; dredging and marine disposal; commercial and recreational vessel traffic; small aircraft flight; and military training and testing activities. These activities are expected to continue or increase into the foreseeable future. Although noise generated as a result of the Program would likely add only a small increment to the overall (cumulative) noise levels in the GOM, locally it could represent the dominant noise in the environment, resulting in more moderate impacts on marine and coastal birds.

Climate Change and Storm Events. Populations of marine and coastal birds throughout the GOM may be adversely affected by climate change and, to a lesser extent, by storm events (including hurricanes). As discussed in Section 3.3, there is growing evidence that climate change is occurring, and potential effects in the GOM may include sea level rise and increases in water temperatures in the GOM. Over time these changes will result in a loss of wetlands in the GOM, important water bird habitat. Climate change could also affect the distribution, availability, and quality of feeding habitats and the abundance of food resources. It is not possible at this time to identify the likelihood, direction, or magnitude of any changes in the environment of the GOM due to changes in climate; therefore, it is not possible to predict the extent of effects on GOM populations of marine and coastal birds as a result of climate change. It should be noted that such information is not essential to a reasoned choice among OCS program alternatives, even in a cumulative analysis, because the information missing here is missing across the board for all action alternatives (see Section 1.4.2).

Severe storm events such as hurricanes may result in direct or indirect mortality of marine and coastal birds and may impact important coastal habitats. Heightened wave action and intensity could alter nearshore channels, affecting the abundance and distribution of shallow-water habitats such as lagoons and bays, while sediments deposited into foraging habitats by storm waves may alter the thermal environment and affect aquatic vegetation in feeding habitats. Extreme wind conditions could damage or destroy historic rookery sites or disrupt nesting birds. Because storms (including hurricanes) are annual events that are an inherent component of the overall GOM ecosystem, it could be assumed that marine and coastal birds have experienced and largely tolerated extreme weather conditions in the past and may be expected to continue to do so in the foreseeable future. The occurrences and aftermaths of Hurricanes Katrina and Rita in 2004, however, have impacted avian habitats on a large scale throughout the GOM. Large areas of coastal wetlands have been converted to open-water habitat, potentially affecting avian species that utilized the wetlands for foraging, nesting, and as stopover points during migration (Congressional Research Service 2005). Impacts on these habitats have the potential to result in population-level impacts affecting both abundance and distribution of some species.

Hurricane impacts on bottomland forest habitat along the Louisiana and Mississippi coasts represent further loss of avian habitat affecting many species. For example, all forested areas at the Big Branch Marsh National Wildlife Refuge were heavily damaged, with some areas that were previously densely forested left with few standing trees (USFWS 2007). These damaged areas provided habitat for a variety of avian species, and included cavity trees used by the endangered red-cockaded woodpecker. The long-term effects of avian habitat loss due to these hurricanes is not known, and agencies such as the USFWS and USGS are implementing numerous studies and monitoring programs to determine the extent and magnitude of impacts on affected avian populations. The occurrence of similar magnitude storms during the life of the 5-year OCS program could result in population-level impacts on some bird species.

Conclusion. Marine and coastal birds in the GOM could be adversely affected by activities associated with the Program as well as those associated with other OCS program and non-OCS program activities. Potential impacts include injury or mortality of birds from collisions with platforms associated with OCS and State oil and gas development and other onshore and offshore structures (e.g., radio, television, cell phone, or wind towers), non-energy mineral mines; onshore industrial, commercial, and residential development; exposure to discharges from permitted point sources or accidental releases; exposure to emissions from various onshore and offshore sources; ingestion of trash or debris; loss or degradation of habitat due to construction and operations activities; and behavioral disturbance due to the presence of, and noise generated by, equipment and human activity. Other trends such as sea level rise and increasing seawater temperature brought on by global climate change, as well as extreme wind conditions from storm events, are also expected to adversely affect marine and coastal birds over the next 40 to 50 years. While the cumulative impact of all OCS and non-OCS activities in the GOM is expected to be moderate (some impacts are unavoidable, but mitigation can help to alleviate some of the stress on species), the incremental contribution due to the Program would be negligible to medium as most impacts would be temporary and would not be expected to cause population-level impacts (see Section 4.4.7.2.1).

Marine and coastal birds may also be adversely affected by exposure to oil (via direct contact or through the inhalation or ingestion of oil or tar deposits) that is accidentally released from OCS and non-OCS activities, especially near coastal areas and affecting feeding and nesting areas. The incremental contribution of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on marine and coastal birds would be small to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and nesting areas; the timing and nature of spill containment; and the status of the affected birds (see Section 4.4.7.2.1). Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from moderate to major if it were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to the impacts of spills regardless of size, but their incremental contribution to cumulative impacts is generally expected to be small. A more detailed discussion of the effects of oil spills on marine and coastal birds in the GOM is presented in Section 4.4.7.2.1.

4.6.4.1.3 Fish. Section 4.4.7.3.1 discusses direct and indirect impacts on fish communities in the GOM resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on these resources result from the incremental impacts of the Program (described in Section 4.4.6.1.1) when added to impacts from ongoing and reasonably foreseeable future actions, including those of ongoing and future OCS programs and other non-OCS activities. Table 4.6.1-2 presents the exploration and development scenario for the GOM cumulative case, which takes into account activities associated with the Program in combination with those from ongoing and future OCS programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in the GOM are summarized in Table 4.6.1-5 and discussed below, as applicable.

There are numerous fish species that inhabit different niches throughout the surface waters, water column, and benthic environments of the GOM. Routine activities will have varied cumulative effects on fish populations depending on their habitat and life history. Impacts on fish resulting from ongoing and future routine OCS program activities, including those of the

Program, could result primarily from noise (marine vessel traffic, seismic surveys, and construction), well drilling, pipeline placement (trenching, landfalls, and construction), platform placement (anchoring, mooring, and removal, except in deep waters) and routine discharges (drilling, production, platform, and vessel). Accidental oil spills are also counted among OCS program-related activities. Cumulative impacts could result from the combination of the Program and past, present, and reasonably foreseeable future OCS and non-OCS activities.

Routine OCS activities that temporarily disturb sediments and increase turbidity include installation of new pipelines and platforms and discharges of drill cuttings and associated fluids. This could cause soft-bottom fish such as Atlantic croaker, sand sea trout, Atlantic bumper, sea robins, and sand perch to temporarily move from or be attracted to the disturbed area. Fish species that are normally associated with reefs, such as snappers, groupers, grunts, and squirrelfishes, may also move from areas of increased turbidity. Sedimentation could smother eggs, larvae, and juvenile fishes as well as the benthic prey of some of these fish species (see Table 4.6.1-2 for bottom area of disturbance and drilling and operational discharges expected during the life of the Program). The impacts of routine activities (exploration and site development, production and decommissioning) on fish communities are discussed in detail in Section 4.4.7.3.1. Overall, routine activities would result in a minor impact, primarily from disturbance affecting demersal fishes, with the severity of the impacts generally decreasing dramatically with distance from bottom-disturbing activities.

Up to 2,000 new platforms could be constructed under ongoing and future OCS activities, including up to 450 from the Program (Table 4.6.1-2). The addition of new platforms may act as fish attracting devices (FADs) that will significantly alter local fish communities and food web relationships. Many reef species, as well as highly migratory species, use platforms as habitat. There has been some speculation that an increase in FADs could impact the migration patterns of highly migratory species. While many platforms may be allowed to remain as artificial reefs, removal of platforms will reduce available substrate and structures for these fish and some of their prey species. Some fish will be killed in the process of these platform removals, especially when explosives are used to accomplish the removals. A total of up to 1,200 platforms would be subject to explosive removal over the life of the Program, including up to 275 platforms under the Program. A detailed discussion of oil platforms as FADs can be found in Section 4.4.7.3.1.

Non-OCS actions may also negatively influence fish resources in various life stages and habitats. Non-OCS oil and gas exploration and production activities in GOM State waters occur primarily off Louisiana and Texas, and off Alabama in the vicinity of Mobile Bay. The States of Florida and Mississippi have had limited activities in State waters, with a moratorium on drilling activity now in effect in Florida waters. The increasing presence of offshore LNG facilities could lead to impacts associated with entrainment and impingement of eggs, larvae, and juvenile lifestages and discharges of water used in the vaporization process. In addition to the thermal discharge, biocides are also discharged from the facilities. Other non-OCS activities that could impact fish communities include non-OCS activities with a potential to impact marine benthic and pelagic habitats, such as sand mining, sediment dredging and disposal, anchoring, offshore marine transportation, and pollutant inputs from point and non-point sources. Many of these activities would affect bottom-dwelling fishes at various life stages as well as their food sources in a manner similar to OCS bottom-disturbing activities (Section 4.4.7.3.1).

Commercial fishing practices that are indiscriminate, such as some types of trawling and pots, are responsible for significant amounts of bycatch that can injure or kill juveniles of many fish species. These types of fishing practices could damage future year classes, reduce available prey species, and damage benthic habitat for many GOM fish resources. Sportfishing may also contribute significantly to cumulative effects on some fishery resources, and in some cases may affect fish stocks more than commercial fishing. As a consequence of the pressure fishing places on fishery resources, NOAA manages fish stocks using catch and gear limits and regulations in order to prevent the depletion of fish stocks due to overharvesting. A variety of natural and anthropogenic factors influence fish populations; these include food availability, climate, habitat loss, and pollution. Consequently, the possibility of fish stocks declining still exists even for managed species. Currently, gag, tray triggerfish, greater amberjack, and red snapper are overfished in the GOM (NOAA 2011e). OCS Program activities may interact with fishing activities. For example, continued platform placement may increase fishing pressure on overfished reef associated species like snapper and grouper. Large numbers of reef fish may also be killed by explosive platform removal.

The eutrophication that has contributed to the hypoxic zone in the GOM will continue to act as a source of lethal and sublethal stress to fish communities. In addition, natural events, including hurricanes and turbidity plumes, could also cause localized damage to important habitat areas and could affect individuals or populations. However, the GOM fish community as a whole should be adapted to such natural events.

Climate change could affect fish communities through direct physiological action, habitat loss, and by altering large-scale oceanographic and ecosystem processes (Section 3.8.4.1). At the level of individual behavior and physiology, increasing water temperature could increase the spread and virulence of new and existing pathogens, and alter reproductive rates by speeding growth and altering the timing of migrations (including reproductive movements). Fish in river-influenced systems such as the GOM would be particularly susceptible to changes in salinity, turbidity, and temperature linked to changes in the hydrology of the Mississippi River and Atchafalaya River. At larger scales, climate change could promote the range expansion of new species into the GOM, reduce or eliminate critical fish habitats including estuarine waters and coral reef due to sea level rise, and increase the size of the GOM "dead zone," reducing the amount of benthic habitat available to demersal fishes (Rabalais et al. 2010). Physiological and ecosystem-level stressors related to climate change may interact with the non-climate anthropogenic stressors such as overfishing, pollution, and habitat loss discussed above. For example, a climate change related increase in water temperature that results in physiological stress could also make individuals more susceptible to pollution stress or the effects of an accidental oil spill. Another potential interaction could occur between oil and gas platforms and climate change, in which new hard-bottom associated species are able to expand northward due to warming and the availability of hard substrate in the form of active or decommissioned oil platforms. By acting as stepping stones across the GOM, oil platforms have been implicated in the introduction of a non-native fishes such as sergeant majors (*Abudefduf saxatilis*) and yellowtail snapper (*Ocyurus chrysurus*) into the FGB (Hickerson et al. 2008).

Oil spills resulting from both OCS and non-OCS activities could impact fish communities in the GOM. See Table 4.6.1-4 for anticipated oil spills over the life of the Program.

Catastrophic spill assumptions are provided in Table 4.4.2-2. Crude oil may also enter the environment from naturally occurring seeps. Large spills may also occur from tankers carrying imported oil in the GOM. The potential effects of spills from non-OCS activities would be similar to those described for OCS activities (Section 4.4.7.3.1). Most adult fish in marine environments are highly mobile and are capable of avoiding high concentrations of hydrocarbons, although they may be subject to sublethal exposures. However, eggs and larvae do not have the ability to avoid spills and may therefore suffer lethal or sublethal effects. Any oil spills reaching shallow seagrass, estuarine, or coastal marine habitats could affect fish species that use the affected areas as spawning or juvenile nursery habitat. Coastal pelagic fish and highly migratory species throughout the GOM could come into contact with surface oil, but would most likely move away from affected areas. Because of the wide dispersal of early life history stages of fishes in the GOM surface waters, it is anticipated that only a relatively small proportion of early life stages present at a given time would be impacted by a particular oil spill, which would limit the potential for population-level effects. However, the impact magnitude would also depend on the temporal and spatial scope of the oil spill. Since some species of fish spawn in a limited geographic area(s) during a small temporal window, a spill could have population-level impacts if the spill coincided in time and space with spawning activity. In addition, fish species such as tuna, swordfish, and billfish that currently have depressed populations and important spawning grounds in the GOM could experience population-level impacts if high numbers of early life stages were killed by a spill. The potential impacts of oil spills on fish communities are discussed in detail in Section 4.4.7.3.1.

In addition to effects on individuals and species, impacts to fish can result in ecosystem-level effects if the population impacts are significant. For example, fish in the GOM can occupy a number of trophic levels ranging from herbivore to top level carnivore. As such, fish are critical to energy flow within nearshore and marine food webs. They are also seasonally important food sources to transient carnivores. Consequently, impacts to fish can propagate throughout the food web, affecting sea turtles, birds, and marine mammals. In addition, many GOM fishes migrate between and within marine, estuarine, and freshwater habitats. In doing so, they transfer nutrients and carbon over a broad area and connect offshore and coastal ecosystems (Deegan et al. 2002; Kneib 2002; Haertel-Borer et al. 2004). Significant impacts to fish populations could reduce this transfer, resulting in local changes in productivity.

Fish Species Listed under the Endangered Species Act. Routine activities such as placement and removal of structures, discharges of operational wastes, and accidental spills of oil have the potential to physically harm or disturb individual Gulf sturgeon, smalltooth sawfish, or their respective habitats; cause sedimentation of areas that provide food; or elicit lethal or sublethal toxic effects. As described in Section 3.8.4.1.4, most routine activities would not take place in shallow nearshore habitat preferred by Gulf sturgeon. Gulf sturgeon are also not likely to be directly affected by routine operations that impact estuarine areas because the more vulnerable egg and larval stages are not present in estuarine areas and juveniles and adults will be able to avoid most disturbances. Consequently, it is anticipated that effects on Gulf sturgeon from routine OCS activities would be limited. Smalltooth sawfish are primarily found in peninsular Florida away from the Central and Western Planning Areas. Vulnerable early life stages of smalltooth sawfish exist only in shallow estuarine areas far removed from most routine OCS activities. Adults and larger juveniles do occupy coastal waters where OCS activities would occur. However, it is expected that, given their size, they will be able to avoid direct impacts from routine operations, although their habitat would be disturbed.

In addition to potential effects from OCS oil and gas activities identified above, Gulf sturgeon and smalltooth sawfish could be affected by non-OCS activities such as commercial fishing, water quality degradation, coastal and upland development, dredge and fill activities, and damming of major spawning rivers (Section 3.8.4.1.4). Even though it is illegal to fish for Gulf sturgeon or smalltooth sawfish, some individuals, particularly smalltooth sawfish, may be harmed or killed when captured as bycatch during trawling activities. Dredging and fill activities in estuaries may disturb smalltooth sawfish and Gulf sturgeon habitat. Increased barriers (e.g., locks or dams) to major spawning sites may result in Gulf sturgeon reproducing in less desirable locations. The eggs and fry of Gulf sturgeon are also susceptible to other fish and invertebrate predators as well as anthropogenic effects, such as artificially increased water temperatures due to the release of cooling water from power plants and exposure to pesticides and heavy metals.

Other events, including hurricanes, turbidity plumes, and hypoxia, could also affect Gulf sturgeon, smalltooth sawfish, or their habitat. Regardless, a severe event could cause localized damage to important habitat areas and could result in the introduction of contaminants via surface-water runoff. Therefore, such events could affect individual Gulf sturgeon or population levels for some period of time.

Oil is released in GOM waters by accidental oil spills (OCS and non-OCS) and natural seepage. Non-OCS oil and gas exploration and production activities in GOM State waters occur primarily off Louisiana and Texas, and off Alabama in the vicinity of Mobile Bay. The States of Florida and Mississippi have had limited activities in State waters, with a moratorium on drilling activity now in effect in Florida waters. Non-OCS spills in the GOM could have impacts similar to those for OCS spills. Smalltooth sawfish are primarily found in peninsular Florida and are uncommon in most of the Central and Western GOM Planning Areas. Therefore, oil spills in the GOM have the greatest potential to impact Gulf sturgeon populations. Most spills would be minor and are unlikely to reach estuarine and shelf habitat of adult sturgeon. Spills in shallow areas have the greatest potential to affect Gulf sturgeon. As identified in Section 3.8.4.1, eggs and larvae of Gulf sturgeon are typically located in freshwater areas, and oil from OCS-related spills are unlikely to come into contact with these life stages. Because adult sturgeons are benthic feeders, they are relatively unlikely to come into contact with surface oil in deeper waters.

Conclusion. Cumulative impacts on fish communities in the GOM as a result of ongoing and future OCS and non-OCS activities and natural phenomena could be moderate to major over the next 40 to 50 years. Non-OCS activities or phenomena affecting these resources include oil and gas development in State waters, sand mining, sediment dredging and disposal, LNG facilities, hypoxia, anchoring, fishing/trawling, commercial shipping, and pollutant inputs from point and non-point sources. Many of these activities would affect bottom-dwelling fish at various life stages as well as their food sources in a manner similar to OCS bottom-disturbing activities. The incremental contribution of routine Program activities to these impacts (primarily as a result of disturbance affecting demersal fishes) would be negligible to small, with the severity of impacts generally decreasing with distance from the disturbance. Fish could also be affected by naturally occurring oil seeps and the environmental changes predicted to result from climate change.

Fish communities may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS activities as well as naturally occurring seeps. The cumulative impacts of past, present, and future oil spills on these resources would be minor to moderate. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on fish would be negligible to medium, depending on the location, timing, duration, and volume of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and could range up to moderate if they were to occur. Oil from large spills or a CDE has the greatest potential to contact shoreline areas used for spawning or providing habitat for early life stages of fish and, therefore, could result in large-scale lethal and long-term sublethal effects on fish. Overall population levels for individual species would not likely be affected; however, fish species that currently have depressed populations or have critical spawning grounds present in the affected area could experience population-level impacts. A more detailed discussion of the effects of oil spills on fish in the GOM is presented in Section 4.4.7.3.1.

Although Gulf sturgeon may be affected by a variety of OCS and non-OCS activities, most OCS activities occur in deeper areas that are outside of the normal habitat areas used by Gulf sturgeon. Similarly, smalltooth sawfish are primarily found in peninsular Florida away from the Central and Western Planning Areas. Consequently, it is anticipated that the cumulative effects of OCS and non-OCS activities on Gulf sturgeon and smalltooth sawfish would be similar to the effects of non-OCS activities alone, and the Program is expected to contribute little if any overall incremental impacts on these species.

4.6.4.1.4 Reptiles. Section 4.4.7.4 discusses direct and indirect impacts on reptiles in the GOM coastal environment resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on these resources result from the incremental impacts of the Program when added to impacts from ongoing and reasonably foreseeable future actions, including those of ongoing and future OCS programs and other non-OCS activities. Table 4.6.1-2 presents the exploration and development scenario for the GOM cumulative case, which takes into account activities associated with the Program in combination with those from ongoing and future OCS programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in the GOM are summarized in Table 4.6.1-5 and discussed below, as applicable.

Ongoing and future routine OCS program activities include seismic surveys, onshore and offshore construction (including pipeline trenching and removal of offshore structures), the discharge of operational wastes (such as produced water and ship wastes), and marine vessel traffic. All these activities have the potential to adversely affect reptiles in the GOM via physical injury or death, lethal or sublethal toxic effects, or loss of reproductive, nursery, and feeding habitats (Section 4.4.7.4). Accidental oil spills are also counted among OCS program-related activities; assumptions for oil spills under the cumulative case scenario are provided in Table 4.6.1-4.

Non-OCS program activities contributing to adverse cumulative impacts on reptiles include activities associated with offshore construction (e.g., seismic surveys, dredging and marine disposal, extraction of nonenergy minerals, State oil and gas development, domestic transportation of oil and gas, and foreign crude oil imports), onshore construction (e.g., coastal and community development), the discharge of municipal and other waste effluents, and vessel traffic (e.g., commercial shipping, recreational boating, and military training and testing activities).

Anthropogenic mortality in sea turtles has been attributed to a number of sources (NRC 1990; NOAA 2003). Human activities responsible for mortality of sea turtle eggs and hatchlings include (in descending order of relative importance) beach development, beach lighting, beach use, entanglement in trash and debris, and beach replenishment. Each of these activities is associated, either exclusively or to a large degree, with coastal development. In addition, the contributions of exposure of eggs and hatchlings to toxins and of the ingestion of plastics and debris by hatchlings are unknown (NRC 1990; NOAA 2003). Human activities responsible for mortality of juvenile and adult turtles include shrimp trawling and other fisheries, beach lighting, beach use, vessel collisions, dredging, entanglement, power plant entrainment, and oil platform removal (NRC 1999; NOAA 2003). The role of exposure to toxins in overall sea turtle mortality is unknown. However, this information is not necessary to make a reasoned choice among the alternatives (see Section 1.4.2).

Non-OCS offshore (deepwater and nearshore) construction activities in the GOM that could affect sea turtles include channel construction and maintenance activities (e.g., dredging) conducted by Federal, State, and local governments and the public; the offshore extraction of nonenergy minerals; State oil and gas development; and the transport of domestic and foreign oil and gas (requiring loading and offloading facilities). Potential impacts on sea turtles from these activities may include physical injury or death of individuals present in the immediate construction area. In addition, construction or removal of offshore OCS facilities may result in a relatively small incremental increase in the potential for adverse impacts on sea turtles within the GOM planning areas. However, the mitigation measures established by BOEM for construction and platform removal activities may be expected to reduce the contribution of these proposed activities to cumulative impacts to sea turtles from all offshore construction activities throughout the GOM planning areas (MMS 2003d, 2004a, 2005d).

Onshore construction activities can impact nesting habitat for sea turtles and the Alabama red-belly turtle, as well as impact terrestrial habitat for the gopher tortoise. Coastal development is an ongoing activity throughout the GOM and may be expected to continue or increase for the foreseeable future. Residential (i.e., housing developments) and commercial (i.e., casinos) development near nesting beaches may disrupt nesting adults and disorient emerging hatchlings, while increasing the potential for recreational human activities on nesting beaches. Compliance with regulatory requirements and the implementation of appropriate mitigation measures may be expected to reduce the potential for the siting, construction, and operation of onshore facilities.

There are a number of types of facilities or activities that discharge wastes to GOM waters and thus expose sea turtles to potentially toxic materials or solid debris that could entangle or be ingested by sea turtles. These facilities or activities include sewage treatment plants, industrial manufacturing or processing facilities, electric generating plants, cargo and tanker shipping, cruise ships, commercial fishing, pleasure craft, and vessel traffic associated with the Program. In addition, the Mississippi River (and to a lesser extent other rivers and streams that discharge to the northern GOM) annually discharges waters containing suspended sediments, agricultural fertilizers and herbicides, and urban runoff (Rabalais et al. 2001, 2002b). The exposure of sea turtles to these discharges may result in physical injury or death, or a variety of lethal or sublethal toxic effects on adults, juveniles, and hatchlings. These discharges may also affect habitat quality in the vicinity of the discharges.

Operational discharges and wastes associated with OCS activities could adversely affect sea turtles, especially those in the immediate vicinity of discharging platforms and vessels (Section 4.4.7.4). However, discharges from OCS program-related vessels and platforms would be strongly regulated under the Program (as they are for current OCS program-related discharges). Thus, the potential for sea turtles to be exposed to discharges under the Program may be expected to be much less than the potential of exposure to many of the nonpoint and non-OCS related discharge sources. Similarly, because of existing USCG and USEPA regulations, the nature of the OCS discharges that could occur are expected to be less toxic or less likely to cause entanglement than discharges from non-OCS program sources.

The GOM is one of the world's most concentrated shipping areas, with extensive commercial traffic transporting a variety of materials ranging from agricultural products to domestic and foreign oil (USACE 2003). For example, in 2003, the Port of New Orleans handled over 255,000 domestic and foreign container vessels, while the port at Gulfport, Mississippi, handled more than 161,000 foreign container vessels (USACE 2003b). The GOM also supports extensive commercial fisheries as well as recreational boating. For example, there were 2 million recreational watercraft between 4 and 20 m (12 and 64 ft) in length registered in the GOM States, many of which are used in GOM waters (USCG undated). The GOM also supports training by U.S. Navy vessels as well as routine USCG activities. Because of the very large number of vessels typically present in the GOM, the potential for sea turtles colliding with watercraft is high, and may be expected to continue and increase into the foreseeable future. In comparison with the overall level of vessel traffic in the GOM, the additional numbers of vessel trips that would occur to support OCS Program activities is expected to result in a minor incremental increase to the overall potential for sea turtle–vessel collisions in the GOM planning areas.

The information on the extent to which sea turtles may be affected by noise is very limited (Section 4.4.7.4). However, this information is not necessary to make a reasoned choice among the alternatives (see Section 1.4.2). Current noise generating activities in the GOM unrelated to OCS activities or the Program include the construction of offshore structures (such as those supporting State oil and gas development or nonenergy minerals extraction), dredging, commercial and recreational vessel traffic, and military training and testing activities. These may be expected to continue or increase in the foreseeable future.

Sea turtles could be exposed to OCS oil spills that could occur from platform, pipeline, and/or vessel accidents (see Section 4.4.7.4). Most spills associated with the Program would be relatively small (less than 50 bbl), and most would be expected to occur in water depths of 300 m (984 ft) or more (BOEMRE 2011a).

Storms, operator error, and mechanical failures may result in accidental oil releases from a variety of non-OCS related activities, such as the domestic transportation of oil, the import of foreign crude oil, and State development of oil. Crude oil may also enter the environment of the northern GOM from naturally occurring seeps. At least 63 seeps have been identified in the northern GOM (mostly off the coast of Louisiana) (MacDonald et al. 1996), and more than 350 naturally occurring and constant oil seeps that produce perennial slicks of oil at consistent locations may be present in the GOM (MacDonald et al. [2002], as cited in Kvenvolden and Cooper [2003]). Seeps in the northern GOM have been estimated to discharge more than 1.2 million gal of crude oil annually to overlying GOM waters (MacDonald 1998). Using remotely sensed satellite data, Mitchell et al. (1999) identified approximately 1,000 km^2 (390 mi^2) of floating oil in the northern GOM, presumably from natural seeps.

Accidental oil releases from these activities and from naturally occurring seeps could impact reptiles by oiling (fouling) nesting beaches and nest sites and hatchlings, and through the inhalation or ingestion of oil or tar deposits. The magnitude and severity of potential effects on reptiles from such exposure will be a function of the location, timing, duration, and size of the spill; the proximity of the spill to nesting beaches and feeding habitats; and the timing and nature of spill containment and cleanup activities. Depending on their location, as well as the location of spills from other sources and releases from natural seeps, accidental spills associated with the Program could contribute to the overall exposure of nest beaches, eggs, and hatchlings to oil, and subsequent lethal and sublethal effects, in the GOM planning areas. For example, the American crocodile and Alabama red-belly turtle might be affected by natural seepage and accidental releases of oil in the Eastern Planning Area, but probably only by catastrophic spills in the Central and Western Planning Areas.

Reptile populations throughout the GOM may be adversely affected by climate change or hurricane events. As previously discussed (Section 4.4.7.4), there is growing evidence that climate change is occurring, and potential effects in the GOM may include a change (i.e., rise) in sea level or a change in water temperatures. Climate change could affect the availability or quality of nesting beaches, the location and duration of current convergence areas utilized by hatchlings in the open waters of the GOM, and the distribution, availability, and quality of feeding habitats. For reptiles that rely on temperature to determine the gender of offspring in incubating eggs (referred to as temperature-dependent sex determination), including sea turtles and crocodilians, subtle increases in atmospheric temperatures could skew sex ratios of hatchlings, which could have future population implications (Walther et al. 2002).

Severe storm events such as hurricanes have the potential to impact nesting beaches if they result in a change in beach topography or in the composition of beach materials. Heightened wave action and intensity could erode nesting beach sites, storm surges could flood beaches and drown eggs and hatchlings, and sediments deposited onto beach surfaces by storm waves may alter the thermal and structural environment of nest sites, potentially decreasing the availability and/or quality of the nesting areas (Milton et al. 1994; Hays et al. 2001; Holloman and Godfrey 2005). Hurricanes Katrina and Rita adversely affected sea turtle habitats in 2005. Approximately 50 Kemp's ridley sea turtle nesting sites were destroyed along the Alabama coast (Congressional Research Service 2005; USFWS 2006). The loss of beaches through the affected coastal areas has probably affected other existing nests and nesting habitats of this species, as well as the loggerhead turtle. Similarly, impacts on seagrass beds may affect the local distribution and abundance of species that use these habitats, such as the green sea turtle and Kemp's ridley sea turtle. Although hurricanes are annual events that are an inherent component of the overall GOM ecosystem, including sea turtle nesting beaches, if hurricanes similar in magnitude to Katrina and Rita occur during the life of the Program, population-level impacts on reptiles could occur, particularly since the availability of nesting habitat (e.g. beaches) has become limited because of coastal residential and commercial development.

Conclusion. Cumulative impacts on reptiles in the GOM as a result of ongoing and future OCS and non-OCS activities and natural phenomena could be moderate to major over the next 40 to 50 years. Non-OCS activities or phenomena include climate change, natural catastrophes, onshore and offshore construction, contaminant releases (through waste effluents), vessel traffic, power plant entrainment, and human-related activity (e.g., beach use, noise, and shrimp trawling). The incremental contribution of routine Program activities to these impacts would be small to medium (see Section 4.4.7.4).

Expected accidental oil spills under the Program (most of which are less than 1,000 bbl) would result in a comparatively negligible to medium incremental increase in the overall impact of exposure to oil from other anthropogenic activities (such as spills from foreign tankers) because such spills are relatively easy to contain and would only affect small areas of habitat (and few individuals). However, large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could potentially result in population-level effects. Although such spills are rare events, impacts would be major and long-term if multiple individuals and their habitat (especially nesting habitat) are exposed to oil. Additional impacts on reptiles may occur as a result of habitat loss or alteration due to climate change and hurricanes, and from exposure to oil from naturally occurring seeps.

4.6.4.1.5 Invertebrates and Lower Trophic Levels. Section 4.4.7.5.1 discusses direct and indirect impacts on invertebrates and lower trophic levels in the GOM resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on these resources result from the incremental impacts of the Program (described in Section 4.4.6.1.1) when added to impacts from ongoing and reasonably foreseeable future actions, including those of ongoing and future OCS programs and other non-OCS activities. Table 4.6.1-2 presents the exploration and development scenario for the GOM cumulative case, which takes into account activities associated with the Program in combination with those from ongoing and future OCS programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in the GOM are summarized in Table 4.6.1-5 and discussed below, as applicable.

Cumulative impacts could result from the combination of the Program and past, present, and reasonably foreseeable future OCS and non-OCS activities. Routine activities would cumulatively have varied effects on invertebrate populations in the sediment and water column depending on their habitat and life history. Impacts resulting from ongoing and future routine OCS program activities, including those of the Program, could result primarily from noise (vessel, seismic surveys, and construction), well drilling, pipeline placement (trenching, landfalls, and construction), platform placement (anchoring, mooring, and removal, except in deep waters) and routine discharges (drilling, production, platform, and vessel). Accidental oil spills are also counted among OCS program-related activities.

Routine activities that temporarily disturb sediments and increase turbidity include installation of new pipelines and platforms and discharges of drill cuttings and associated fluids. Under the cumulative scenario, as much as 81,000 ha (32,780 ac) of sea bottom would be disturbed by construction of platforms and pipelines over the period of the Program (Table 4.6.1-1). Bottom-disturbing impacts would most directly affect benthic and near bottom invertebrates. The impacts of routine activities (exploration and site development, production and decommissioning) on invertebrate communities are discussed in detail in Section 4.4.7.5.1. Overall, routine activities represent up to a moderate disturbance, with the severity of the impacts generally decreasing dramatically with distance from bottom-disturbing activities.

The addition of up to 2,000 new platforms over the life of the Program (up to 450 new platforms under the Program) would allow the colonization of invertebrates requiring hard substrate. While many platforms may be allowed to remain as artificial reefs, removal of platforms will reduce available substrate and structures for invertebrates and injure or kill them during removal.

Non-OCS actions may negatively influence invertebrate resources in various life stages and habitats. Non-OCS oil and gas exploration and production activities in GOM State waters occur primarily off Louisiana and Texas, and off Alabama in the vicinity of Mobile Bay. The States of Florida and Mississippi have had limited activities in State waters, with a moratorium on drilling activity now in effect in Florida waters. The increasing presence of offshore LNG facilities could lead to impacts associated with discharges of water used in the vaporization process. In addition to the thermal discharge, biocides are also discharged from the facilities. Other non-OCS activities that could impact invertebrate communities include non-OCS activities with a potential to impact marine benthic and pelagic habitats, such as sand mining, sediment dredging and disposal, anchoring, fishing/trawling, offshore marine transportation, and pollutant inputs from point and non-point sources. Many of these activities would affect bottom-dwelling invertebrates at various life stages as well as their food sources in a manner similar to OCS bottom-disturbing activities (Section 4.4.7.5.1).

The eutrophication that has contributed to the hypoxic zone in the GOM will continue to act as a source of lethal and sublethal stress to invertebrate communities. Natural events, including hurricanes and turbidity plumes, could also cause localized damage to important habitat areas and could affect individuals or populations, although the invertebrate community as a whole should be adapted to such natural events.

Commercial fishing practices that are indiscriminate, such as some types of trawling and pots, are responsible for significant amounts of bycatch that can injure or kill large numbers of invertebrates. Bottom trawling also degrades benthic habitats and temporarily increases the turbidity of the water, both of which represent chronic disturbances to invertebrates. Bottom trawling is particularly common in the GOM because of the importance of the shrimp fishery.

Several major classes of invertebrates could be affected by the environmental changes predicted to result from climate change. Climate change could affect invertebrate communities through direct physiological action, habitat loss, and by altering large-scale oceanographic and ecosystem processes (Section 3.8.5.1). A significant loss of habitat-forming invertebrates like corals could result from increased water temperature and ocean acidification. The impacts of climate change on habitat-forming invertebrates are discussed in detail in Section 3.7.2.1. Potential impacts on benthic and water column invertebrates resulting from climate change include:

- An increase in the range and temporal variability of a water column's oxygen, salinity, and temperature, which could significantly alter the existing invertebrate community structure, particularly in nearshore areas;
- A reduction in important estuarine habitats from sea level rise;
- A range expansion of new invertebrate species into the GOM;
- An increase in the extent and duration of the GOM hypoxic zone that could kill or displace existing invertebrate communities and reduce the amount of suitable habitat available; and
- Reduced oceanic pH, which could reduce the fitness of calcifying marine organisms like corals, echinoderms, foraminiferans, and mollusks.

In addition, physiological and ecosystem-level stressors related to climate change may interact with non-climate-related anthropogenic stressors; these include overfishing, pollution, and habitat loss. For example, an increase in water temperature that results in physiological stress could make individuals more susceptible to stress from pollution or accidental oil spills.

Oil spills resulting from both OCS and non-OCS activities could impact invertebrate communities in the GOM. See Table 4.6.1-4 for anticipated oil spills over the life of the Program. Crude oil also enters the environment from naturally occurring seeps. Spills could occur from tankers carrying imported oil in the GOM. The potential effects of spills from non-OCS activities would be similar to those described for OCS activities (Section 4.4.7.5.1). In general, larger benthic and water column invertebrates that come into contact with oil would most likely move away from affected areas, while zooplankton and sessile or small infauna would not be able to avoid spills. Oil contacting invertebrates could have lethal or sublethal impacts. Any oil spills reaching shallow seagrass, estuarine, or coastal marine habitats could affect commercially important species such as shrimp, oysters, and blue crab that use these areas as spawning or juvenile nursery habitat. If they were to occur, deepwater surface spills could also affect invertebrate eggs and larvae, neuston communities such as jellyfish species, and *Sargassum*, together with any associated vertebrate and its invertebrate organisms. Because of the wide dispersal of invertebrates in the GOM surface waters, it is anticipated that only a relatively small proportion of early life stages present at a given time would be impacted by a particular oil spill event, which would limit the potential for population-level effects. The potential impacts of oil spills on invertebrate communities are discussed in Section 4.4.7.5.1.

Benthic and pelagic invertebrates are important trophic links that connect primary producers to higher-trophic-level organisms. Consequently, oil spill contamination on a large scale could result in contaminant transfer to higher trophic levels and/or reduce food availability to higher trophic levels if invertebrate populations were severely depressed by a CDE. Multiple investigations of the long-term impacts of the DWH event on invertebrates are ongoing and, over time, these studies will add to our understanding on of the impact of oils spills on invertebrates and will allow a better understanding of the potential for impacts to invertebrates at the population level. A description of these studies can be found at http://www.gulfspillrestoration.noaa.gov/oil-spill/gulf-spill-data.

Species Listed under the Endangered Species Act.

Elkhorn Coral. In much of its natural range, elkhorn coral has been adversely affected by the same anthropogenic stressors as other coral communities. Climate change may add to these stressors in the form of higher water temperatures, diseases, and ocean acidification, all of which can increase the frequency of bleaching. However, increasing surface water temperature may promote the northern expansion of elkhorn coral, increasing their abundance on the topographic features in the northern GOM. As discussed in Section 4.4.7.5.1, potential impacts from routine OCS operations would be minimized by existing stipulations, which prohibit exploration and development activities in the vicinity of the FGBNMS. Overall, the cumulative impacts on invertebrates would be moderate to major when considering OCS routine operations along with the significant impact to coral communities resulting from past, present, and future activities.

As discussed in Section 4.4.7.5.1, a CDE could also affect elkhorn corals, although the likelihood would be significantly reduced by the infrequency of a CDE and the stipulations prohibiting oil and gas activities in the vicinity of the FGBNMS. There is no evidence that elkhorn corals have been affected by oil spills either in the past or as a result of the recent DWH event. However, impacts to or extirpation of the elkhorn corals in the FGBNMS would not result in overall population-level impacts, as this species is primarily located in the southern GOM, Caribbean, and south Florida. Overall, the cumulative impacts of accidental spills on elkhorn coral would range up to moderate.

Conclusion. Cumulative impacts on invertebrate communities in the GOM as a result of ongoing and future OCS and non-OCS activities and natural phenomena could be moderate to major over the next 40 to 50 years. Non-OCS activities or phenomena affecting these resources include offshore LNG facilities, sand mining, sediment dredging and disposal, hypoxia, anchoring, fishing/trawling, offshore marine transportation, and pollutant inputs from point and non-point sources. The incremental contribution of routine Program activities to these impacts (mainly due to bottom-disturbing activities) would be negligible to medium, with the severity of the impacts generally decreasing with distance from bottom-disturbing activities. Several major classes of invertebrates could also be affected by naturally occurring oil seeps and the environmental changes predicted to result from climate change.

Invertebrate communities may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS activities as well as naturally occurring seeps. The cumulative impacts of past, present, and future oil spills on these resources would be minor to moderate. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on invertebrates would be negligible to small, depending on the location, timing, duration, and size of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and would range up to moderate if they were to occur. Spills in deeper water, whether from OCS or non-OCS sources, are unlikely to have overall population-level effects on invertebrate resources because of the relatively small proportion of similar available habitats that would come in contact with released oil at concentrations great enough to elicit toxic effects. A more detailed discussion of the effects of oil spills on invertebrates in the GOM is presented in Section 4.4.7.5.1.

4.6.4.2 Alaska Region – Cook Inlet

4.6.4.2.1 Mammals.

Marine Mammals. The cumulative analysis considers past, ongoing, and foreseeable future human and natural activities that may occur and adversely affect marine mammals in the same general area. These activities include effects of the OCS Program (proposed action and prior and future OCS sales), oil and gas activities in State waters, commercial shipping, commercial and subsistence fishing, recreational fishing and boating activities, military operations, scientific research, and natural phenomena. Specific types of impact-producing factors considered include noise from numerous sources, pollution, ingestion and entanglement in marine debris, vessel strikes, habitat degradation, subsistence harvests, military activities, industrial development, community development, climate change, and natural catastrophes. Section 4.4.7.1.2 provides the major impact-producing factors for the Program in Cook Inlet.

Routine Activities.

<u>OCS Activities.</u> Marine mammals and their habitats in the Cook Inlet Planning Area could be affected by a variety of exploration, development, and production activities as a result of the proposed and future OCS leasing actions (see Section 4.4.7.1.2). These activities include seismic exploration, offshore and onshore infrastructure construction, the discharge of operational wastes, and vessel and aircraft traffic. Impacts on marine mammals from these activities may include physical injury or death; behavioral disturbances; lethal or sublethal toxic effects; and loss of reproductive, nursery, feeding, and resting habitats. The degree of impact at the population level depends greatly on the status of the population (reflected in its listing under

the ESA) and the degree of disturbance or harm from OCS-related activities in areas important to species survival (i.e., feeding, breeding, molting, rookery, or haulout areas).

Potential impacts (primarily behavioral disturbance) on marine mammals from OCS-related seismic activity would be short-term and temporary and, therefore, would not result in greater than minor impacts on any affected species.

Impacts from OCS construction and operation activities could include the temporary disturbance and displacement of individuals or groups by construction equipment and long-term disturbance of some individuals from operational noise. No long-term, population-level effects would be expected because individuals most affected by these impacts would be those in the immediate vicinity of the construction site or operational platform and disturbance of individuals during construction would be largely temporary. In addition, appropriate mitigation measures could lessen the potential for impacts.

Operational and waste discharges (e.g., produced water, drilling muds, and drill cuttings) would be disposed of through downhole injection into NPDES-permitted disposal wells, and thus would not be expected to result in any incremental impacts on marine mammals. Liquid wastes (such as bilge water) may also be generated by OCS support vessels and on production platforms. While these wastes may be discharged (if permitted) into surface waters, they would be rapidly diluted and dispersed and would result in minor incremental impacts on marine mammals. Drilling and production wastes may contain materials such as metals and hydrocarbons, which can bioaccumulate through the food chain into the tissues of marine mammals. Although the bioaccumulation of anthropogenic chemicals has been reported for a variety of marine mammals, adverse impacts or population-level effects resulting from such bioaccumulation have not been demonstrated (Norstrom and Muir 1994; Muir et al. 1999).

Marine mammals could be temporarily disturbed by OCS vessel traffic (all species) or incur injury or death from collisions with support vessels (primarily larger, slower moving cetaceans). The low level of expected OCS vessel trips in the Cook Inlet Planning Area under the Program (one to three trips per week) would be a minor contribution to all vessel traffic occurring in the Cook Inlet. Noise from the one to three helicopter overflights expected each week would be transient in nature and be a minor component of all aircraft flights that occur within Cook Inlet. Overflights disturbing active rookery sites could result in decreased pup survival and in population-level impacts on some species, although overflight restrictions and flightline selection to avoid rookeries would greatly limit the potential for adversely affecting animals at these locations.

No platforms would be removed under the Program for the Cook Inlet Planning Area. It is possible that platforms would be removed from future lease sales or from platforms associated with oil and gas activities in State waters. There have been no documented losses of marine mammals resulting from explosive removals of offshore oil and gas structures, but there are sporadic incidents reported of marine mammals being killed by underwater detonations (Continental Shelf Associates 2004b; MMS 2007e, 2008a). Harassment of marine mammals as a result of a non-injurious physiological response to the explosion-generated shock wave, as well as to the acoustic signature of the detonation, is also possible. However, explosive platform removals would comply with appropriate BOEM or State guidelines and would not be expected to adversely affect marine mammals in Cook Inlet.

Non-OCS Activities. A number of non-OCS activities such as oil and gas exploration and development in State waters: commercial, subsistence, and recreational fishing; vessel traffic; and climate change could also affect marine mammals in the Cook Inlet Planning Area (or portions of the Gulf of Alaska that could be affected by activities in Cook Inlet). Many of the effects of these activities on marine mammals would be similar in nature to those resulting from OCS-related activities, namely, behavioral disturbance, habitat disturbance, injury or mortality, and exposure to toxic substances. Marine mammals may also be adversely affected by climate change.

Oil and Gas Exploration and Development in State Waters. The State of Alaska has made nearshore State lands available for leasing along the northern portion of Cook Inlet (above Homer). Exploration, construction, and operation activities associated with State leases would occur in nearshore and coastal areas, while OCS platforms and pipelines would be located away from coastal areas. Thus, State oil and gas leasing activities may be expected to have a greater potential for affecting marine mammals in coastal habitats than would the proposed OCS actions.

Commercial and Subsistence Fishing and Harvesting. Commercial and subsistence fishing has been identified as impacting many of the marine mammals in Alaskan waters (Allen and Angliss 2011). These fisheries employ a variety of methods, such as longlines, seines, trawls, and traps, and can result in the entanglement, injury, and death of individuals of marine mammal species. Fisheries also remove a portion of the prey base for some marine mammals. Subsistence harvest has targeted and continues to target some marine mammal species, especially some of the whale species.

The following are minimum reported estimated annual mortality rates incidental to commercial fisheries and subsistence harvests for marine mammals that occur in Cook Inlet and/or in the Gulf of Alaska that could be affected by the Program in Cook Inlet (Allen and Angliss 2011):

- The estimated minimum mortality rate for Western U.S. Stock of the Steller sea lion incidental to Alaska commercial fisheries is 26.2 animals per year. The best estimate of annual subsistence harvest of the Steller sea lion is 197 animals.

- The estimated minimum mortality rate for Eastern Pacific Stock of the northern fur seal incidental to Alaska commercial fisheries is 1.9 animals per year. The best estimate of annual subsistence harvest of the northern fur seal is 562 animals.

- The estimated minimum mortality rate for Gulf of Alaska Stock of the harbor seal incidental to Alaska commercial fisheries is 24 animals per year. The best estimate of annual subsistence harvest of the harbor seal is 807 animals.

- There are no reports of mortality incidental to commercial fisheries for the Cook Inlet Stock of the beluga whale. Annual subsistence harvest of Cook Inlet beluga whales ranged from 30 to over 100 between 1993 and 1999. Since 2000, subsistence harvests totaled only 11 whales, with no subsistence harvests allowed between 2008 and 2012 (Allen and Angliss 2011; NMFS 2008b).

- The estimated minimum mortality rate for the Alaska Resident Stock of the killer whale incidental to Alaska commercial fisheries is 1.2 animals per year. There are no reports of subsistence harvests of killer whales in Alaska.

- The estimated minimum mortality rate for the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient Stock of the killer whale incidental to Alaska commercial fisheries is 0.4 animal per year. There are no reports of subsistence harvests of killer whales in Alaska.

- There are no reports of mortality incidental to commercial fisheries or subsidence harvest for the ATI Transient Stock of the killer whale.

- There were no serious injuries or mortalities observed or reported incidental to commercial fisheries between 2002 and 2006 for the North Pacific Stock of the Pacific white-sided dolphin. However, between 1978 and 1991, thousands of individuals died annually incidental to high seas fisheries (these fisheries have not operated in the central North Pacific since 1991). There are no reports of subsistence harvests of Pacific white-sided dolphins.

- The estimated minimum mortality rate for the Gulf of Alaska Stock of the harbor porpoise incidental to commercial fisheries is 71.4 animals per year. There are no reports of subsistence harvests of the harbor porpoise. Two harbor porpoises were taken incidentally in subsistence gillnets in 1995.

- The estimated minimum mortality rate for the Alaska Stock of the Dall's porpoise incidental to commercial fisheries is 29.6 animals per year. There are no reports of subsistence harvests of the Dall's porpoise.

- The estimated minimum mortality rate for the North Pacific Stock of the sperm whale incidental to commercial fisheries in the Gulf of Alaska is 2.01 animals per year. There are no reports of subsistence harvests of the sperm whale. The sperm whale was the dominant species killed by the commercial whaling industry in the North pacific in the years following the Second World War.

- The estimated annual mortality rate for the Alaska Stock of Cuvier's beaked whale incidental to commercial fisheries is zero. There are no reports of subsistence harvests of the Cuvier's beaked whale.

- Serious injuries to or mortalities of Eastern North Pacific Stock of the gray whale occur throughout their range incidental to commercial fisheries and from strandings due to various causes. The annual mortality rate incidental to U.S. commercial fisheries is 3.3 whales. Annual subsistence take averaged 121 whales between 2003 to 2007. Russian Chukotka people take most of the gray whales. The U.S. Makah Indian Tribe has a yearly average quota of only 4 whales. In 2005, an unlawful subsistence hunt and kill of a gray whale occurred in Alaska.

- The Western North Pacific Stock of the humpback whale's feeding area includes the Gulf of Alaska. The estimated annual mortality incidental to U.S. commercial fisheries is 0.2 humpback whales per year based on one mortality observed in the Bering Sea sablefish pot fishery from 2002 through 2006. Bycatch in Japan and Korea average 1.1 to 2.4 humpback whales per year. The annual mortality rate for subsistence takes for the 2003 to 2007 period was 0.2 whales. The species received full protection in 1965; however, the Union of Soviet Socialist Republics (USSR) continued illegal catches until 1972. From 1961 through 1971, 6,793 humpback whales were illegally killed. Many of these were taken from the Gulf of Alaska and the Bering Sea.

- The Central North Pacific Stock of the humpback whale feeding area includes the Gulf of Alaska area that encompasses Cook Inlet. Based on observations from 2003 through 2007, the estimated annual mortality in Alaska is 3.4 animals per year from commercial fishery, 0.2 animals per year from recreational fishery, and 1.6 animals per year from vessel collisions. Subsistence harvesting is not allowed for humpback whales from the Central North Pacific Stock.

- There was one observed incidental mortality of a fin whale from the Northeast Pacific Stock in the Bering Sea/Aleutian Island pollock trawl fishery. No current or historical subsistence takes of this stock are reported from Alaska or Russia. Between 1925 and 1975, commercial whaling throughout the North Pacific killed 47,645 fin whales.

- For the Alaska Stock of the minke whale, the total estimated mortality and serious injury incidental to U.S. commercial fisheries for 2002 through 2006 was zero. Prior to that time, whale mortalities were very rare. Subsistence take by Alaska Natives is rare (e.g., only nine between 1930 and 1995).

- There are no records of North Pacific right whale mortalities incidental to U.S. commercial fisheries. There are no reported subsistence takes of the species in Alaska or Russia. Up to 37,000 North Pacific right whales were killed by whaling from 1839 to 1909; while 742 were killed by whaling from 1900 to 1999, in addition to 372 killed illegally, taken by the U.S.S.R., from 1963 through 1967, primarily in the Gulf of Alaska and Bering Sea, that left the population at an estimated 50 individuals (Allen and Angiss 2011; Encyclopedia of Life 2011).

- Based on commercial fisheries observer program results, fishing mortality and serious injury for the south central Alaska Stock of the northern sea otter is insignificant (i.e., approaches zero mortalities and serious injuries). The mean annual report of subsistence take for the stock from 2002 through 2006 was 346 animals.

- The total fishery mortality and serious injury rate for the Southwest Alaska stock of the northern sea otter is less than 10 animals per year. The mean annual report of subsistence take for the stock from 2002 through 2006 was 91 animals.

In addition to the above, no serious injuries or mortalities due to fisheries or subsistence have been reported for blue whales in Alaska (Carretta et al. 2011).

Climate Change. A concern regarding marine mammals in polar regions is the potential for climate change and associated changes in the extent of sea ice in some Arctic and subarctic waters. It is not possible at this time to identify the likelihood, direction, or magnitude of any changes in the environment of Cook Inlet waters due to changes in the climate, or how climate change could impact marine mammals in these waters. The current state of climate change and its impacts on marine mammals would also be further considered in any subsequent environmental reviews for lease sales or other OCS-related activities; therefore, this information is not essential to a reasoned choice among the alternatives presented in this PEIS (see Section 1.4.2).

Other Impacting Factors. Marine mammals in the Cook Inlet area may also be impacted by other factors such as UMEs and invasive species. A UME is an unexpected stranding that involves a significant die-off of any marine mammal population, and demands immediate response (NMFS 2011b). Since establishment of the UME program in 1991, there have been 55 formally recognized UMEs in the United States; two UMEs occurred in southern Alaska and involved sea otters (NMFS 2011b). Causes have been determined for 26 of the UMEs; they include infections, biotoxins (particularly domoic acid and brevetoxin), human interactions, and malnutrition. The cause of the UMEs in Alaska is undetermined (NMFS 2011b). Invasive species could affect some marine mammals by disrupting local ecosystems and fisheries of the area of Cook Inlet. For example, introduced northern pike (*Esox lucius*) consume salmon, trout, and whitefish, affecting total populations of these prey species where pike become established. The potential introductions of other invasive species of concern, such as the Chinese mitten crab (*Eriocheir sinensis*), which could eat and/or out compete native invertebrate species, could adversely affect natural communities (McClory and Gotthardt 2008). These and other invasive species could affect the prey base for some marine mammals. As climate change continues to warm Alaskan waters, Alaska may become more susceptible to invasive species (McClory and Gotthardt 2008).

Accidents. Marine mammals could be exposed to oil accidentally released from platforms, pipelines, and vessels in each of the areas offshore Alaska included in the proposed Program (Table 4.4.2-1). Non-OCS sources of oil in Cook Inlet may include the domestic transportation of oil, State oil and gas development, and natural sources such as seeps. Accidental oil releases from OCS activities and other sources could expose marine mammals to oil by body contact or through the inhalation or ingestion of oil or tar deposits. Indirect effects may occur as a result of loss or displacement of prey resources or habitat loss resulting from oil. The magnitude and duration of exposure will be a function of the location, timing, duration, and size of the spill; the proximity of the spill to feeding and other important habitats; the timing and nature of spill containment; and the status of the affected animals. Most expected small to medium spills (less than 1,000 bbl) would have limited effects on marine mammals due to the relatively small areas likely to incur high concentrations of hydrocarbons and the short period of time during which potentially toxic concentrations would be present. The magnitude of impact would be expected to increase should a spill occur in habitats important to marine mammals or affect a number of individuals from a population listed under the ESA, and, as such, a significant spill would have a high probability of producing significant, population-level cumulative impacts on Cook Inlet marine mammals.

Conclusion**.** Cumulative impacts on marine mammals in the Cook Inlet Planning Area as a result of future OCS program and ongoing and future non-OCS program activities could be minor to moderate over the next 40 to 50 years. Non-OCS program activities or phenomena include climate change, natural catastrophes, contaminant releases, vessel traffic, commercial fishing, subsistence harvests, and invasive species. The incremental contribution of routine Program activities to these impacts would be negligible to small (see Section 4.4.7.1.2).

Marine mammals may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS activities as well as naturally occurring seeps. The cumulative impacts of past, present, and future oil spills on marine mammals would be minor to moderate. The incremental impacts of expected accidental spills associated with the Program on marine mammals would be negligible to small, depending on the location, timing, and volume of the spills; the environmental settings of the spills; and the species exposed to the spills (Section 4.4.7.1.2). Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from minor to major if it were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to the impacts of spills regardless of size, but their incremental contribution to cumulative impacts is generally expected to be small. A more detailed discussion of the effects of oil spills on marine mammals in Cook Inlet is presented in Section 4.4.7.1.2.

Terrestrial Mammals. Terrestrial mammals and their habitats could be affected by a variety of activities associated with the proposed OCS actions (Section 4.4.7.1.2). These activities include the construction and operation of onshore pipelines and aircraft traffic. Impacts on terrestrial mammals may include physical injury or death; behavioral disturbances; lethal or sublethal toxic effects; and loss of reproductive, nursery, feeding, and resting habitats. There are currently no ongoing OCS activities in the Cook Inlet; thus all OCS development and any associated impacts on terrestrial wildlife in the Cook Inlet Planning Area would result from the Program and future actions.

Impacts from OCS pipeline construction and operation could include the injury or death of smaller mammals (such as mice and voles) and the disturbance and displacement of individuals or groups of larger species (such as deer and bear). Individuals most affected by these impacts would be those in the immediate vicinity of the pipeline. Because of the limited areal extent of new facilities under the Program, disturbance (primarily behavioral in nature) of most of these species during construction would be largely temporary, and no long-term population-level effects would be expected. However, careful siting of pipelines to avoid important habitats could minimize the potential impacts.

Under the Program, vehicle traffic associated with normal construction, operation, and maintenance of the onshore pipelines could disturb wildlife. Vehicle traffic could disturb wildlife foraging along pipelines or access roads, causing affected wildlife to temporarily stop normal activities (e.g., foraging, resting) or leave the area, while collision with vehicles could injure or kill some individuals. Because vehicle traffic would be infrequent, vehicle-related impacts associated with the Program would be minimal. In the Cook Inlet, vehicle traffic along any new access roads would be very light and infrequent and, thus, not expected to affect more than a few individuals or result in population-level impacts on wildlife.

In the Cook Inlet area, terrestrial mammals are mostly habituated to aircraft due to year-round military and civilian aircraft operations. Only up to three weekly helicopter trips are projected in the Cook Inlet Planning Area under the Program. Impacts on terrestrial mammals from helicopter overflights would be behavioral in nature, primarily resulting in short-term disturbance in normal activities, and would not result in population-level effects.

Terrestrial mammals could also be affected by a number of non-OCS activities, including oil and gas exploration and development in State waters, and coastal and community development. Many of the effects of these activities on terrestrial mammals would be similar in nature to those resulting from OCS-related activities, namely behavioral disturbance, habitat disturbance, and injury or mortality. The State of Alaska has made leases of State waters available along the northern portion of Cook Inlet (above Homer) since the 1950s. Impacts on terrestrial mammals that could result with oil and gas lease sales in State waters may exceed potential impacts that could occur under the OCS Program because of the greater extent of offshore and onshore development related to the State lease sales. In addition, much of the infrastructure is over 40 years old, and many of the pipes are aging and corroded (NMFS 2008c). Terrestrial mammals may be affected as a result of coastal and community development. Such development may result in the loss of habitat and the permanent displacement of some species from the developing areas. Implementation of the Program could increase coastal and community development, indirectly adding to impacts on terrestrial mammals and their habitats.

Terrestrial wildlife could be adversely affected by the accidental release of oil from an onshore pipeline, or by offshore spills contacting beaches and shorelines utilized by terrestrial mammals (such as Sitka black-tailed deer or brown bear). Impacts on terrestrial mammals from an oil spill would depend on such factors as the time of year, volume of the spill, type and extent of habitat affected, food resources used by the species, and home range or density of the wildlife species. Spills contacting high-use areas could locally affect a relatively large number of animals. It is anticipated that most of the spills would have limited effects on terrestrial mammals, due to the relatively small, mostly offshore, areas likely to be directly exposed to the spills and due to the small number and size of spills projected for the Program and for any future OCS oil and gas developments.

State oil and gas development poses a major potential for accidental oil releases in the Cook Inlet Planning Area. Because of the much greater level of oil and gas development in State waters and the aging infrastructure associated with many of these developments, accidental spills associated with the proposed OCS action could contribute relatively little to the overall potential exposure of terrestrial mammals to accidental oil releases in Cook Inlet.

Conclusion. Cumulative impacts on terrestrial mammals in the Cook Inlet Planning Area as a result of future OCS program and ongoing and future non-OCS activities could be minor to moderate over the next 40 to 50 years. Non-OCS activities or phenomena that may affect populations of terrestrial mammals include climate change, natural catastrophes, contaminant releases, and vehicle traffic. The incremental contribution of routine Program activities to these impacts would be negligible to small (see Section 4.4.7.1.2).

Terrestrial mammals may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS operations. The cumulative impacts of past, present, and future oil spills on terrestrial mammals would be minor to moderate. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on terrestrial mammals would be negligible to small, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and other important habitats; the timing and nature of spill containment; and the status of the affected animals (see Section 4.4.7.1.2).

An unexpected, low-probability CDE has a greater potential to affect terrestrial habitats; therefore, impacts could range from minor to major if one were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to the impacts of spills regardless of size, but their incremental contribution to cumulative impacts is generally expected to be small. A more detailed discussion of the effects of oil spills on terrestrial mammals in Cook Inlet is presented in Section 4.4.7.1.2.

4.6.4.2.2 Marine and Coastal Birds. Section 4.4.7.2.2 discusses impacts on marine and coastal birds in Cook Inlet resulting from the Program (OCS program activities from 2012 to 2017). Cumulative impacts on marine and coastal birds result from the incremental impacts of the Program when added to impacts from reasonably foreseeable future OCS program activities (that are not part of the Program) and other non-OCS program activities. Table 4.6.1-2 presents the exploration and development scenario for the Cook Inlet cumulative case (encompassing the Program and other OCS program activities) over the next 40 years. A number of OCS program activities could affect Cook Inlet marine or terrestrial birds or their habitats; these include offshore exploration, construction of offshore platforms and pipelines, construction of onshore pipeline landfalls and pipelines, operations of offshore and onshore facilities, and OCS-related marine vessel and aircraft traffic. Potential impacts on marine and coastal birds from OCS program activities include injury or mortality from collisions with platforms, vessels, and aircraft; lethal and sublethal exposure to operational discharges; injury or mortality from the ingestion of trash or debris from OCS vessels and platforms; loss or degradation of habitat due to construction; and behavioral disturbance due to the presence of, and noise generated by, equipment and human activity.

Non-OCS program activities affecting marine and coastal birds in Cook Inlet (both inside and outside of the Planning Area proper) include dredging and marine disposal; coastal and community development; onshore and offshore construction and operations of facilities associated with State oil and gas development and other industrial complexes (e.g., at Nikiski); commercial and recreational boating; and small aircraft traffic. Potential impacts on marine and coastal birds from these activities are similar to those under the OCS program and include injury or mortality of birds from collisions with platforms associated with State oil and gas development and other onshore and offshore structures (e.g., radio, television, or cell phone towers), onshore industrial, commercial, and residential development; exposure to discharges from permitted point sources such as sewage treatment discharges and nonpoint sources such as urban runoff, or accidental releases (e.g., oil spills), as described in Section 4.6.2.1.2 and Table 4.6.1-4; exposure to emissions from various onshore and offshore sources (e.g., power generating stations, refineries, and marine vessels), as described in Section 4.6.2.1.2; ingestion of trash or debris; loss or degradation of habitat due to construction and operations activities; and behavioral disturbance due to the presence of, and noise generated by, equipment and human activity. Other trends such as extensive melting of glaciers (and increasing river discharges) and increased precipitation brought on by global climate change are also expected to adversely affect marine and coastal birds over the next 40 years.

Injury or Mortality from Collisions. Under the cumulative scenario, annual collision injury or mortality in Cook Inlet could increase in the near term as platforms are built under the Program. Such impacts would be minor relative to those that currently involve non-OCS structures. Over time, the injury or mortality impacts from collisions could decrease as oil and gas production in the inlet declines.

Exposure to Wastewater Discharges and Air Emissions. The discharge of operational wastes and air emissions from current non-OCS related vessel traffic and platform operations in Cook Inlet is strongly regulated and would continue to be so regulated over the next 40 years. However, such wastes and emissions would still expose marine and coastal birds to potentially toxic materials or to solid debris that could be ingested or result in entanglement. These facilities and activities include sewage treatment plants, industrial manufacturing or processing facilities, electric generating plants, dredging and marine disposal, and vessel traffic (e.g., cargo and tanker ships, cruise ships, commercial fishing vessels, and recreational vessels). Operational wastewater discharges and air emissions associated with the Program would contribute to the overall cumulative risk of toxic exposure and debris ingestion or entanglement of existing non-OCS wastewater discharges and air emissions in the inlet, but the incremental increase in impact is expected to be small relative to these other activities.

Under the Program, marine and coastal birds could be exposed to oil accidentally released from platforms, pipelines, and vessels, and would be most susceptible to adverse impacts from spills occurring in coastal areas and affecting feeding and nesting areas. Most of the oil released to Cook Inlet is from commercial and recreational vessels (Section 4.6.2.2.1). Oil releases from all sources may expose marine and coastal birds via direct contact or through the inhalation or ingestion of oil or tar deposits (see Section 4.4.7.2.1).

Marine and coastal birds may become entangled in, or ingest, floating, submerged, and beached debris (Heneman and the Center for Environmental Education 1988; Ryan 1987, 1990). Entanglement may result in strangulation, injury or loss of limbs, entrapment, or the prevention or hindrance of the ability to fly or swim; all of these effects may be considered lethal. Ingestion of debris may irritate, block, or perforate the digestive tract, suppress appetite, impair digestion of food, reduce growth, or release toxic chemicals (Fry et al. 1985; Dickerman and Goelet 1987; Ryan 1988; Derraik 2002). Because the discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by BOEM (30 CFR 250.40) and the USCG (MARPOL, Annex V, Public Law 100 220 [101 Statute 1458]), entanglement in or ingestion of OCS-related trash and debris by marine and coastal birds would not be expected under normal operations.

Oil Spills and Cleanup Activities. Oil spills under the cumulative scenario are shown in Table 4.6.1-3. No more than one large spill (between 1,000 and 5,300 bbl from either a platform or a pipeline) and 18 small spills (less than 1,000 bbl) would be expected as a result of the Cook Inlet Planning Area OCS program over the next 40 years. Previous modeling of similar-sized oil spills in Cook Inlet indicates that land segments with the highest chance of contact with an offshore platform or pipeline spill are generally along the western shore of lower Cook Inlet in Kamishak Bay and Shelikof Strait (MMS 2002b). A large number of seabird colonies occur in these areas (USGS undated) and could be affected by oil spills reaching these areas.

Nesting and brood-rearing seabirds, waterfowl, and a few shorebirds, as well as the many species of waterfowl/loons, seabirds, and shorebirds that molt, stage, migrate through, or overwinter in large numbers in south central Alaska would be vulnerable to the potential disturbance resulting from elevated vessel and aircraft activity associated with cleanup of an oil spill. For all species, the degree of impact depends heavily on the location of the spill and cleanup response and its timing with critical natural behaviors (e.g., breeding, molting, feeding). Survival and fitness of individuals may be affected, but this infrequent disturbance is not expected to result in significant population losses.

As a result of response to the *Exxon Valdez* oil spill of 1989, and subsequent study of its effect on regional bird populations, there exists an extensive literature concerning the effects of a large oil spill in the South Alaska region (e.g., Agler and Kendall 1997; Boersma et al. 1995; Day et al. 1997a, b; *Exxon Valdez* Oil Spill Trustee Council 2004; Irons et al. 2000; Klowsiewski and Laing 1994; Lanctot et al. 1999; Murphy et al. 1997; Piatt and Ford 1996; Piatt et al. 1990; Rosenberg and Petrula 1998; van Vliet and McAllister 1994; Wiens et al. 2001). An estimated 100,000 to 300,000 marine birds died as a result of this spill (Piatt and Ford 1996), which occurred in March, when substantial numbers of overwintering birds were present in Prince William Sound and downstream to the west, and large numbers of seabirds were aggregating near colonies from Prince William Sound to the western Gulf of Alaska, prior to the breeding season. Although surveys and other studies carried out every year since the spill occurred indicate that populations of some marine bird species have recovered from their initial losses (e.g., common murre, black oystercatcher [*Exxon Valdez* Oil Spill Trustee Council 2004]), or are recovering (e.g., marbled murrelet), several species have shown little or no recovery (e.g., common loon, three cormorant species, harlequin duck, pigeon guillemot) or the recovery status is unknown (Kittlitz's murrelet). Although the effect on a bird population that is observed immediately following a spill to have suffered a large mortality is quite obvious, without frequent monitoring of each species following a spill it usually is difficult to be certain whether changes in measured population parameters are the result of lingering spill effects or natural variations that generally occur in all populations over time (Wiens and Parker 1995; Wiens 1996; Wiens et al. 2001). For example, forage fish populations utilized by many marine bird species may have experienced lingering spill effects of severe mortality or interruption of the annual cycle, in turn affecting food availability following the spill and thus influencing the effect of the spill on these bird populations or their recovery from it.

In addition to the birds occupying the open water of bays and inlets, shorebirds numbering in the tens to hundreds of thousands are at risk of oiling where they occupy various shore habitats during their spring passage to northern breeding areas (Gill and Tibbitts 1999). Particularly large numbers would be at risk on the southern Redoubt Bay, Fox River Delta, northern Montague Island, Kachemak Bay, and Copper River Delta, but substantial numbers may be at risk along most shorelines of the region during this season (Gill and Senner 1996; Gill and Tibbitts 1999; Alaska Shorebird Working Group 2000). Based on the experience of the *Exxon Valdez* oil spill, where studies extending 15 years after the event continue to find oil or effects on organisms from exposure to oil, it is highly probable that not all oil spilled would be removed from the environment. Because substantial numbers of birds are present year round in the marine environment of south central Alaska, major effects are expected to result from a spill at any time of year.

Loss or Degradation of Habitat. Marine and coastal birds could be affected by platform construction and removal activities, and pipeline trenching, which could disrupt behaviors of nearby birds. Platforms constructed under the Program would increase the number of offshore platforms present in the inlet by three, and up to 241 km (150 mi) of new offshore pipeline could be constructed. Platform emplacement could disturb birds temporarily; pipeline trenching may also affect birds in nearshore coastal habitats if it occurs in or near foraging, overwintering, or staging areas, or near seabird colonies. About 169 km (105 mi) of new pipeline and one pipeline landfall may be constructed under the Program. The pipelines would likely result in the short- and/or long-term disturbance of a small amount of habitat along the pipeline routes.

While habitat impacts from the construction and operations of onshore facilities could be long term in nature, the areas disturbed would be largely limited to the immediate vicinity of the pipelines and represent a very small portion of habitat available in the Cook Inlet Planning Area. Siting new pipelines and facilities away from coastal areas would reduce the amount of marine or coastal bird habitat that could be affected. Potential habitat impacts could be further reduced by locating the new pipelines within existing utility or transportation rights-of-way, and by locating the new pipeline landfalls away from active colony sites or coastal staging areas of migratory birds. Because there are relatively few nesting colonies in Cook Inlet of Anchor Point (USGS undated), only a few seabird colonies could be affected by onshore construction activities in this area. The disturbance of birds in these colonies could be reduced or avoided by siting new pipelines and facilities away from colony sites, and by scheduling construction activities to avoid nesting periods. Overall, onshore construction activities are expected to affect only a relatively small number of birds and not result in population-level effects.

Only small numbers of nesting birds are likely to be displaced away from the vicinity of onshore pipeline corridors (a few hundred meters) by construction activity and support vessel traffic in the Cook Inlet Planning Area. Onshore habitat alteration is likely to be relatively minor in most of the development support centers. Offshore, disturbance of bottom habitats by platform placement may disrupt small areas of potential diving duck and seabird foraging habitat, but these small removals would be inconsequential.

Construction of landfalls, onshore pads, and roads is not expected to affect the relatively low numbers of loons, waterfowl, and shorebirds nesting in south central Alaska adjacent to likely oil development areas, particularly because construction may take place mainly during the winter season. Like loons and waterfowl that do not migrate out of State, seabirds disperse into nearshore or offshore waters in winter, away from likely development activity.

Disturbance Due to Noise. Noise and human activities (such as normal maintenance) could disturb birds arriving in the area during spring migration and later in the year during nesting, fall molting, and staging periods, causing them to avoid the area and nearby habitats. Because of the small number of new platforms (no more than three), the disturbance of birds in offshore waters by operational noise and human activity would likely be limited to the individuals that might be present around a platform. Potential impacts on colonies could be avoided or mitigated by siting platforms and onshore facilities away from colony sites. Noise from air guns and disturbance from survey vessel traffic could displace foraging seabirds in offshore waters, especially if exploration occurs in high seabird density areas such as the open waters adjacent to the Stevenson and Kennedy Entrances to Cook Inlet and off of the northwestern coast of Kodiak Island (MMS 2003b).

Nesting, staging, migrant, or overwintering loons, waterfowl, and seabirds occurring in areas closer to primary Cook Inlet support facilities on the Kenai Peninsula and vicinity, for example, are more likely to be overflown by aircraft than those in more distant lease areas. This is due to the convergence of routes from offshore sites to the support area, and is expected to be the case in the Gulf of Alaska, Kodiak Island, and Alaska Peninsula areas, where there are few communities capable of adequate support activity. Effects from noise disturbance would be greater in areas where higher concentrations of birds occurred and less where birds were more dispersed and in fewer numbers. The degree of effect is also dependent on whether birds are engaged in critical aspects of their seasonal activity, as well as the intensity and type of disturbance (aircraft overflights, seismic surveys, vessel traffic). In addition, several open-water areas in the vicinity of Kachemak and Kamishak Bays represent important wintering areas (December–April) for the threatened Steller eider (USFWS unpublished data), and disturbance during the winter in these areas has a greater potential to affect this listed species.

Effects on ESA-Listed Species in South Central Alaska. The cumulative effects of OCS and non-OCS program activities on the endangered short-tailed albatross, threatened

Steller's eider, formerly threatened Aleutian Canada goose, and proposed Kittlitz's murrelet are expected to be similar to those noted for nonlisted species over the next 40 years. Continued compliance with ESA regulations and coordination with the USFWS would ensure that lease-specific OCS operations would be conducted in a manner likely to avoid or greatly minimize the potential for affecting these species.

Short-tailed albatrosses occur in waters of south central Alaska, and particularly in continental shelf waters, which places them at considerable oil-spill risk. Although their small population is spread throughout the North Pacific Ocean and few would be expected to be present during any given oil-spill event, the species has a high oil vulnerability index (King and Sanger 1979), and the loss of a few individuals could be detrimental to their small population size (MM 2003b). Because Aleutian Canada geese are not known to occupy marine waters during migration to any great extent, their risk of oil-spill contact in that habitat is considered low. It is unlikely that infrastructure development would occur near the two nesting areas, thus avoiding disturbance and onshore spills that could contact the species.

Factors such as disturbance due to increased boat traffic related to wildlife cruises and offshore oil and gas development, impacts related to oil spills, and a high oil vulnerability index (King and Sanger 1979) make the Kittlitz's murrelet particularly vulnerable to population declines. Although impacts of oil spills have been documented (van Vliet and McAllister 1994; Carter and Kuletz 1995), little is known about potential impacts of disturbance on courtship behavior, foraging ecology and feeding, or energetics (Day et al. 1999). The relatively small population size, limited distribution, apparent periodic breeding failures and low reproductive potential (Beissinger 1995), in conjunction with the above factors, has led to Kittlitz's status as a candidate species (priority 5; 50 CFR Part 17) under the ESA.

Steller's eiders occupying nearshore areas of the eastern Aleutian Islands to Cook Inlet from late fall to early spring could be exposed to the disturbance of air and vessel traffic, seismic surveys, oil-spill cleanup, and pipeline construction. Such activities would be scattered in occurrence, as are the flocks of eiders, or confined to specific corridors in the case of aircraft and vessels, which the flocks are likely to avoid. In general, interactions are expected to result in short-term and localized displacement. Pipeline construction is expected to result in the loss of a small amount of eider nearshore bottom-feeding habitat. Steller's eiders could be killed or injured as a result of collisions with platforms. This is most likely during migration; when visual conditions are reduced, such as in foggy weather; and during movement among habitats on wintering grounds. Because they typically are present throughout the winter, they are at risk for oil-spill contact, particularly in the northern portion of the region including Cook Inlet, where development may first occur, and potentially in the Kodiak Archipelago. However, mortality from a spill is difficult to estimate because of the substantial variation in between-year, seasonal, or even weekly presence and distribution of eiders and uncertainties of where an oil spill might occur. Based on USFWS assumptions, there is greater potential for the majority of individuals affected by factors discussed above to be from the Russian breeding population rather than the ESA-listed Alaska breeding population.

Kittlitz's murrelets typically show a very patchy distribution and are generally found in the vicinity of glaciated fjords of Cook Inlet, Prince William Sound, and southeast Alaska

(Kendall and Agler 1998; Day et al. 1999; Kuletz et al. 2003a). Exploration and development activities are expected to be separated in time, so exposure to disturbing factors such as aircraft and vessel traffic, seismic surveys, and pipeline construction could be infrequent and localized in areas where this species concentrates. There is a greater potential for effects if disturbance occurs in areas where murrelets concentrate and displacement becomes a possibility. In addition, the potential impacts from oil spills vary depending on the timing and location of the spill. For example, oil spills in College or Harrison Fjords during peak breeding or post-breeding would have larger impacts and could cause population-level effects, especially if birds come in contact with spilled oil or larger numbers of breeding age females are impacted. A large spill is likely to spread over a sufficiently large area to contact one or more bays where they may be concentrated during the summer breeding season, or offshore areas where they may be wintering in the Gulf of Alaska. For example, the *Exxon Valdez* oil spill resulted in the loss of an estimated 500 to 1,000 individuals, probably a substantial proportion of the world population, and certainly a major effect on this species.

Conclusion. Marine and coastal birds in Cook Inlet, including those that are ESA-listed, could be adversely affected by activities associated with the Program, as well as those associated with future OCS and non-OCS program activities. Potential impacts include injury or mortality of birds from collisions with platforms associated with OCS and State oil and gas development and other onshore and offshore structures (e.g., radio, television, or cell phone towers), onshore industrial, commercial, and residential development; exposure to discharges from permitted point sources such as sewage treatment discharges and nonpoint sources such as urban runoff, or accidental releases (e.g., oil spills); exposure to emissions from various onshore and offshore sources; ingestion of trash or debris; loss or degradation of habitat due to construction and operations activities; and behavioral disturbance due to the presence of, and noise generated by, equipment and human activity. Other trends such as extensive melting of glaciers (and increasing river discharges) and increased precipitation brought on by global climate change are also expected to adversely affect marine and coastal birds over the next 40 to 50 years. While the cumulative impact of all OCS and non-OCS activities in Cook Inlet could be minor to moderate, the incremental contribution due to routine Program activities would be negligible to medium (see Section 4.4.7.2.2). Compliance with ESA regulations and coordination with the USFWS would ensure that lease-specific OCS operations would be conducted in a manner that is likely to avoid or to greatly minimize the potential for affecting these species.

Marine and coastal birds may also be adversely affected by exposure to oil (via direct contact or through the inhalation or ingestion of oil or tar deposits) that is accidentally released from OCS and non-OCS activities, especially near coastal areas and affecting feeding and nesting areas. The incremental contribution of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on marine and coastal birds would be small to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and nesting areas; the timing and nature of spill containment; and the status of the affected birds (see Section 4.4.7.2.2). Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from moderate to major if it were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to the impacts of spills regardless of size, but their incremental contribution to cumulative impacts is generally expected to be small. A more detailed discussion of the effects of oil spills on marine and coastal birds in Cook Inlet is presented in Section 4.4.7.2.2.

Whether net cumulative impacts are minor or moderate depends on the nature and duration of activities that reduce bird survival and productivity. Losses would be limited in areas occupied by scattered flocks during relatively brief staging and migration periods or scattered nest sites during the brief nesting season; however, in cases for which exposure to localized disturbance is greater, impacts have the potential to rise to the population level.

4.6.4.2.3 Fish. Section 4.4.7.3.2 discusses direct and indirect impacts on fish communities in Cook Inlet resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on these resources result from the incremental impacts of the Program (described in Section 4.4.6.1.1) when added to impacts from ongoing and reasonably foreseeable future actions, including those of future OCS programs and other non-OCS activities. Table 4.6.1-3 presents the exploration and development scenario for the Cook Inlet cumulative case, which takes into account activities associated with the Program in combination with those from ongoing and future OCS programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in Cook Inlet are summarized in Table 4.6.1-6 and discussed below, as applicable.

The primary routine OCS activities in the Cook Inlet Planning Area that could result in impacts on fish include seismic surveys, drilling, platform and pipeline placement; releases of permitted discharges from wells; and removal of existing structures. Potential environmental impacts associated with the building and operation of OCS facilities such as platforms and pipelines would increase in conjunction with the increased number of wells. The impacts of routine activities (exploration and site development, production, and decommissioning) on fish communities are discussed in detail in Section 4.4.7.3.2. Overall, routine activities represent up to a minor disturbance, primarily affecting demersal fishes, with the severity of the impacts generally decreasing dramatically with distance from bottom-disturbing activities.

In the Cook Inlet Planning Area, up to three platforms would be constructed, all of which would result from the Program. The addition of new platforms may act as FADs that would attract rockfish and cod-like fishes in Cook Inlet. While some platforms may be allowed to remain as artificial reefs, removal of platforms would reduce available substrate and structures for these fish and some of their prey species. Some fish would be killed in the process of these platform removals although the chance of mortality would be greatly reduced by the fact that explosives would not be used in removal.

Oil and gas exploration and development in State waters could also contribute to cumulative effects on fishery resources in the Cook Inlet. Drilling of wells in State waters could also require construction of platforms and pipelines in waters of Alaska. The effects on fish would be similar to those described above for OCS oil and gas programs (Section 4.4.7.3.2). Other non-OCS activities that could impact fish communities include land use practices, point and non-point source pollution, logging, dredging and disposal of dredging spoils in OCS waters, anchoring, and commercial or sportfishing activities, and commercial shipping (including imported oil). Many of these activities would result in bottom disturbance that would affect bottom-dwelling fishes as well as their food sources in a manner similar to those described for OCS activities (Section 4.4.7.3.2).

Logging could also degrade riverine habitats that are important reproductive and juvenile habitat for migratory fish species. Erosion from areas undergoing commercial logging could increase the silt load in streams and rivers, which could reduce levels of invertebrate prey species and adversely affect spawning success and egg survival. The introduction of fine sediments into spawning gravels may render these habitats unsuitable for salmon spawning. Logging could also remove riparian canopies along some streams, which could increase solar heating of freshwater habitats. Downed timber could physically block salmon migrations. Because of past damage inflicted by commercial logging, improved forestry practices have been initiated, and timber harvests have been curtailed. Continued implementation of effective forest management techniques should help mitigate the adverse effects of logging in the future. Cumulative impacts on migratory species could also occur as a result of activities that obstruct fish movement in marine environments during migration periods.

Commercial fishing practices that are indiscriminate, such as trawling and pots, are responsible for significant amounts of bycatch that can injure or kill juveniles of many fish species (Cooke and Cowx 2006). These types of fishing practices could damage future year classes, reduce available prey species, and damage benthic habitat for many Cook Inlet fish resources. A wide variety of methods are used to target numerous species of fishes and shellfishes, including longlines, seines, setnets, trawls, and traps. Some fisheries target particular fish species returning to their natal stream or river, while other fisheries take place in pelagic waters and target mixed stocks of fishes or shellfishes.

As a consequence of the pressure commercial fishing places on fishery resources, appropriate management is required to reduce the potential for depletion of stocks due to overharvesting. Fisheries in the Cook Inlet Planning Area are managed by State (Alaska Department of Fish and Game) and Federal (North Pacific Fishery Management Council of the National Marine Fisheries Service) agencies. Even with management, the possibility of overfishing still exists. Occasionally fisheries are closed when stocks are considered insufficient to support harvesting, and will sometimes remain closed for multiple seasons before stocks are deemed sufficient.

Although the magnitude of harvests is considerably smaller than for commercial fisheries (Fall et al. 2009), sportfishing also contributes to cumulative effects on the abundance of some fishery resources. Recreational fisheries have a potential to result in overharvest of managed species over the life of the Program. Recreational fishing is subject to harvest limits that reduce the potential for overfishing and recreational fishing methods are less destructive of EFH compared to commercial fisheries.

Subsistence fishing may also contribute to the cumulative effects on the abundance of some fishery resources. Alaska State law defines subsistence as the "noncommercial customary and traditional uses" of fish and wildlife. Subsistence fishing is subject to harvest limits that reduce the potential for overfishing. Also, much of Cook Inlet is defined as a nonsubsistence area and subsistence fishing is therefore not authorized. Consequently, subsistence fishing makes a relatively minor contribution to the reduction in fish stocks compared to commercial fishing (Fall et al. 2009).

Another source of cumulative impacts to fishery resources is the "personal use" fishery which is a legally defined as "the taking, fishing for, or possession of finfish, shellfish, or other fishery resources, by Alaska residents for personal use and not for sale or barter, with gill or dip net, seine, fish wheel, long line, or other means defined by the Board of Fisheries." In the Cook Inlet Planning Area, there are personal use fisheries for salmon, herring, and eulachon. Personal use fisheries are subject to harvest limits that reduce the potential for overfishing. Like subsistence fishing, the personal use fishery is a relatively minor contributor to the reduction in fish stocks compared to commercial fishing.

Climate change may affect fish communities in the Cook Inlet Planning Area and interact with past, present, and future OCS and non-OCS stressors. Physiological and ecosystem-level stressors related to climate change may interact with the non-climate-related anthropogenic stressors such as overfishing, pollution, and habitat loss discussed above. For example, a climate change–related increase in water temperature that results in physiological stress could make individuals more susceptible to stress from pollution or accidental oil spills. Fish respond directly to climate fluctuations, as well as to changes in their biological environment including predators, prey, species interactions, disease, and fishing pressure. Projected changes in hydrology and water temperatures, salinity, and currents could affect the growth, survival, reproduction, and spatial distribution of marine fish species and of the prey, competitors, and predators that influence the dynamics of these species (Watson et al. 1998). Changes in primary production levels in the ocean because of climate change may affect fish stock productivity.

Climate change could potentially affect large-scale ecological processes. Important coastal habitats could be reduced or eliminated by rising sea levels and increased storm damage. For species spawning in low-lying areas or the intertidal zone, or species using coastal estuaries as nursery grounds, rising sea levels could eliminate spawning or juvenile habitat. Anadromous fish and species using nearshore marshes are likely to be most affected. In addition, the current trend of steadily increasing sea surface temperature may favor higher trophic-level fish by increasing their local productivity or by promoting the expansion of large temperate predators into Alaskan waters (Litzow 2006). The establishment of temperate species and non-native fish introduced by human activities could come at the expense of native species, particularly forage fish like herring and capelin. However, given the complexity and compensatory mechanisms of the ecosystem, predictions about the indirect effects of climate change on specific fish species are subject to great uncertainty.

Oil spills could result from OCS and non-OCS activities. The total number of oil spills and the extent of affected areas would likely increase under the Program in conjunction with increased levels of petroleum exploration and production (Table 4.6.1-4). Non-OCS activities, such as oil and gas development in State waters, domestic transportation of oil or refined petroleum products, and commercial shipping, may also result in accidental spills that could potentially impact fish resources within the Cook Inlet Planning Area. While effects on fishery resources would depend on the timing, location, and magnitude of specific oil spills, it is anticipated that most small to medium spills that occur in OCS waters would have limited effects on fishery resources due to the relatively small areas likely to be exposed to high concentrations of hydrocarbons and the short period of time during which potentially toxic concentrations would be present. Most adult fish in marine environments are highly mobile and may avoid high concentrations of hydrocarbons, although they may be subject to sublethal exposures. However, eggs and larvae as well as small obligate benthic species do not have the ability to avoid spills and may therefore suffer lethal or sublethal effects. Oil from a catastrophic spill that reaches shallower, nearshore areas of these planning areas has the potential to be of greatest significance to fish communities. Impacts from such spills could result in long-term, population level impacts on fish communities. The potential impacts of OCS oil spills on fish communities in Cook Inlet are discussed in detail in Section 4.4.7.3.2.

Oil reaching salmon spawning areas, nursery areas, or migration routes has the greatest potential to reduce salmon stocks. However, because of the limited area affected by oil spills relative to the wide pelagic distribution and highly mobile migratory patterns of salmonids, it is anticipated that most impacts would be limited to small fractions of exposed salmon populations. Oil spills occurring at constrictions in migration routes would have an increased potential for adversely affecting salmon. However, the weathering and dispersal of the spilled oil would limit the length of time that an area would be affected. Pacific salmon are also able to detect and avoid oil spills in marine waters (Weber et al. 1981), which would help to reduce the potential for contact. Aggregations of salmon in marine waters typically consist of mixed stocks, so even in the unlikely event of contact with an oil spill, it is anticipated that only a small fraction of any unique spawning population would be adversely affected.

Adverse effects of oil spills on groundfishes of south central Alaska would also be a function of spill magnitude, location, and timing. Adult groundfishes are primarily demersal and would generally be subjected only to the insoluble oil and water-soluble fractions of oil that reach deeper strata. Insoluble oil fractions would sink to the bottom and be distributed diffusely as tar balls over a wide area, and would be unlikely to produce noticeable reductions in the overall numbers of adult fishes. Egg and larval stages would be at a greater risk of exposure to oil spills because spawning aggregations of many groundfish species (e.g., walleye pollock) produce pelagic eggs that could come into contact with surface oil slicks. Herring are also potentially susceptible to oil spills because they spawn in nearshore waters for protracted periods of time.

In addition to effects on individuals and species, impacts to fish can result in ecosystem-level effects if the population impacts are significant. For example, fish can occupy a number of trophic levels ranging from herbivore to top level carnivore. As such, fish are critical to energy flow within nearshore and marine food webs. They are also seasonally important food sources to transient carnivores. Consequently, impacts to fish can propagate throughout the food web, affecting birds and marine mammals. In addition, many Alaskan fishes, particularly salmonids, migrate between and within marine, estuarine, and freshwater habitats. In doing so, they transfer nutrients and carbon over a broad area and connect offshore and freshwater and terrestrial ecosystems (Naiman et al. 2002). Significant impacts to fish populations could reduce this transfer, resulting in local changes in productivity.

Conclusion. Cumulative impacts on fish communities in Cook Inlet as a result of ongoing and future OCS and non-OCS activities and natural phenomena could be moderate to major over the next 40 to 50 years. Non-OCS activities or phenomena affecting these resources include oil and gas development in State waters, sediment dredging and disposal, logging, anchoring, fishing/trawling, commercial shipping, and pollutant inputs from point and non-point sources. Many of these activities would affect fish at various life stages as well as their food sources in a manner similar to OCS activities. The incremental contribution of routine Program activities to these impacts (primarily as a result of displacement, injury or mortality of fish and their food sources) would be negligible to small. Fish could also be affected by the environmental changes predicted to result from climate change.

Fish communities may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS activities as well as naturally occurring seeps. The cumulative impacts of past, present, and future oil spills on these resources would be minor to moderate. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on fish would be negligible to medium, depending on the location, timing, duration, and volume of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities. Impacts associated with unexpected large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and could range up to moderate if it were to occur. Oil from large spills or a CDE has the greatest potential to contact shoreline areas used for spawning or providing habitat for early life stages of fish and, therefore, could result in large-scale lethal and long-term sublethal effects on fish. Oil is slow to break down in Alaskan waters; therefore, oiling could measurably depress some fish populations for several years. A more detailed discussion of the effects of oil spills on fish in Cook Inlet is presented in Section 4.4.7.3.2.

4.6.4.2.4 Invertebrates and Lower Trophic Levels. Section 4.4.7.5.2 discusses direct and indirect impacts on invertebrates and lower trophic levels in Cook Inlet resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on these resources result from the incremental impacts of the Program (described in Section 4.4.6.1.1) when added to impacts from ongoing and reasonably foreseeable future actions, including those of ongoing and future OCS programs and other non-OCS activities. Table 4.6.1-3 presents the exploration and development scenario for the Cook Inlet cumulative case, which takes into account activities associated with the Program in combination with those from ongoing and future OCS programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in the GOM are summarized in Table 4.6.1-6 and discussed below, as applicable.

The primary routine OCS activities that could result in impacts on invertebrates include seismic surveys, drilling, platform and pipeline placement; releases of permitted discharges from wells; and removal of existing structures. Potential environmental impacts associated with the building and operation of OCS facilities such as platforms and pipelines would increase in conjunction with the increased number of wells. The impacts of routine activities (exploration and site development, production and decommissioning) on invertebrate communities are discussed in detail in Section 4.4.7.5.2. Overall, routine activities represent up to a moderate disturbance, primarily affecting benthic infaunal invertebrates, with the severity of the impacts generally decreasing dramatically with distance from bottom-disturbing activities.

Up to three platforms could be constructed over the life of the Program, all of which would result from the Program, would allow the colonization of invertebrates requiring hard substrate. While some platforms may be allowed to remain as artificial reefs, removal of platforms will reduce available substrate and structures for invertebrates and injure or kill them during removal.

Oil and gas exploration and development in State waters could also contribute to cumulative effects on invertebrates in the Cook Inlet Planning Area. Drilling of wells in State waters could also require construction of platforms and pipelines in waters of Alaska. The effects on invertebrates would be similar to those described above for OCS oil and gas programs (Section 4.4.7.5.2). Other non-OCS activities that could impact invertebrate communities include land use practices, point and non-point source pollution, logging, dredging and disposal of dredging spoils in OCS waters, anchoring, commercial or sportfishing activities, and commercial shipping (including shipping of imported oil). Many of these activities would affect bottom-dwelling invertebrates at various life stages as well as their food sources in a manner similar to OCS bottom-disturbing activities (Section 4.4.7.5.2). Other non-OCS activities generating pollution and noise may contribute to general habitat degradation (Section 4.6.3.2.2).

Commercial fishing practices that are indiscriminate, such as trawling and pots, are responsible for significant amounts of bycatch that can injure or kill juveniles of many invertebrate species. These types of fishing practices could also damage benthic habitat for many Cook Inlet invertebrate resources.

Physical and chemical changes to invertebrate habitat resulting from climate change could alter the existing distribution, composition, and abundance of invertebrates in Cook Inlet, since physical and chemical parameters are the primary influence on invertebrate communities. For example, the increase in seawater temperature may facilitate a northward expansion of subarctic and temperate invertebrate species. Rising seawater temperatures are also expected to decrease winter ice extent and duration. Currently, ice formation primarily occurs on the western side of Cook Inlet, and changes in benthic invertebrate community structure could result from the reduction in ice scour. In addition, in heavily river influenced systems like Cook Inlet, the predicted hydrologic alterations associated with climate change can rapidly alter existing invertebrate communities in the water column and benthos if the new chemical conditions are not within the physiological tolerance of the existing communities. Another significant source of physiological stress is the expected increase in ocean acidification. Crustaceans, echinoderms, foraminiferans, and mollusks could have greater difficulty in forming shells, which could result in a reduction in their fitness, abundance, and distribution (Fabry et al. 2008).

Oil spills could result from OCS and non-OCS activities. The total number of oil spills and the extent of affected areas would likely increase under the Program in conjunction with increased levels of petroleum exploration and production (Table 4.6.1-3). Non-OCS activities, such as oil and gas development in State waters, domestic transportation of oil or refined petroleum products, and commercial shipping, may also result in accidental spills that could potentially impact invertebrate resources within the Cook Inlet Planning Area. While effects on invertebrate resources would depend on the timing, location, and magnitude of specific oil spills, it is anticipated that most small to medium spills that occur in OCS waters would have limited effects due to the relatively small areas likely to be exposed to high concentrations of hydrocarbons and the short period of time during which potentially toxic concentrations would be present. Large water column and benthic invertebrates are mobile and therefore have the potential to avoid high concentrations of hydrocarbons although they may be subject to sublethal exposures. However, zooplankton and infauna do not typically have the ability to avoid spills and may therefore suffer lethal or sublethal effects. Oil from catastrophic spills that reaches shallower, nearshore areas of the Cook Inlet Planning Area has the potential to be of greatest significance to invertebrate communities. Impacts from such spills could result in long-term, population-level impacts on intertidal invertebrate communities. Benthic and pelagic invertebrates are important trophic links that connect primary producers to higher-trophic-level organisms. Consequently, oil spill contamination on a large scale could result in contaminant transfer to higher trophic levels and/or in reduced food availability to higher trophic levels if invertebrate populations were severely depressed by a CDE. The potential impacts of OCS oil spills on invertebrate communities in Cook Inlet are discussed in detail in Section 4.4.7.5.2.

Commercial shellfish stocks (such as tanner, snow, and red king crab) are unlikely to be exposed to surface oil. Although soluble and insoluble hydrocarbon fractions could reach deeper strata, these fractions would be distributed diffusely over wide areas and would likely not constitute a threat to shellfish stocks. Pelagic crab larvae could be affected if a large surface oil spill occurred during the spring spawning season. However, because the area affected by most spills would be expected to be small relative to overall distributions of crab larvae, overall population levels are unlikely to be noticeably affected.

Conclusion. Cumulative impacts on invertebrate communities in the Cook Inlet Planning Area as a result of ongoing and future OCS and non-OCS activities and natural phenomena could be moderate to major over the next 40 to 50 years. Non-OCS activities or phenomena affecting these resources include oil and gas production in State waters, sediment dredging and disposal, logging, anchoring, fishing/trawling, commercial shipping, and pollutant inputs from point and non-point sources. The incremental contribution of routine Program activities to these impacts (mainly due to bottom-disturbing activities) would be negligible to medium, with the severity of impacts generally decreasing with distance from the disturbance. Several major classes of invertebrates could also be affected by naturally occurring oil seeps and the environmental changes predicted to result from climate change. Invertebrate communities may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS activities as well as naturally occurring seeps. The cumulative impacts of past, present, and future oil spills on these resources would be minor to moderate. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on invertebrates would be negligible to small, depending on the location, timing, duration, and size of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and could range up to moderate if it were to occur. Spills in deeper water, whether from OCS or non-OCS sources, are unlikely to have overall population-level effects on invertebrate resources because of the relatively small proportion of similar available habitats that would come in contact with released oil at concentrations great enough to elicit toxic effects. A CDE could also contaminate or reduce the abundance of seasonally abundant copepods, which may in turn impact higher trophic levels. A more detailed discussion of the effects of oil spills on invertebrates in Cook Inlet is presented in Section 4.4.7.5.2.

4.6.4.3 Alaska Region – Arctic

4.6.4.3.1 Mammals.

Marine Mammals. The cumulative analysis considers past, ongoing, and foreseeable future human and natural activities that may occur and adversely affect marine mammals in the Arctic Planning Areas. These activities include effects of the OCS Program (Programs and prior and future OCS sales), oil and gas activities in State waters, shipping, commercial fishing, recreational fishing, subsistence fishing, personal-use fishing, and boating activities, military operations, scientific research, and natural phenomena. Specific types of impact-producing factors considered include noise from numerous sources, pollution, ingestion and entanglement in marine debris, vessel strikes, habitat degradation, subsistence harvests, military activities, industrial development, community development, climate change, and natural catastrophes. Section 4.4.7.1.3 provides the major impact-producing factors related to the Program in Cook Inlet.

Routine Activities.

OCS Activities. Marine mammals and their habitats in the Arctic Planning Areas could be affected by a variety of exploration, development and production activities as a result of the proposed and future OCS leasing actions (see Section 4.4.7.1.3). These activities include seismic exploration, offshore and onshore infrastructure construction, the discharge of operational wastes, and vessel and aircraft traffic. Impacts to marine mammals from these activities may include physical injury or death; behavioral disturbances; lethal or sublethal toxic effects; and loss of reproductive, nursery, feeding, and resting habitats. The degree of impact at the population level depends greatly on the status of the population (reflected in its listing under the ESA) and the degree of disturbance or harm from OCS-related activities in areas important to species survival (i.e., feeding, breeding, molting, rookery or haulout areas).

Potential impacts (primarily behavioral disturbance) to marine mammals from OCS-related seismic activity would be short-term and temporary, and not expected to result in population level impacts for any affected species if appropriate mitigation measures are implemented.

Impacts from OCS construction and operation activities could include the temporary disturbance and displacement of individuals or groups by construction equipment and long-term disturbance of some individuals from operational noise. No long-term, population-level effects would be expected because individuals most affected by these impacts would be only those in the immediate vicinity of the construction site or operational platform and disturbance of individuals during construction would be largely temporary. In addition, appropriate mitigation measures could lessen the potential for impacts.

Operational and waste discharges (e.g., produced water, drilling muds, and drill cuttings) would be disposed of through downhole injection into NPDES-permitted disposal wells, and thus would not be expected to result in any incremental impacts to marine mammals. Liquid wastes (such as bilge water) may also be generated by OCS support vessels and on production platforms. While these wastes may be discharged (if permitted) into surface waters, they would be rapidly diluted and dispersed, and would not be expected to result in any incremental impacts to marine mammals from exposure to these wastes. Drilling and production wastes may contain materials such as metals and hydrocarbons, which can bioaccumulate through the food chain into the tissues of marine mammals. Although the bioaccumulation of anthropogenic chemicals has been reported for a variety of marine mammals, adverse impacts or population-level effects resulting from such bioaccumulation have not been demonstrated (Norstrom and Muir 1994; Muir et al. 1999).

Marine mammals could be temporarily disturbed by OCS vessel traffic (all species) or incur injury or death from collisions with support vessels (primarily larger, slower moving cetaceans). The low level of OCS vessel trips in the Arctic Planning Areas under the Program would likely limit potential cumulative impacts to a few individuals, be largely short-term in nature, and not result in population-level effects. Noise from helicopter overflights would be transient in nature. Impacts to marine mammals would be behavioral in nature, primarily resulting in short-term disturbance in normal activities, and would not be expected to result in population-level effects. Overflights and vessels could disturb pinnipeds on rookeries and haul-outs. In particular, disturbance of walruses can cause stampedes, where younger animals and calves can be killed, possibly causing population-level impacts to some species. Appropriate mitigation measures such as overflight restrictions and flightline selection to avoid rookeries and haul-outs would limit the potential for adversely affecting animals at these locations.

No platforms would be removed under the Program for the Arctic Planning Areas.

Non-OCS Activities. A number of non-OCS activities such as oil and gas exploration and development in State waters, subsistence harvests, vessel traffic, and climate change could also affect marine mammals in the Arctic Planning Areas. Many of the effects of these activities on marine mammals would be similar in nature to those resulting from OCS-related activities, namely, behavioral disturbance, habitat disturbance, injury, or mortality, and exposure to toxic substances. Marine mammals may also be adversely affected by climate change.

<u>Oil and Gas Exploration and Development in State Waters.</u> The State of Alaska has made nearshore State lands available for leasing along the Beaufort Sea coast. The exploration activities (and associated impacts to marine mammals) that could result with State oil and gas lease sales may greatly outnumber exploration activities (and potential impacts to marine mammals) that could occur under the OCS Program.

Exploration, construction, and operation activities associated with State leases would occur in nearshore and coastal areas, while OCS platforms and pipelines would be located away from coastal areas (with the exception of relatively few pipeline landfalls and onshore bases and processing facilities). Thus, State oil and gas leasing activities may be expected to have a greater potential for affecting marine mammals in coastal habitats than would the proposed OCS actions.

Subsistence Harvesting. Subsistence harvesting has been identified as impacting marine mammals in Alaskan waters (Allen and Angliss 2011). However, annual mortality from subsistence harvests is considered to have little adverse effect on most marine mammal populations or stocks. The following are the reported estimated annual Alaska-wide subsistence harvests for marine mammals that occur in the Beaufort and/or Chukchi Seas (Allen and Angliss 2011):

- The best estimate of annual subsistence harvest of spotted seals is 5,265 animals.
- The best estimate of annual subsistence harvest of bearded seals is 6,788 animals.
- The best estimate of annual subsistence harvest of ringed seals is 9,567 animals.
- The best estimate of annual subsistence harvest of ribbon seals is 193 animals.
- The best estimate of annual subsistence harvest for the Beaufort Sea beluga whale stock is 139 animals, which includes 25 individuals in Alaska and 114 individuals in Canada.
- The best estimate of annual subsistence harvest for the Eastern Chukchi Sea beluga whale stock is 59 animals.
- There are known subsistence harvests of narwhals by Alaska Natives.
- There are no known subsistence harvests of the Bering Sea stock of harbor porpoises by Alaska Natives. However, Suydam and George (1992) noted that individuals from this stock have been entangled in subsistence nets.
- Annual subsistence take of grey whales averaged 121 individuals between 2003 to 2007. Russian Chukotka people take most of the gray whales. The U.S. Makah Indian Tribe has a yearly average quota of 4 whales. In 2005, an unlawful subsistence hunt and kill of a gray whale occurred in Alaska.
- No subsistence takes of the Northeast Pacific stock of fin whales are reported from Alaska or Russia.

- Subsistence take of minke whales by Alaska Natives is rare (e.g., only nine between 1930 and 1995).

- Alaska Native subsistence hunters take 14 to 72 bowhead whales per year (0.1 to 0.5% of the population). Russian and Canadian subsistence hunters also take a few bowhead whales. The annual subsistence take from 2004 to 2008 for Alaska, Russian, and Canadian Natives averaged 41.2 bowhead whales. Several cases of fishing rope or net entanglement have been reported from whales taken in subsistence hunts.

- The 1925 to 1953 estimated annual Alaska harvests of polar bears for subsistence, handicrafts, and recreation was 120 animals. Recreational harvests by non-Native sports hunters using aircraft averaged 150 annually from 1951 to 1960 and 260 annually from 1960 to 1972. A prohibition on non-Native hunting became effective in 1973. The annual subsistence harvests for the Chukchi/Bering Seas stock was 92/year in the 1980s, 49/year in the 1990s, and 43/year in the 2000s.

- The annual harvests for the Southern Beaufort Sea polar bear stock was 39/year in the 1980s, 33/year in the 1990s, and 32/year in the 2000s.

- The estimated annual subsistence harvest mortalities for the Pacific walrus from 2003 to 2007 averaged from 4,960 to 5,457 animals/year. This includes 1,630 to 1,918 harvested in the United States; 1,247 harvested in Russia; and 2,083 to 2,292 struck and lost.

Climate Change. A concern regarding marine mammals in polar regions is the potential for climate change and associated loss in the extent of sea ice in some Arctic and subarctic waters. Some species, such as the bearded seal and polar bear, are dependent on sea ice for at least part of their life history, and may be more sensitive to changes in Arctic weather, sea-surface temperatures, or extent of ice cover (Allen and Angliss 2011). Ice edges are biologically productive systems where ice algae form the base of the food chain. The ice algae are crucial to Arctic cod, which is a pivotal species in the Arctic food web. As ice melts, there is concern that there will be loss of prey species of marine mammals, such as Arctic cod and amphipods, that are associated with ice edges (MMS 2004a). Changes in the extent, concentration, and thickness of the sea ice in the Arctic may alter the distribution, geographic ranges, migration patterns, nutritional status, reproductive success, and, ultimately, the abundance of ringed seals and other ice-dependent pinnipeds that rely on the ice platform for pupping, resting, and molting (MMS 2004a). Reductions in sea ice coverage would adversely affect the availability of pinnipeds as prey for polar bears. More polar bears may stay onshore during the summer (MMS 2004a). If the Arctic climate continues to warm and early spring rains become more widespread, ringed seal lairs might collapse prematurely, exposing ringed seal pups to increased predation by polar bears and Arctic foxes, negatively impacting the ringed seal population and, therefore, eventually the polar bear population (MMS 2004a).

The loss of sea ice could have several potential effects on bowhead whales. These would include increased noise and disturbance related to increased shipping, increased interactions with commercial fisheries, including noise and disturbance, incidental intake, and gear entanglement; changes in prey species concentrations and distribution; changes in subsistence-hunting practices; increased predation from expanding killer whale range; and competition from expanding fin, humpback, and other baleen whale ranges. Bowhead whale seasonal distribution may change with changes in seasonal ice distribution as well.

Other Impacting Factors. Marine mammals may also be impacted by other factors such as UMEs and invasive species. A UME is an unexpected stranding that involves a significant die-off of any marine mammal population, and demands immediate response (NMFS 2011b). Causes of UMEs include infections, biotoxins, human interactions, and malnutrition (NMFS 2011b). Since establishment of the UME program in 1991, there have been 55 formally recognized UMEs in the U.S., one of the ongoing UMEs involving pinnipeds includes the Arctic (NMFS 2011b). Section 3.8.1.3.1 discusses this UME. Invasive species could affect some marine mammals by disrupting local species and ecosystems, affecting the prey base for some marine mammals. Currently, invasive species are not a major factor in the Arctic Planning Areas. However, as climate change continues to warm Alaskan waters, the Arctic Planning Areas may become more susceptible to invasive species (e.g., from ballast discharges associated with increased vessel traffic).

Accidents. Marine mammals could be exposed to oil accidentally released from platforms, pipelines, and vessels from the Program (Table 4.4.2-1). Potential non-OCS sources of oil spills include the domestic transportation of oil, oil and gas development in State waters, and natural sources such as seeps. Accidental oil releases could expose marine mammals to oil by direct contact or through the inhalation or ingestion of oil or tar deposits. The magnitude and duration of exposure will be a function of the location, timing, duration, and size of the spill; the proximity of the spill to feeding and other important habitats; the timing and nature of spill containment; and the status of the affected animals. Most expected small to medium spills (less than 1,000 bbl) would have limited effects on marine mammals due to the relatively small areas likely to incur high concentrations of hydrocarbons and the short period of time during which potentially toxic concentrations would be present. The magnitude of impact would be expected to increase should a spill occur in habitats important to marine mammals or affect a number of individuals from a population listed under the ESA. Some spills from OCS activity may locally represent the principal source of oil exposure for some species, especially for spills contacting important coastal and island habitats or collecting along ice leads.

Conclusion. Cumulative impacts on marine mammals in the Beaufort and Chukchi Sea Planning Areas as a result of future OCS program and ongoing and future non-OCS program activities could be minor to moderate over the next 40 to 50 years. Non-OCS program activities or phenomena that may affect populations of marine mammals include climate change, contaminant releases, vessel traffic, subsistence harvests, and invasive species. The incremental contribution of routine Program activities to these impacts would be negligible to small (see Section 4.4.7.1.3).

Marine mammals may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS activities. The cumulative impacts of past, present, and future oil spills on marine mammals would be minor to moderate. The incremental impacts of expected accidental spills associated with the Program on marine mammals would be negligible to large, depending on the location, timing, and volume of the spills; the environmental settings of the spills; and the species (and number of individuals) exposed to the spills (Section 4.4.7.1.3). Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from minor to major if it were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to the impacts of spills regardless of size, but their incremental contribution to cumulative impacts is generally expected to be small. A more detailed discussion of the effects of oil spills on marine mammals in the Arctic is presented in Section 4.4.7.1.3.

Terrestrial Mammals. Terrestrial mammals and their habitats could be affected by a variety of activities associated with the proposed OCS actions (Section 4.4.7.1.3). These activities include construction and operation of onshore pipelines and vehicle and aircraft traffic. Impacts to terrestrial mammals from these activities may include physical injury or death; behavioral disturbances; lethal or sublethal toxic effects; and loss of reproductive, nursery, feeding, and resting habitats. In the Arctic Planning Areas, these impacts would be in addition to similar (in nature) impacts resulting from ongoing and planned OCS lease sales under previously approved 5-year programs.

Impacts from OCS construction and operation activities could include the injury or death of smaller mammals (such as mice and voles) and the disturbance and displacement of individuals or groups of larger species (such as caribou, muskoxen, and brown bear). Because of the limited areal extent of new pipeline under the Program, disturbance (primarily behavioral in nature) of most of these species during construction would be largely temporary, and no long-term population level effects would be expected. However, construction activities in the Arctic could disturb caribou in calving, foraging, or insect avoidance habitats, which could affect adult and calf survival. However, the potential for such impacts could be minimized by careful siting of new pipelines to avoid important habitats.

Species such as the Arctic fox that habituate to human activity and facilities could experience local increases in density, while bears may experience increases in mortality associated with defense of life and property killings. In the Arctic, pipelines and roads associated with the Program have the potential to incrementally affect local and seasonal movements of caribou.

Under the Program, vehicle traffic associated with normal operations and maintenance of onshore pipelines could disturb wildlife. Vehicle traffic could disturb wildlife foraging along pipelines or access roads, causing affected wildlife to temporarily stop normal activities (e.g., foraging, resting) or leave the area, while collision with vehicles could injure or kill some individuals. Because vehicle traffic would be infrequent, vehicle-related impacts associated with the Program would result in little incremental increase in vehicle-related impacts from current or ongoing OCS activities in the Arctic.

Up to 27 weekly helicopter trips would occur to platforms in the Arctic Planning Areas. Impacts to terrestrial mammals from helicopter overflights would be behavioral in nature, primarily resulting in short-term disturbance in normal activities, and would not be expected to result in population-level effects. Overflights disturbing active calving and overwintering sites could result in decreased survival of young or adults, and potentially result in population level impacts to some species. Selection of flight lines to avoid overflights of important habitats would greatly limit the potential for adversely affecting calving or overwintering animals.

Terrestrial mammals in the Arctic Planning Area could also be affected by a number of non-OCS activities, including oil and gas exploration and development in State waters, and coastal and community development, and climate change. Many of the effects of these activities on terrestrial mammals would be similar in nature to those resulting from OCS-related activities, namely behavioral disturbance, habitat disturbance, and injury or mortality. The State of Alaska has made leases of State waters available along much of the Beaufort Sea coast. Because these leases are closer to shore than those for the Program, impacts on terrestrial mammals may exceed the potential impacts that could occur under the OCS Program. Implementation of the Program could increase coastal and community development, indirectly adding to impacts to terrestrial mammals and their habitats. Terrestrial mammals could be adversely affected by the accidental release of oil from an onshore pipeline, or by offshore spills contacting beaches and shorelines utilized by terrestrial mammals (such as caribou or brown bears). Impacts to terrestrial mammals from an oil spill would depend on such factors as the time of year and volume of the spill, type and extent of habitat affected, and home range or density of the species. Spills contacting high-use areas (such as caribou calving areas) could locally affect a relatively large number of animals. It is anticipated that most of the spills would have limited effects on terrestrial mammals, due to the relatively small areas likely to be directly exposed to the spills, and the small number and size of spills projected for the Program and for current and planned OCS oil and gas developments. However, some spills may locally represent the principal source of oil exposure for some species, especially for spills contacting important calving or overwintering habitats.

Conclusion. Cumulative impacts on terrestrial mammals in the Beaufort and Chukchi Sea Planning Areas as a result of future OCS program and ongoing and future non-OCS activities could be minor to moderate over the next 40 to 50 years. Non-OCS activities or phenomena that may affect populations of terrestrial mammals include climate change, natural catastrophes, contaminant releases, and vehicle traffic. The incremental contribution of routine Program activities to these impacts would be negligible to small (see Section 4.4.7.1.3).

Terrestrial mammals may also be adversely affected by exposure to oil that is accidentally released from onshore (e.g., Prudhoe Bay) and State offshore oil and gas activities. The cumulative impacts of past, present, and future oil spills on terrestrial mammals would be minor to moderate. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on terrestrial mammals would be negligible to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and other important habitats; the timing and nature of spill containment; and the status of the affected animals (see Section 4.4.7.1.3).

An unexpected, low-probability CDE has a greater potential to affect terrestrial habitats; therefore, impacts could range from minor to major if one were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to the impacts of spills regardless of size, but their incremental contribution to cumulative impacts is generally expected to be small. A more detailed discussion of the effects of oil spills on terrestrial mammals in the Arctic region is presented in Section 4.4.7.1.3.

4.6.4.3.2 Marine and Coastal Birds. Section 4.4.7.2.3 discusses impacts to marine and coastal birds in the Arctic region resulting from the Program (OCS program activities from 2012 to 2017). Cumulative impacts on marine and coastal birds result from the incremental impacts of the Program when added to impacts from existing and reasonably foreseeable future OCS program activities (that are not part of the Program) and other non-OCS program activities. Table 4.6.1-2 presents the exploration and development scenario for the Beaufort and Chukchi Seas cumulative cases (encompassing the Program and other OCS program activities) over the next 50 years. A number of OCS program activities could affect Arctic marine or terrestrial birds or their habitats; these include offshore exploration, construction of offshore platforms and pipelines, construction of onshore pipelines, operations of offshore platforms, operational discharges and wastes, and OCS-related marine vessel and aircraft traffic. Potential impacts on marine and coastal birds from OCS program activities include injury or mortality of birds from collisions with platforms, vessels, and aircraft; exposure to operational discharges; ingestion of trash or debris; loss or degradation of habitat due to construction; and behavioral disturbance due to the presence of, and noise generated by, equipment and human activity.

Non-OCS program activities affecting marine and coastal birds in the Beaufort Sea and Chukchi Sea Planning Areas include dredging and marine disposal; coastal and community development; onshore and offshore construction and operations of facilities associated with State oil and gas development (mainly Prudhoe Bay); commercial and recreational boating; and small aircraft traffic. Potential impacts on marine and coastal birds from these activities are similar to those under the OCS program and include injury or mortality of birds from collisions with platforms associated with State oil and gas development and other onshore and offshore structures (e.g., radio, television, or cell phone towers); onshore industrial, commercial, and residential development; exposure to discharges from permitted point sources such as sewage treatment discharges and nonpoint sources such as snowmelt and stormwater runoff; or accidental releases (e.g., oil spills), as described in Section 4.6.2.1.3 and Table 4.6.2-4; exposure to emissions from various onshore and offshore sources (e.g., power generating stations and marine vessels), as described in Section 4.6.2.1.3; ingestion of trash or debris; loss or degradation of habitat due to construction and operations activities; and behavioral disturbance due to the presence of, and noise generated by, equipment and human activity. Other trends such as extensive melting of glaciers (and increasing river discharges), thawing of permafrost, and increased precipitation brought on by global climate change are also expected to adversely affect marine and coastal birds over the next 50 years.

Injury or Mortality from Collisions. Under the cumulative scenario, annual collision injury or mortality in the Beaufort and Chukchi Sea Planning Areas could increase in the near term as platforms are built under the Program. Such impacts would be minor relative to those that currently involve non-OCS structures. Over time, the injury or mortality impacts from collisions could decrease as oil and gas production in the inlet declines.

Exposure to Wastewater Discharges and Air Emissions. The discharge of operational wastes and air emissions from current non-OCS related vessel traffic and platform operations in the Beaufort and Chukchi Seas is strongly regulated and would continue to be so regulated over the next 50 years. Many wastes (such as produced water, drilling muds, and drill cuttings) would be disposed of through onsite injection into NPDES-permitted disposal wells. However, such wastes and emissions would still expose marine and coastal birds to potentially toxic materials or to solid debris that could be ingested or result in entanglement. These facilities and activities include sewage treatment plants, industrial manufacturing or processing facilities, electric generating plants, dredging and marine disposal, and vessel traffic (e.g., cargo and tanker ships and military and research vessels). Operational wastewater discharges and air emissions associated with the Program would contribute to the overall cumulative risk of toxic exposure and debris ingestion or entanglement of existing non-OCS wastewater discharges and air emissions in the inlet, but the incremental increase in impact is expected to be small relative to these other activities.

Under the Program, marine and coastal birds could be exposed to oil accidentally released from platforms, pipelines, and vessels, and would be most susceptible to adverse impacts from spills occurring in coastal areas and affecting feeding and nesting areas. Most of the oil released to Arctic waters is from leaks related to the oil industry (Section 4.6.2.3.1). Oil releases from all sources may expose marine and coastal birds via direct contact or through the inhalation or ingestion of oil or tar deposits (see Section 4.4.7.3.1).

Marine and coastal birds may become entangled in, or ingest, floating, submerged, and beached debris (Heneman and the Center for Environmental Education 1988; Ryan 1987, 1990). Entanglement may result in strangulation, injury or loss of limbs, entrapment, or the prevention or hindrance of the ability to fly or swim; all of these effects may be considered lethal. Ingestion of debris may irritate, block, or perforate the digestive tract, suppress appetite, impair digestion of food, reduce growth, or release toxic chemicals (Fry et al. 1985; Dickerman and Goelet 1987; Ryan 1988; Derraik 2002). Because the discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by BOEM (30 CFR 250.40) and the USCG (MARPOL, Annex V, Public Law 100 220 [101 Statute 1458]), entanglement in or ingestion of OCS-related trash and debris by marine and coastal birds would not be expected under normal operations.

Oil Spills and Cleanup Activities. Oil spills under the cumulative scenario are shown in Table 4.6.1-3. No more than six large spills (between 1,000 and 5,300 bbl from either a platform or a pipeline) and 530 small spills (less than 1,000 bbl) would be expected as a result of the Beaufort Sea and Chukchi Sea Planning Areas OCS program over the next 50 years.

Loons, waterfowl, and shorebirds in onshore habitats are generally at low risk of contacting a spill while nesting, but risk of exposure increases as they leave the mainland nesting areas and concentrate in coastal or marine habitats for brood rearing, molting, or staging prior to southward migration. In addition, some species (e.g., red-throated loons) forage almost exclusively offshore and bring food back to their nestlings or young, so impacts of oil spills may be greater on these species (Eberl and Picman 1993). Likewise, species nesting on barrier islands, such as common eider, gulls, and terns, are at risk when post-nesting individuals join other species in lagoons and other nearshore habitats. Substantial numbers occupy Simpson and other Beaufort Sea lagoons, Harrison and Smith Bays, Kasegaluk Lagoon, and Peard and Ledyard Bays in the Chukchi Sea at this time. For example, tens of thousands of long-tailed ducks molting in Beaufort Sea lagoons, far outnumbering other species, are at risk in July and August, and in late August and early September, a large proportion of the Pacific flyway brant population could be exposed to a spill that enters Kasegaluk Lagoon. Substantial numbers of non-breeding, foraging, or staging birds that occupy offshore areas in both the Beaufort and Chukchi Seas, when open water beyond the barrier islands is available, could be exposed to an oil spill. Most brood rearing of loons, swans, and geese occurs on large lakes or coastal saltmarsh. Risk of oil spill contact is much greater for those using the latter habitat. The most important molting area for brant and several other species of geese (and to a lesser extent ducks) is the Teshekpuk Lake Special Area (Derksen et al. 1979, 1982). Beached oil along these coastlines could expose hundreds to low thousands or possibly greater numbers of shorebirds that pause along the coast during migration (Connors et al. 1979; Smith and Connors 1993; Andres 1994). In the southeastern Chukchi Sea, large numbers of murres and kittiwakes nesting in seabird colonies at Capes Lisburne and Thompson, together with nonbreeding individuals, form foraging flocks containing tens to hundreds of individuals that also could be exposed to an oil spill. Major effects on bird populations during the open water season are expected to follow a spill. A spill occurring in winter, when birds are virtually absent, still may have serious impacts if substantial quantities of oil are entrained in the ice and then released during the following breeding season.

Large flocks of long-tailed ducks molting in Beaufort Sea lagoons and common eiders occupying barrier islands or lagoons are particularly susceptible to oil spill impacts if they are nesting, brood rearing, or flightless. Likewise, brant staging in Kasegaluk Lagoon in the Chukchi Sea would be particularly vulnerable. For all species, the degree of impact depends heavily on the location of the spill and its timing with respect to critical natural behaviors (e.g., breeding, molting, feeding). Survival and fitness of individuals may be affected, but in many cases, this infrequent disturbance is not expected to result in significant population losses. However, effects may be greater if a spill and cleanup were to occur in the spring when large numbers of king and common eiders, long-tailed ducks, and other waterfowl, seabirds, and shorebirds are present following spring ice-lead systems. In addition, it is unlikely that all spilled oil would be removed from the environment, especially in winter; thus the remaining accumulations could move under the ice and into leads.

In addition to the potential impacts from spilled oil, the oil spill cleanup process may also affect marine and coastal birds in the Arctic region. The presence of large numbers of workers, boats, and additional aircraft during the breeding season following a spill is expected to displace waterfowl or other seabirds occupying affected offshore or nearshore waters, and shorebirds in coastal habitats for one to several seasons. Cleanup in coastal areas late in the breeding season may disturb brood-rearing, juvenile, or staging birds. Cleanup and the presence of oil can dramatically influence avian species composition and distribution (Piatt et al. 1990). It is extremely difficult to separate the effects of oiling and disturbance from cleanup activities, but either separately or together they have the potential to influence habitat use by birds (Wiens 1996). Survival and fitness of individuals may be affected to some extent, but this infrequent disturbance is not expected to result in significant population losses.

Loss or Degradation of Habitat. Marine and coastal birds could be affected by platform construction and removal activities, and pipeline trenching, which could disrupt behaviors of nearby birds. The Program would include the placement of up to 36 exploration and development wells and 9 offshore platforms; up to 652 km (405 mi) of new offshore pipeline and 129 km (80 mi) (0 in the Chukchi Sea) of onshore pipeline could be constructed (Table 4.4.1.1-4). Platform emplacement could disturb birds temporarily; pipeline trenching may also affect birds in nearshore coastal habitats if it occurs in or near foraging, overwintering, or staging areas, or near seabird colonies. No pipeline landfalls would be constructed under the Program. Depending on where they are sited, new offshore pipelines would likely result in the permanent elimination of a small amount of habitat along pipeline routes.

Any construction activities that take place in summer (one season) (e.g., platform installation for field development) could displace birds from within about 1 km (0.62 mi) of the construction site. However, localized burial of potential prey and destruction of a few square kilometers of foraging habitat as a result of pipeline trenching or island construction are not expected to cause a significant decline in prey availability. It is likely that much construction, particularly of gravel islands, roads, pads, and pipelines, would take place during winter when most birds are absent. Several studies speculate that increased predator populations sustained by scavenging opportunities around human habitation may indirectly contribute to long-term declines of common eiders and long-tailed duck populations currently in evidence (Day 1998; Johnson 2000; Troy 2000). The effect of any habitat loss on the species' productivity would likely be localized to these areas but may persist over the life of any offshore field and beyond. The potential exists for long-term adverse effects to occur (e.g., fecundity reduced after location to suboptimal habitat due to disturbance).

Gravel placement (for artificial islands) results in nesting and foraging habitat loss for most shorebirds (Troy 2000). On the North Slope, gravel is generally extracted from the floodplains of large rivers (Pamplin 1979; BLM 2002). The effects of gravel extraction/ placement would be reduced if areas where particular species seasonally concentrate are avoided.

Winter construction would also utilize ice roads to build and access gravel island construction sites. Ice roads may be constructed over both tundra habitats and frozen ocean habitats. Ice roads constructed in tundra habitats may delay ice-off and snow melt (NRC, 2003b), potentially reducing the availability of such areas for early nesting species. Ice roads could also flatten underlying vegetation, which may discourage use of the area by tundra-nesting birds (Walker et al., 1987a, b). Water removal from lakes and ponds for ice road construction may reduce the quality or quantity of aquatic habitats important for breeding and postmolting for some species. In each of these cases, the impacts to potential nesting habitat would be temporary and localized, and birds would likely respond by selecting other areas for nesting or postmolting.

Construction camps to support onshore construction activities would temporarily remove some areas from potential use by birds, and this loss may be short- or long-term depending on the nature and effectiveness of camp abandonment following completion of construction activities. Regardless of the duration of the effect, the amount of habitat that would be disturbed would be relatively small and not be expected to affect more than a few birds.

The construction and operation of up to 320 km (200 mi) of new overland pipelines would be expected to affect bird populations in a manner similar to that identified for the construction and operation of new onshore processing facilities and associated infrastructure (especially access roads). Potential nesting or post-molting habitat would be permanently lost within the footprint of the new pipelines, causing birds to select habitats in other locations.

Although pipeline trenching would also be carried out in winter when most seabird and waterfowl species are not present, seafloor trenching could locally disrupt benthic invertebrate communities that may serve as food sources for waterfowl during other seasons. The extent to which benthic food sources could be affected and the subsequent impact to waterfowl will depend on the type and amount of benthic habitat that would be permanently disturbed by trenching, the importance of the specific habitats in providing food resources to waterfowl, and the number of waterfowl that could be affected. Because no more than three new pipelines would be built under the Program within the entire Arctic region, relatively little benthic habitat would be disturbed (no more than 120 ha [297 ac] within the entire region). In addition, portions of the new pipelines would be in water depths down to 60 m (200 ft) and potentially unavailable for many marine birds and waterfowl. Thus, any impacts to food sources from pipeline trenching would be very localized and short-term, and not expected to result in population-level impacts to local waterfowl populations.

The construction of new facilities and pipelines would permanently eliminate potential bird habitat at the construction sites. While this habitat loss would be long-term, the areas disturbed would represent a small portion of the habitat present in the Arctic region. Careful siting of any new facilities to avoid important nesting or post-molting habitat would further reduce the magnitude of any potential effects on local bird populations.

Helicopter or fixed-wing aircraft overflights are generally conducted at low altitudes and could disturb birds in onshore and offshore locations (Ward and Stein 1989; Ward et al. 1994; Miller 1994; Miller et al. 1994). Helicopter and aircraft overflights during spring breakup of pack ice may disturb marine species feeding in open waters and waterfowl in coastal waters, causing birds to leave the area. Similarly, overflights in summer could displace waterfowl and seabirds from preferred foraging areas and waterfowl from coastal nesting or brood-rearing areas such as the lagoon systems of the Beaufort and Chukchi Seas. Molting and staging waterfowl may temporarily leave an area experiencing helicopter overflights (Derksen et al. 1992), while geese have been reported to exhibit alert behavior and flight in response to helicopter overflights (Ward and Stein 1989; Ward et al. 1994). The type of response elicited by the birds and the potential effect on the birds will depend in large part on the time of year for the overflights and the species disturbed. Birds experiencing frequent overflights may permanently relocate to less favorable habitats (MMS 2002b). In addition, the temporary absence of adult birds may increase the potential for predation of unguarded nests and young (NRC 2003b).

Marine vessel trips could disturb seabirds and waterfowl in preferred foraging, molting, and staging areas, causing them to leave the area and move to potentially less favorable habitats. Vessel traffic that displaces nesting seabirds or waterfowl may result in an increased predation rate on eggs and young, especially in areas near gull colonies (Day 1998; Johnson 2000; Noel et al. 2005). However, the amount of vessel and aircraft traffic that could occur under the Program would be relatively limited. Which birds could be affected, the nature of their response, and the potential consequences of the disturbance will be a function of a variety of factors, including the specific routes, the number of trips per day, the seasonal habitats along the routes, the species using the habitats and the level of their use, and the sensitivity of the birds to vessel traffic. Traffic over heavily used feeding or nesting habitats of sensitive species could result in population-level effects, while impacts from traffic over other areas with less sensitive species would largely be limited to a few individuals and not result in population-level effects.

Marine and coastal birds could be affected by accidental oil spills from offshore platforms and pipelines, as well as from onshore processing facilities and pipelines. In general, loons, waterfowl, seabirds, and shorebirds are not expected to survive moderate to heavy oil contact. Oiled feathers lose their insulative and water repellent characteristics, and birds die of hypothermia (Albers and Gay 1982). Swallowed oil is toxic and causes impaired physiological function and production of fewer young. Oiled eggs have significantly reduced hatching success (Albers 1980). Vulnerability of bird populations to an oil spill is highly variable because of their seasonally patchy distribution in areas where the probability of spill contact also is variable and depends on location, oceanography, weather patterns, and habitats typically occupied by and habits of, the particular species. Because they are unable to fly, molting birds probably are the most vulnerable. For all species, the degree of impact depends heavily on the location of the spill and its timing with respect to critical natural behaviors (e.g., breeding, molting, feeding).

If losses are substantial in a species with a low reproductive rate, including most marine species, recovery may take many years, or populations may not recover to their prespill size. Rate of recovery from oil spill mortality depends both on the numbers lost from a particular species population and its prevailing population trend, which in turn are determined by reproductive rate and survival rate. Population dynamics of wildlife recovering from an oil spill may be influenced by multiple factors including predation, prey availability, immigration of new individuals into the recovering population, and competition for resources (depends on the impact of the oil spill on competition within a species and among species) (Bodkin et al. 2002; Gilfillan et al. 1995; Golet et al. 2002). Oil contamination of food resources may influence recovery of a local population by affecting reproductive success and survival, with the degree of impact largely dependent on the patterns of prey distribution (Trust et al. 2000; Golet et al. 2002). Species dependent on widely dispersed prey would have more limited effects. However, seabirds, in particular, are attracted to patchy prey sources found on oceanic fronts (Piatt and Springer 2003) and would experience greater effects from prey reduction. In addition, nonbreeding individuals and those that have completed annual parental activities are better able to search for prey in uncontaminated areas. However, those individuals actively feeding young and dependent upon nearby food resources would be unable to seek uncontaminated prey elsewhere. If a leak in an onshore pipeline were to occur on a pad, the extent of the spill likely would be restricted by containment berms. If the spill occurred along the off-pad portion of the pipeline, the area covered may include several acres; if the spill were to enter streams or lakes, a larger area could be affected as the oil spreads over a water surface or is carried down a watercourse. From mid- to late summer, such an occurrence could contact broodrearing females and their young, as well as potentially large flocks of nonbreeding and postbreeding individuals undergoing wing molt.

Most bird species are absent from the Arctic region from late October to at least early April. During spring migration, substantial numbers of migrants moving north along the spring lead system in the Chukchi Sea are at risk if oil enters this habitat, since there are few alternatives until open water off river deltas is available as the ice breaks up in late spring. The most numerous species include king eider, common eider, long-tailed duck, brant, and murres. Likewise, a similar rather restricted open water situation exists in both the Beaufort and Chukchi Seas for migrants that pause awaiting further melting to the north or east, and for birds occupying delta waters and nearshore areas that have melted prior to general ice breakup and awaiting the availability of onshore habitats.

Disturbance Due to Noise. Noise and human activities (such as normal maintenance) could disturb birds. Operational facilities may provide additional nesting and feeding opportunities for some species. Unexpected noise can startle birds and potentially affect feeding, resting, or nesting behavior, and often causes flocks of birds to abandon the immediate area. Some species may react by avoiding nearby habitats, while other species may show little response or become habituated. Because of the small number of new onshore facilities (no more than four in the entire Arctic region), the disturbance of birds by operational noise and activity would likely be limited to relatively few individuals and would not be expected to result in population-level effects. Prolonged or repeated periods of maintenance activities could have a greater impact on nesting birds by increasing cooling periods of eggs, and on brood-rearing birds by increasing the time that young and adult birds are separated.

Effects on ESA-Listed Species in the Arctic Region. The cumulative effects of OCS and non-OCS program activities on ESA-listed species in the Arctic region, including the spectacled eiders and Steller's eider, are expected to be similar to those noted for nonlisted species over the next 50 years. Continued compliance with ESA regulations and coordination with the USFWS would ensure that lease-specific OCS operations would be conducted in a manner likely to avoid or greatly minimize the potential for impacting these species.

The risk of oil contact to spectacled eiders using the spring lead system to move north into the Chukchi Sea during spring migration could be high if a spill entered the area of the leads. Since most spectacled eiders probably use overland routes from the Chukchi to complete their spring migration to nesting areas on the ACP, they are not likely to be contacted by an oil spill during migration. During the broodrearing period, when the young are led to watercourses and ultimately to nearshore marine environments for further development, staging, and fall migration, the risk of oil contact is much greater. Males could be exposed to an oil spill in any of the several bays and lagoons occupied for molting and staging in both the Beaufort and Chukchi Seas (Petersen et al. 1999). The period of highest exposure risk for a given individual migrating across the Beaufort is about 3–5 days. Females and young are at risk of contact primarily when they occupy Smith Bay in the Beaufort (Troy 2003) and Ledyard and Peard Bay (Laing and Platte 1994) in the Chukchi (this area is used by nonbreeding, failed breeding, and successful breeders, as well as both sexes) for the molt prior to fall migration (Petersen et al. 1999).

Ledyard Bay has been defined as critical habitat for spectacled eiders. Since most, if not all, of the successfully breeding females (and their young) from the ACP could be concentrated in Ledyard Bay critical habitat area during the molt period, a spill affecting this group in this location could have a long-term population-level effect.

The small ACP population of Steller's eider is not likely to be exposed to an oil spill during nesting or postnesting periods, since most presumably move to the Russian side of the Chukchi prior to migrating south to molting areas. However, there is some evidence to suggest use of Peard Bay by postbreeding Steller's eiders (Martin unpubl. data; Dau and Larned 2004, 2005).

Climate Change. Climate change could have dramatic impacts on the Beaufort Sea and Chukchi Sea Planning Areas. The expected changes in air temperature would have the most immediate effect on the distribution and biology of Arctic seabirds and the seabird species most dependent on the presence of ice and snow would be expected to be among the first affected. If temperature increases in the Arctic region are as high as predicted, the Beaufort Sea pack ice could retreat more than 100 km (62 mi) from mainland Alaska (Meehan et al. 1998). This sea ice retreat could have major adverse effects on seabirds that rely on prey associated with ice edges.

Conclusion. Marine and coastal birds in the Beaufort and Chukchi Sea Planning Areas, including those that are ESA-listed, could be adversely affected by activities associated with the Program as well as those associated with future OCS and non-OCS program activities. Potential impacts include injury or mortality of birds from collisions with platforms associated with OCS and State oil and gas development and other onshore and offshore structures (e.g., radio, television, or cell phone towers), onshore industrial, commercial, and residential development; exposure to discharges from permitted point sources such as sewage treatment discharges and nonpoint sources such as urban runoff, or accidental releases (e.g., oil spills); exposure to emissions from various onshore and offshore sources; ingestion of trash or debris; loss or degradation of habitat due to construction and operations activities; and behavioral disturbance due to the presence of, and noise generated by, equipment and human activity. Other trends such as extensive melting of glaciers (and increasing river discharges) and increased precipitation brought on by global climate change is also expected to adversely affect marine and coastal birds over the next 40 to 50 years. While the cumulative impact of all OCS and non-OCS activities in the Beaufort and Chukchi Seas could be minor to moderate, the incremental contribution due to the Program would be negligible to medium (see Section 4.4.7.2.3). Compliance with ESA regulations and coordination with the USFWS would ensure that lease-specific OCS operations would be conducted in a manner that is likely to avoid or to greatly minimize the potential for impacting ESA species.

Marine and coastal birds may also be adversely affected by exposure to oil (via direct contact or through the inhalation or ingestion of oil or tar deposits) that is accidentally released from OCS and non-OCS activities, especially near coastal areas and affecting feeding and nesting areas. The incremental contribution of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on marine and coastal birds would be small to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and nesting areas; the timing and nature of spill containment; and the status of the affected birds (see Section 4.4.7.2.3). Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from moderate to major if it were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to the impacts of spills regardless of size, but their incremental contribution to cumulative impacts is generally expected to be small. A more detailed discussion of the effects of oil spills on marine and coastal in the Arctic region is presented in Section 4.4.7.2.3.

Whether net cumulative impacts are minor or moderate depends on the nature and duration of activities that reduce bird survival and productivity. Losses would be limited in areas occupied by scattered flocks during relatively brief staging and migration periods or scattered nest sites during the brief nesting season; however, in cases where exposure to localized disturbance is greater, impacts have the potential to rise to the population level. Population-level effects could be incurred due to the tendency for large numbers of individuals of some bird species to concentrate in certain coastal Arctic locations.

4.6.4.3.3 Fish. Section 4.4.7.3.3 discusses direct and indirect impacts on fish communities in the Beaufort Sea and Chukchi Sea Planning Areas resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on these resources result from the incremental impacts of the Program (described in Section 4.4.6.1.1) when added to impacts from ongoing and reasonably foreseeable future actions, including those of ongoing and future OCS programs and other non-OCS activities. Table 4.6.1-3 presents the exploration and development scenario for the Arctic region cumulative case, which takes into account activities associated with the Program in combination with those from ongoing and future OCS programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in the Arctic are summarized in Table 4.6.1-7 and discussed below, as applicable.

The primary routine OCS activities that could result in impacts on fish include seismic surveys; construction of artificial islands, ice roads, drilling, platforms and pipeline placement; releases of permitted discharges from wells; and removal of existing structures. Potential environmental impacts associated with the building and operation of OCS facilities such as subsea production wells, platforms, artificial islands, and pipelines would increase in conjunction with the increased number of wells. Although all of these activities would disturb bottom habitats to some degree, artificial islands result in a more complete loss of benthic habitat due to larger footprints (approximately 9 ha for artificial islands versus less than 1.5 ha for platforms) and due to complete burial of existing substrate during construction. The impacts of routine activities (exploration and site development, production and decommissioning) on fish communities are discussed in detail in Section 4.4.7.3.3. Overall, routine activities represent up to a minor disturbance, primarily affecting demersal fishes, with the severity of the impacts generally decreasing with distance from bottom-disturbing activities.

Oil and gas exploration and development in State waters could also contribute to cumulative effects on fishery resources in the Beaufort and Chukchi Planning Areas. Drilling of wells in State waters could also require construction of platforms and pipelines in waters of Alaska. The effects on fish would be similar to those described above for OCS oil and gas programs (Section 4.4.7.3.2). Other non-OCS activities that could impact fish communities include subsistence fishing, hardrock mining, sediment dredging and disposal of dredging spoils in OCS waters, and commercial shipping (tanker vessels) and anchoring. Many of these activities would result in bottom disturbance that would affect bottom dwelling fishes as well as their food sources in a manner similar to those described for OCS activities (MMS 2008b; ADEC 2007a; Section 4.4.7.3.3). Commercial fishing does not occur in the Beaufort and Chukchi Sea Planning Areas, and sportfishing is minor in the Arctic but could increase if regulations change and if warming temperatures allow an increase in vessel traffic. Effects on fish resources from non-OCS dredging and marine disposal activities are expected to be similar to those described for OCS bottom disturbing activities (Section 4.4.7.3.3). Due to the small number and limited use of disposal sites in the vicinity of the Beaufort and Chukchi Sea Planning Areas, these activities are not expected to noticeably alter fish populations.

The Beaufort and Chukchi Seas fall in the Kotzebue Sound and Northern Subsistence fishing areas. Subsistence fishing may contribute to the cumulative effects on the abundance of some fishery resources. Alaska State law defines subsistence as the "noncommercial customary and traditional uses" of fish and wildlife. The Alaska Department of Fish and Game defines subsistence fishing to include "the taking of, fishing for, or possession of fish, shellfish, or other fisheries resources by a resident of the state for subsistence uses with gill net, seine, fish wheel, long line, or other means defined by the Board of Fisheries." These fishing methods have more limited impacts on fish and fish habitat compared to commercial fishing methods. In addition, subsistence fishing is subject to harvest limits that reduce the potential for overfishing. Consequently, subsistence fishing makes a relatively minor contribution to the reduction in fish stocks.

Cumulative impacts on diadromous species could also occur as a result of activities that obstruct fish movement in marine environments during migration periods. For example, some structures along the Beaufort Sea mainland (e.g., the West Dock) have been shown to block the movements of diadromous fishes, particularly juveniles, under certain meteorological conditions (Fechhelm 1999; Fechelm et al. 1999). Causeways such as the 40 m wide and 60 m long structure associated with the Red Dog Mine may impede coastal movement either by directly blocking fish or by modifying nearshore water conditions to the point where they might become too cold and saline for some species (Fechhelm et al. 1999). Although the presence of causeways has been an issue associated with oil development activities in the Beaufort Sea, the small size of the Red Dog causeway would likely have little effect on the coastal movements and distributions of Chukchi Sea fishes and shellfishes. However, it is anticipated that proper placement and design considerations for future causeway construction along the North Slope would alleviate the potential for such effects on fish movement.

There are several contaminant sources in the Beaufort and Chukchi Sea Planning Areas. The Red Dog Mine in Alaska is the largest lead and zinc mine in the world, and is presently the only base-metal lode mine operating in northwest Alaska. A study for the National Park Service (Hasselbach et al. 2004) showed extensive airborne transport of cadmium and lead from Red Dog Mine; although the study was focused only on the limits of the Cape Krusenstern National Monument, these contaminants are probably carried out into the Chukchi Sea. There are also natural sources of metals and hydrocarbons. Sediments, peats, and soils from the Sagavanirktok, Kuparuk and Colville Rivers are the largest source of dissolved and particulate metals and saturated and polycyclic aromatic hydrocarbons in the development area. However, concentrations of metals and organics in fish sampled in the Arctic Planning Areas are typically at background levels (Neff & Associates, LLC 2010).

Climate change may affect fish communities in the Beaufort and Chukchi Sea Planning Areas and interact with past, present, and future OCS and non-OCS stressors. Physiological and ecosystem level stressors related to climate change may interact with the non-climate-related anthropogenic stressors such as overfishing, pollution, and habitat loss discussed above. For example, a climate change–related increase in water temperature that results in physiological stress could make individuals more susceptible to stress from pollution or accidental oil spills. Climate would only be one of several factors that regulate fish abundance and distribution. Many fish populations are already subject to stresses, and global climate change may aggravate the impacts of ongoing and future human use of the coastal zone. Fish respond directly to climate fluctuations, as well as to changes in their biological environment including predators, prey, species interactions, and disease. Projected changes in hydrology and water temperatures, salinity, and currents can affect the growth, survival, reproduction, and spatial distribution of marine fish species and of the prey, competitors, and predators that influence the dynamics of these species (Watson et al. 1998). Changes in primary production levels in the ocean because of climate change may affect fish stock productivity. Climate change may have a number of effects on fish communities, including:

- Changes in the timing of seasonal fish migrations;
- Increased storm damage to nearshore areas as the amount of open water increases and their reduction or elimination by rising sea levels;
- Reduction in habitat for sea ice dependent species; and
- Replacement of true Arctic species such as Arctic cod and capelin by the range expansions of subarctic species.

Large-scale changes in oceanographic and ecosystem processes resulting from climate change could indirectly affect fish populations in the Arctic in several ways. For example, under the existing temperature regime, the Chukchi Sea has a food web dominated by benthic consumers and cryopelagic (sea ice-associated) fishes. The loss of sea ice and the increased surface water temperature may promote a shift to a pelagic-based food web with high phytoplankton and zooplankton productivity and greater numbers of predatory fish (Loeng 2005; Hopcroft et al. 2008). Ultimately, however, predictions about the indirect and cascading ecological impacts of climate change on specific species are subject to great uncertainty, given the complexity of the ecosystem.

Oil spills could result from OCS and non-OCS activities. The total number of oil spills and the extent of affected areas would likely increase under the Program in conjunction with increased levels of petroleum exploration and production. The potential impacts of OCS oil spills on fish communities in the Beaufort and Chukchi Sea are discussed in detail in

Section 4.4.7.3.3. Non-OCS activities, such as oil and gas development in State waters, domestic transportation of oil or refined petroleum products, and commercial shipping (including tankering), may also result in accidental spills that could potentially impact fish resources within the Beaufort and Chukchi Sea Planning Areas. While effects to fishery resources would depend on the timing, location, and magnitude of specific oil spills, it is anticipated that most small to medium spills that occur in OCS waters would have limited effects on fishery resources due to the relatively small areas likely to be exposed to high concentrations of hydrocarbons and the short period of time during which potentially toxic concentrations would be present. In general, adult fish in marine environments are highly mobile and capable of avoiding high concentrations of hydrocarbons although they may be subject to sublethal exposures. However, fish eggs and larvae as well as small benthic obligate fish species do not typically have the ability to avoid spills and may therefore suffer lethal or sublethal effects. Oil from large and catastrophic spills that reaches shallower, nearshore areas of these planning areas has the potential to be of greatest significance to fish communities. The potential impacts of OCS oil spills on fish communities in the Beaufort and Chukchi Sea Planning Areas are discussed in detail in Section 4.4.7.3.3.

Some diadromous species of the Beaufort and Chukchi Sea Planning Areas could be at greater risk from oil spills because of their unique life-history cycles. Oil spills occurring at constrictions in migration routes, nursery areas, and spawning areas would have an increased potential for adversely affecting diadromous fishes, and catastrophic spills could result in long-term, population-level impacts on diadromous fish communities. Pacific salmon are also able to detect and avoid oil spills in marine waters (see Section 4.4.7.3.2), which would help to reduce the potential for contact. Aggregations of salmon in marine waters typically consist of mixed stocks, so even in the unlikely event of contact with an oil spill, it is anticipated that only a small fraction of any unique spawning population would be adversely affected. Juveniles of some species of whitefish (including broad whitefish, humpback whitefish, and least cisco) are intolerant of highly saline marine conditions. During their summer feeding dispersals in the Beaufort Sea, these species tend to remain within a narrow band of warm, low-salinity water along the coast. Thus, unlike most subarctic fishes, North Slope whitefish have a reduced capacity to bypass localized disruptions to their migration corridor by moving offshore and around the impasses. An oil spill, even one of limited area, could block the narrow nearshore corridor and prevent fishes from either dispersing along the coast to feed or returning to their overwintering grounds in North Slope rivers.

In addition to effects on individuals and species, impacts to fish can result in ecosystem-level effects if the population impacts are significant. For example, fish can occupy a number of trophic levels ranging from herbivore to top level carnivore. As such, fish are critical to energy flow within nearshore and marine food webs. They are also seasonally important food sources to transient carnivores. Consequently, impacts to fish can propagate throughout the food web, affecting sea turtles, birds and marine mammals. In addition, many Alaskan fishes, particularly salmonids, migrate between and within marine, estuarine, and freshwater habitats. In doing so, they transfer nutrients and carbon over a broad area and connect offshore and coastal ecosystems (Naiman et al. 2002). Therefore, significant impacts to fish populations could reduce this transfer resulting in local changes in productivity.

Conclusion. Cumulative impacts on fish communities in the Beaufort Sea and Chukchi Sea Planning Areas as a result of ongoing and future OCS and non-OCS activities and natural phenomena could be moderate to major over the next 40 to 50 years. Non-OCS activities or phenomena affecting these resources include oil and gas development in State waters, domestic transportation of oil or refined petroleum products, commercial shipping, and pollutant inputs from point and non-point sources. Many of these activities would affect bottom-dwelling fish at various life stages as well as their food sources in a manner similar to OCS bottom-disturbing activities. The incremental contribution of routine Program activities to these impacts (primarily as a result of disturbance affecting demersal fishes) would be negligible to small, with the severity of impacts generally decreasing with distance from the disturbance. Fish could also be affected by the environmental changes predicted to result from climate change.

Fish communities may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS activities as well as naturally occurring seeps. The cumulative impacts of past, present, and future oil spills on these resources would be minor to moderate. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on fish would be negligible to medium, depending on the location, timing, duration, and volume of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDEs would also depend on these factors, and could range up to moderate if they were to occur. Oil from large spills or a CDE has the greatest potential to contact shoreline areas used for spawning or providing habitat for early life stages of fish and, therefore, could result in large-scale lethal and long-term sublethal effects on fish. A more detailed discussion of the effects of oil spills on fish in Arctic waters is presented in Section 4.4.7.3.3.

4.6.4.3.4 Invertebrates and Lower Trophic Levels. Section 4.4.7.5.3 discusses direct and indirect impacts on invertebrates and lower trophic levels in the Beaufort Sea and Chukchi Sea Planning Areas resulting from the 2012-2017 Program under the proposed action (Alternative 1). Cumulative impacts on these resources result from the incremental impacts of the Program (described in Section 4.4.6.1.1) when added to impacts from ongoing and reasonably foreseeable future actions, including those of ongoing and future OCS programs and other non-OCS activities. Table 4.6.1-3 presents the exploration and development scenario for the Arctic region cumulative case, which takes into account activities associated with the Program in combination with those from ongoing and future OCS programs. Other ongoing and reasonably foreseeable future actions contributing to cumulative impacts in Arctic waters are summarized in Table 4.6.1-8 and discussed below, as applicable.

The primary routine OCS activities that could result in impacts on invertebrates include seismic surveys, drilling, the placement of subsea wells, platforms, and pipelines; releases of permitted discharges from wells; and removal of existing structures. Potential environmental impacts associated with the building and operation of OCS facilities such as platforms, and pipelines would increase in conjunction with the increased number of wells. The impacts of routine activities (exploration and site development, production and decommissioning) on invertebrate communities are discussed in detail in Section 4.4.7.5.3. Overall, routine activities represent up to a moderate disturbance, primarily affecting benthic infaunal invertebrates, with the severity of the impacts generally decreasing dramatically with distance from bottom-disturbing activities.

The placement of new platforms over the life of the Program would allow the colonization of invertebrates requiring hard substrate. While some platforms may be allowed to remain as artificial reefs, removal of platforms will reduce available substrate and structures for invertebrates and injure or kill them during removal.

Oil and gas exploration and development in State waters could also contribute to cumulative effects on invertebrates in the Beaufort and Chukchi Sea Planning Areas. Drilling of wells in State waters could also require construction of platforms and pipelines in waters of Alaska. The effects on invertebrates would be similar to those described above for OCS oil and gas programs (Section 4.4.7.5.3). Other non-OCS activities that could impact invertebrate communities include land use practices, point and non-point source pollution, logging, dredging/ and disposal of dredging spoils in OCS waters, and anchoring. Commercial fishing does not occur in the Arctic and therefore is not expected to add to cumulative impacts on invertebrate communities. However, this could change if regulations change and if warming temperatures allow an increase in vessel traffic. Effects on invertebrates from non-OCS dredging and marine disposal activities are expected to be similar to those described for OCS bottom disturbing activities (Section 4.4.7.5.3). Recovery of benthic invertebrates at the dredge and disposal sites to their pre-disturbance composition would likely take multiple years. Many of these activities would affect bottom dwelling invertebrates at various life stages as well as their food sources in a manner similar to OCS bottom disturbing activities (Section 4.4.7.5.1). Other non-OCS activities generating pollution and noise may contribute to general habitat degradation (Section 4.6.3.2.2).

There are several contaminant sources in the Beaufort and Chukchi Sea Planning Areas. The Red Dog Mine in Alaska is the largest lead and zinc mine in the world, and is presently the only base-metal lode mine operating in northwest Alaska. A study for the National Park Service (Hasselbach et al. 2004) showed extensive airborne transport of cadmium and lead from Red Dog Mine; although the study was focused only on the limits of the Cape Krusenstern National Monument, these contaminants are probably carried out into the Chukchi Sea. There are also natural sources of contaminants. Sediments, peats, and soils from the Sagavanirktok, Kuparuk and Colville Rivers are the largest sources of dissolved and particulate metals and saturated and polycyclic aromatic hydrocarbons in the development area. However, contaminant concentrations in the benthic invertebrates collected in the Beaufort and Chukchi Sea Planning Areas are typically at background levels (Neff & Associates, LLC 2010).

It is predicted that physical and chemical changes to Arctic and subarctic invertebrate habitat could result from climate change (Section 3.3). These changes could alter the existing distribution, composition, and abundance of invertebrates, since physical and chemical parameters are the primary influence on invertebrate communities. In general, the increase in seawater temperature will facilitate a northward expansion of subarctic invertebrate species from the Bering Sea. Weslawski et al. (2011) identified the Bering Strait as a major corridor through which new invertebrate species will expand their range northward. Such expansion will likely increase overall invertebrate species diversity in the Arctic, but the new species may displace existing species or alter existing inter-specific species interactions. The change in species composition may be greatest in the eastern Beaufort Sea where Arctic species currently predominate. It is predicted that a decrease in sea ice habitat would result from increasing water temperature. This may have several impacts on invertebrate communities in the Arctic including:

- Loss of habitat for invertebrates specialized to inhabit sea ice;

- An increase in the productivity of water column invertebrates with increasing temperature and open water;

- An increase in the abundance of benthic invertebrates in nearshore areas with the reduction in ice scour extent and duration (Weslawski et al. 2011); and

- An increase in benthic disturbance from severe weather as the amount of open water increases.

Changes in the magnitude, frequency, and timing of river discharge into the Beaufort/Chukchi Shelf Ecoregion are expected to result from climate change (Arctic Council and IASC 2005). Invertebrates in marine ecoregions with strong riverine inputs — like the Beaufort Neritic Ecoregion — would likely be affected by alterations in the salinity, temperature, and sediment delivery regime. Hydrologic change can rapidly alter existing invertebrate communities in the water column and benthos, if the new chemical conditions are not within the physiological tolerance of the existing communities. The greater variability in hydrologic conditions could favor tolerant and opportunistic species, thereby homogenizing invertebrate species composition and decreasing overall species diversity in the Beaufort and Chukchi Seas (Weslawski et al. 20011).

The expected increase in ocean acidification is considered to be another significant source of physiological stress. Crustaceans, echinoderms, foraminiferans, and mollusks could have greater difficulty in forming shells, which could reduce their fitness, abundance, and distribution (Fabry et al. 2008).

Oil spills could result from OCS and non-OCS activities. The total number of oil spills and the extent of affected areas would likely increase under the Program in conjunction with increased levels of petroleum exploration and production (Table 4.6.1-3). The potential impacts of OCS oil spills on invertebrate communities in the Beaufort and Chukchi Sea are discussed in detail in Section 4.4.7.5.3. Non-OCS activities, such as oil and gas development in State waters, domestic transportation of oil or refined petroleum products, and commercial shipping, may also result in accidental spills that could potentially impact invertebrate resources within the Beaufort and Chukchi Sea Planning Areas. While effects to invertebrates would depend on the timing, location, and magnitude of specific oil spills, it is anticipated that most small to medium spills that occur in OCS waters would have limited effects due to the relatively small areas likely to be exposed to high concentrations of hydrocarbons.

Oil from catastrophic spills that reaches shallower, nearshore areas of these planning areas has the potential to be of greatest significance to invertebrate communities. Large, mobile epifaunal invertebrates are capable of avoiding high concentrations of hydrocarbons although they may be subject to sublethal exposures. However, infauna and invertebrate eggs and larvae do not typically have the ability to avoid spills and may therefore suffer lethal or sublethal effects. Catastrophic spills could result in long-term alterations in the abundance of intertidal and shallow subtidal invertebrate communities. Benthic and pelagic invertebrates are important trophic links connecting primary producers to higher-trophic-level organisms. Consequently, oil spill contamination on a large scale could result in contaminant transfer to higher trophic levels and/or reduce food availability to higher trophic levels if invertebrate populations were severely depressed by a CDE. The potential impacts of OCS oil spills on invertebrate communities in the Arctic planning areas are discussed in detail in Section 4.4.7.5.3.

Conclusion. Cumulative impacts on invertebrate communities in the Beaufort Sea and Chukchi Sea Planning Areas as a result of ongoing and future OCS and non-OCS activities and natural phenomena could be moderate to major over the next 40 to 50 years. Non-OCS activities or phenomena offshore marine transportation and pollutant inputs from point and non-point sources. The incremental contribution of routine Program activities to these impacts (mainly due to bottom-disturbing activities) would be negligible to medium, with the severity of the impacts generally decreasing with distance from bottom-disturbing activities. Several major classes of invertebrates could also be affected by the environmental changes predicted to result from climate change.

Invertebrate communities may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS activities. The cumulative impacts of past, present, and future oil spills on these resources would be minor to moderate. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on invertebrates would be negligible to small, depending on the location of the spill and the season in which the spill occurred. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and could range up to moderate if it were to occur. Spills in deeper water, whether from OCS or non-OCS sources, are unlikely to have overall population-level effects on invertebrate resources because of the relatively small proportion of similar available habitats that would come in contact with released oil at concentrations great enough to elicit toxic effects. A CDE could also contaminate or reduce the abundance of seasonally abundant copepods and euphausiids, which may in turn impact higher trophic levels. Oil from a CDE occurring under ice is more difficult to locate and clean than surface spills and may have more persistent effects on water column and sea ice-associated invertebrates. A more detailed discussion of the effects of oil spills on marine mammals in the Arctic region is presented in Section 4.4.7.5.3.

4.6.4.4 Summary for Gulf of Mexico Region

4.6.4.4.1 Marine Mammals. All marine mammals in U.S. waters are protected under the Marine Mammal Protection Act of 1972. The marine mammals in the GOM are diverse and widely distributed throughout the northern GOM. Their distribution and abundance are influenced by oceanographic circulation patterns (which are largely wind-driven, but affected locally by freshwater discharge). There are 21 species of cetaceans (whales) and one species of Sirenian (manatees), several of which are listed as federally endangered under the ESA. Ongoing and future activities or phenomena that affect marine mammals in the GOM include onshore and offshore oil and gas development (and infrastructure), natural phenomena (e.g., hurricanes and diseases), marine vessel traffic, commercial fishing, pollution, military operations, catastrophes, climate change, and invasive species. Cumulative impacts on marine mammals in the GOM region are considered to be minor to moderate.

Routine oil and gas-related activities (e.g., seismic surveys, facility construction, normal operations, and, eventually, decommissioning) would result in minor to moderate impacts on marine mammals. Impacts on marine mammals from these activities could include physical injury or death; behavioral disturbances; lethal or sublethal toxic effects; and loss of reproductive, nursery, feeding, and resting habitats. The contribution of Program activities to cumulative impacts on marine mammals would be negligible to medium. The incremental impacts of expected accidental oil spills (most of which are less than 1,000 bbl) would be small to large, depending on the location, timing, and volume of the spills; the environmental settings of the spills; and the species exposed to the spills. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from moderate to major if it were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to these impacts.

4.6.4.4.2 Terrestrial Mammals. The terrestrial mammals considered in this report are those likely to be present in coastal habitats of the northern GOM. These include the federally endangered GOM coast beach mouse subspecies, which lives in mature coastal barrier sand dunes, and the federally endangered Florida salt marsh vole, which lives in areas vegetated by saltgrass, especially in Dixie and Levy Counties. Ongoing and future activities or phenomena that affect terrestrial mammals include onshore and offshore oil and gas development (and infrastructure), natural phenomena (e.g., hurricanes and tropical storms), industrial and residential development, vehicle traffic, recreation, trash and debris, artificial lighting, climate change (including sea level rise), and invasive and feral species. Present beach mice habitat is no longer of optimal quality because of historical beach erosion, habitat loss and fragmentation from beach front development, and tropical storm damage. The Florida salt marsh vole is rare and has a very restricted range, so catastrophic events could result in its extinction. Cumulative impacts on terrestrial mammals in the GOM region are considered to be minor to moderate.

Routine oil and gas-related activities (e.g., facility construction, normal operations, and, eventually, decommissioning) are not expected to significantly affect the four federally endangered beach mouse subspecies and the federally endangered Florida salt marsh vole. Negligible to minor impacts may result from consumption of or entanglement in beach trash and debris originating from Program activities. The contribution of the Program activities to cumulative impacts therefore would be negligible to medium. The effects of expected accidental oil spills (most of which are less than 1,000 bbl) on these terrestrial mammals would be small to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and other important habitats; the timing and nature of spill containment; and the status of the affected animals. An unexpected, low-probability CDE has a greater potential to affect the habitats of beach mice and the Florida salt marsh vole; therefore, impacts would range from moderate to major if one were to occur. Oil impacts on beach mice would be more likely if a storm surge transports the oil over foredunes.

4.6.4.4.3 Marine and Coastal Birds. The GOM is an important pathway for migratory birds. Most migrant birds either directly cross the GOM or move north or south by traversing the GOM or the Florida peninsula. A diverse range of habitats support migratory and resident bird species along the northern GOM coast. Cumulative impacts on migratory and resident bird species result from direct injury or mortality of marine and coastal birds due to collisions with onshore and offshore structures, ingestion of trash or debris, or exposure to discharges or emissions; loss or degradation of habitat due to coastal development, climate change, or construction and operations activities; and behavioral disturbance due to commercial and recreational boating and small aircraft traffic. Many bird species are currently experiencing a loss or degradation of habitat due to land development and climate change, and these impacts are expected to continue into the foreseeable future. Ongoing and future actions/trends that affect marine and coastal birds in the GOM region include those related to oil and gas development (and infrastructure), coastal development, marine vessel traffic, dredging operations, and climate change. Cumulative impacts on marine and coastal birds in the GOM region are considered to be moderate.

Routine operations may result in localized short-term impacts due to infrastructure construction and marine vessel and aircraft traffic. The contribution of Program activities to cumulative impacts on marine and coastal birds therefore would be negligible to medium. Birds may also be adversely affected by exposure to oil, especially near coastal areas and affecting feeding and nesting areas. The incremental contribution of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on marine and coastal birds would be small to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and nesting areas; the timing and nature of spill containment; and the status of the affected birds. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from moderate to major if it were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to these impacts.

4.6.4.4.4 Fish. Fish in the northern GOM live in the water column (pelagic) and on the seafloor or near bottom waters (demersal) along the gradient from the continental shelf to the abyssal plain. Demersal species are much more abundant and diverse in the hard-bottom habitats found in the eastern GOM. Some fish migrate between saltwater and freshwater habitats. For example, anadromous species (such as the Gulf sturgeon and striped bass) spend most of their adulthood in saltwater but spawn in freshwater; catadromous species (such as the American eel) live primarily in freshwater and spawn in saltwater. Cumulative impacts on fish result from activities that generate lethal or sublethal impacts on individuals as well as habitat loss or degradation. Ongoing and future actions/trends that affect fish in the GOM include oil and gas development, commercial and recreational fishing, noise, dredging and trawling operations, explosive platform removal, land loss, and coastal hypoxia. Climate change is also expected to affect fish habitat, productivity, and community structure. Cumulative impacts on fish in the GOM are considered to be moderate to major. The incremental contribution of routine Program activities to these impacts (primarily as a result of disturbance affecting demersal fishes) would be negligible to small, with the severity of impacts generally decreasing with distance from the disturbance.

Fish communities may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS activities as well as naturally occurring seeps. The cumulative impacts of past, present, and future oil spills on these resources would be minor to moderate. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on fish would be negligible to medium, depending on the location, timing, duration, and volume of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and could range up to moderate if it were to occur.

4.6.4.4.5 Reptiles. Five species of sea turtles are known to inhabit the GOM. The federally protected American crocodile also lives in the eastern GOM, along Florida's southern coast (in mangrove swamps, brackish bays, and inshore freshwater habitats). Hurricanes in 2005 adversely affected sea turtle nesting sites, and the DWH event caused sea turtle mortality and fouling of habitats. Cumulative impacts on sea turtles result from activities that generate lethal and sublethal impacts, or that alter or eliminate habitat required for reproduction, feeding, and early life stage development. Ongoing and future actions/trends that affect sea turtles and crocodiles in the GOM include climate change, oil and gas development, marine vessel traffic, coastal development, dredging, commercial fishing, and land loss. Cumulative impacts on reptiles in the GOM are considered to be moderate to major. The incremental contribution of routine Program activities to these impacts would be small to medium.

Expected accidental oil spills under the Program (most of which are less than 1,000 bbl) would result in a comparatively negligible to medium incremental increase in the overall impact of exposure to oil from other anthropogenic activities (such as spills from foreign tankers) because such spills are relatively easy to contain and would only affect small areas of habitat (and few individuals). However, large spills (1,000 bbl or greater) or an unexpected CDE could potentially result in population-level effects. Although such spills are rare events, impacts would be major and long-term if multiple individuals and their habitat (especially nesting habitat) are exposed to oil.

4.6.4.4.6 Invertebrates and Lower Trophic Levels. Invertebrates (animals without a backbone) occupy multiple habitat types from the intertidal zone to the deep sea. Benthic invertebrates burrow into bottom sediments or move along the sediment surface; pelagic invertebrates either drift with the current or actively swim. In the GOM, invertebrates and lower trophic level organisms include prokaryotes, viruses, protozoa, sponges, jellyfish, worms, mollusks (bivalves, squid, octopi), echinoderms (sea urchins and sea star), and crustaceans (barnacles, crabs, shrimp) among others. Cumulative impacts on invertebrates and lower trophic organisms result from activities that generate lethal or sublethal impacts on individuals as well as habitat loss or degradation. Ongoing and future actions/trends that affect invertebrates and lower trophic organisms in the GOM include oil and gas development, dredging, trawling, land loss, coastal hypoxia, and climate change (especially in terms of ocean acidification). Cumulative impacts on invertebrates and lower trophic organisms in the GOM are considered to be moderate to major.

Routine operations would result in minor to moderate localized impacts primarily due to bottom-disturbing activities and platform placement and removal. The contribution of the Program to cumulative impacts (mainly due to bottom-disturbing activities) would be negligible to medium, with the severity of the impacts generally decreasing with distance from bottom-disturbing activities. Invertebrate communities may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS activities as well as naturally occurring seeps. The cumulative impacts of past, present, and future oil spills on these resources would be minor to moderate. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on invertebrates would be negligible to small, depending on the location, timing, duration, and size of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and could range up to moderate if they were to occur.

4.6.4.5 Summary for Alaska – Cook Inlet

4.6.4.5.1 Marine Mammals. All marine mammals in U.S. waters are protected under the Marine Mammal Protection Act of 1972. Currently, there are 17 marine mammal species in Cook Inlet or nearby waters of the Gulf of Alaska, including whales, sea lions, sea otters, harbor porpoises, and harbor seals; nine of these species are listed as threatened or endangered. Ongoing and future activities or phenomena that affect marine mammals in the inlet include onshore and offshore oil and gas development (and infrastructure); marine vessel traffic; commercial, recreational, and subsistence fishing; subsistence marine mammal harvests; pollution (and marine debris); military operations; development; climate change; and invasive species. Cumulative impacts on marine mammals in the Cook Inlet are considered to be minor to moderate.

Routine oil and gas-related activities (e.g., seismic surveys, facility construction, normal operations, and, eventually, decommissioning) would result in minor to moderate impacts on marine mammals. Impacts on marine mammals from these activities could include physical injury or death; behavioral disturbances; lethal or sublethal toxic effects; and loss of reproductive, nursery, feeding, and resting habitats. The contribution of Program activities to cumulative impacts on marine mammals would be negligible to small. The incremental impacts of expected accidental oil spills (most of which are less than 1,000 bbl) would be negligible to small, depending on the location, timing, and volume of the spills; the environmental settings of the spills; and the species exposed to the spills. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from minor to major if it were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to these impacts.

4.6.4.5.2 Terrestrial Mammals. There are about 40 species of terrestrial mammals in south central Alaska, many of which use the coastal habitats in the Cook Inlet region. These include bison, bears, sheep, beaver, river otters, and wolverine, among others. Ongoing and future activities or phenomena that affect terrestrial mammals in the inlet include onshore and offshore oil and gas development (and infrastructure), aircraft traffic, marine vehicle traffic, coastal and community development, timber harvests, hunting, pollution, climate change, and natural catastrophes. Cumulative impacts on terrestrial mammals in Cook Inlet are considered to be minor to moderate.

Routine oil and gas-related activities (e.g., facility construction including onshore pipelines, normal operations including aircraft and marine vessel traffic, and, eventually, decommissioning) would result in minor impacts on terrestrial mammals. Impacts on terrestrial mammals from these activities could include physical injury or death; behavioral disturbances; lethal or sublethal toxic effects; and loss of reproductive, nursery, feeding, and resting habitats. The contribution of Program activities to cumulative impacts would be negligible to small. The effects of expected accidental oil spills (most of which are less than 1,000 bbl) on terrestrial mammals would be negligible to small, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and other important habitats; the timing and nature of spill containment; and the status of the affected animals. An unexpected, low-probability CDE has a greater potential to affect the terrestrial habitats; therefore, impacts would range from minor to major if one were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to these impacts.

4.6.4.5.3 Marine and Coastal Birds. There are more than 492 naturally occurring bird species in Alaska. Annual use patterns of Cook Inlet are characterized by the sudden and rapid occurrence of very large numbers of birds in early May followed by a sudden and rapid departure in mid- to late-May. Cumulative impacts result from direct injury or mortality of marine and coastal birds due to collisions with onshore and offshore structures, ingestion of trash or debris, or exposure to discharges or emissions; loss or degradation of habitat due to coastal development, climate change, or construction and operations activities; and behavioral disturbance due to commercial and recreational boating and small aircraft traffic. Many bird species are currently experiencing a loss or degradation of habitat due to land development and climate change, and these impacts are expected to continue into the foreseeable future. Ongoing and future actions/trends that affect marine and coastal birds in the inlet include those related to oil and gas development (and infrastructure), coastal development, marine vessel traffic, dredging operations, and climate change. Cumulative impacts on marine and coastal birds in the Cook Inlet region are considered to be minor to moderate.

Routine operations may result in localized short-term impacts due to infrastructure construction and marine vessel and aircraft traffic. The contribution of the Program to cumulative impacts on marine and coastal birds therefore would be negligible to medium. Birds may also be adversely affected by exposure to oil, especially near coastal areas and affecting feeding and nesting areas. The incremental contribution of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on marine and coastal birds would be small to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and nesting areas; the timing and nature of spill containment; and the status of the affected birds. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from moderate to major if it were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to these impacts.

4.6.4.5.4 Fish. The waters of south central Alaska support at least 314 fish species; most of these species can be found in Cook Inlet. Some fish live in the water column (pelagic), others, on the seafloor or near bottom waters (demersal). There are also anadromous species (such as Pacific salmon) that spend most of their adulthood in saltwater but spawn in fresh water. Cumulative impacts result from activities that generate lethal or sublethal impacts to individuals as well as the loss or degradation of fish habitat. Ongoing and future actions/trends that affect fish in the inlet include oil and gas development, commercial and recreational fishing, noise, dredging operations, and wastewater discharge. Climate change is also expected to affect fish habitat, productivity, and community structure. Cumulative impacts on fish in Cook Inlet are considered to be moderate to major. The incremental contribution of routine Program activities to these impacts (primarily as a result of displacement, injury or mortality of fish and their food sources) would be negligible to small.

Fish communities may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS activities as well as naturally occurring seeps. The cumulative impacts of past, present, and future oil spills on these resources would be minor to moderate. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on fish would be negligible to medium, depending on the location, timing, duration, and volume of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and could range up to moderate if they were to occur.

4.6.4.5.5 Invertebrates and Lower Trophic Levels. Invertebrates (animals without a backbone) occupy the rocky and sandy substrates in the intertidal and subtidal zones. Water column invertebrates in Cook Inlet are composed of a mix of oceanic and coastal species. Several species of copepods (small crustaceans) dominate the macrozooplankton assemblage, peaking in late spring and summer. In lower Cook Inlet, benthic invertebrate communities vary spatially as a result of differences in ice formation, with Arctic species being more common on the western side of the inlet and temperate species being more common on the eastern side. Invertebrates and lower trophic level organisms in the rocky and sandy intertidal zone include echinoderms (sea urchins and sea stars), mollusks (bivalves, limpets, and snails), polychaetes (worms), and crustaceans (barnacles, crabs, and amphipods); clams and polychaetes are predominant in subtidal sandy and muddy sediments. Cumulative impacts on invertebrates and lower trophic organisms result from activities that generate lethal or sublethal impacts to individuals as well as habitat loss or degradation. Ongoing and future actions/trends that affect invertebrates in the inlet include oil and gas development, dredging, trawling, and wastewater discharge. Climate change (especially in terms of ocean acidification) is also expected to affect habitat, productivity, and community structure. Cumulative impacts on invertebrates in Cook Inlet are considered to be moderate to major.

Routine operations would result in minor to moderate localized impacts primarily due to bottom-disturbing activities and platform placement and removal. The contribution of the Program to cumulative impacts (mainly due to bottom-disturbing activities) would be negligible to medium, with the severity of the impacts generally decreasing with distance from bottom-disturbing activities. Invertebrate communities may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS activities as well as naturally occurring seeps. The cumulative impacts of past, present, and future oil spills on these resources would be minor to moderate. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on invertebrates would be negligible to small, depending on the location, timing, duration, and size of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and could range up to moderate if they were to occur.

4.6.4.6 Summary for Alaska – Arctic Region

4.6.4.6.1 Marine Mammals. All marine mammals in U.S. waters are protected under the Marine Mammal Protection Act of 1972. In the Arctic region, marine mammals are among the most important subsistence resources for coastal Alaskan Natives. There are 15 species of marine mammals in the Arctic region, four of which are listed as threatened or endangered. These include whales, seals, and polar bears. Polar bears are considered a marine mammal because they inhabit the sea ice surface rather than adjacent land. Ongoing and future activities or phenomena that affect marine mammals in Arctic waters include onshore and offshore oil and gas development (and infrastructure); marine vessel traffic; commercial, recreational, and subsistence fishing; marine mammal subsistence harvests; pollution (and marine debris); development; climate change (including temporal and spatial changes in sea ice); diseases; and natural catastrophes. Cumulative impacts on marine mammals in the Arctic region are considered to be minor to moderate.

Routine oil and gas-related activities (e.g., seismic surveys, facility construction, normal operations, and, eventually, decommissioning) would result in minor to moderate impacts on marine mammals. Impacts on marine mammals from these activities could include physical injury or death; behavioral disturbances; lethal or sublethal toxic effects; and loss of reproductive, nursery, feeding, and resting habitats. The contribution of Program activities to cumulative impacts would be negligible to small. The incremental impacts of expected accidental oil spills (most of which are less than 1,000 bbl) would be negligible to large, depending on the location, timing, and volume of the spills; the environmental settings of the spills; and the species (and number of individuals) exposed to the spills. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from minor to major if it were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to these impacts.

4.6.4.6.2 Terrestrial Mammals. There are about 30 species of terrestrial mammals in the Arctic region. These include the brown bear, caribou, muskox, the Arctic fox, brown lemming, and wolverine, among others. Ongoing and future activities or phenomena that affect terrestrial mammals in the Arctic region include onshore and offshore oil and gas development (and infrastructure), aircraft traffic, marine vehicle traffic, coastal and community development, timber harvests, hunting, pollution, climate change, and natural catastrophes. Cumulative impacts on terrestrial mammals in the Arctic region are considered to be minor to moderate.

Routine oil and gas-related activities (e.g., facility construction including onshore pipelines, normal operations including vehicle and aircraft traffic, and, eventually, decommissioning) would result in minor impacts on terrestrial mammals. Impacts on terrestrial mammals from these activities could include physical injury or death; behavioral disturbances; lethal or sublethal toxic effects; and loss of reproductive, nursery, feeding, and resting habitats. The contribution of Program activities to cumulative impacts would be negligible to small. The effects of expected accidental oil spills (most of which are less than 1,000 bbl) on terrestrial mammals would be negligible to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and other important habitats; the timing and nature of spill containment; and the status of the affected animals. An unexpected, low-probability CDE has a greater potential to affect the terrestrial habitats; therefore, impacts would range from minor to major if one were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to these impacts.

4.6.4.6.3 Marine and Coastal Birds. There are more than 492 naturally occurring bird species in Alaska. Because of the limited seasonal nature of open water and snow-free conditions, the Beaufort and Chukchi Seas support a much smaller number of birds than lower parts of Alaska. Most of the birds occurring in the Arctic region are migratory, being present for all or part of the period between May and early November. Cumulative impacts result from direct injury or mortality of marine and coastal birds due to collisions with onshore and offshore structures, ingestion of trash or debris, or exposure to discharges or emissions; loss or degradation of habitat due to coastal development, climate change, or construction and operations activities; and behavioral disturbance due to commercial and recreational boating and small aircraft traffic. Many bird species are currently experiencing a loss or degradation of habitat due to land development and climate change, and these impacts are expected to continue into the foreseeable future. Ongoing and future actions/trends that affect marine and coastal birds in the Arctic region include those related to oil and gas development (and infrastructure), coastal development, marine vessel traffic, and climate change. Cumulative impacts on marine and coastal birds in the Arctic region are considered to be minor to moderate.

Routine operations may result in localized short-term impacts due to infrastructure construction and marine vessel and aircraft traffic. The contribution of the Program to cumulative impacts on marine and coastal birds therefore would be negligible to medium. Birds may also be adversely affected by exposure to oil, especially near coastal areas and affecting feeding and nesting areas. The incremental contribution of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on marine and coastal birds would be small to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and nesting areas; the timing and nature of spill containment; and the status of the affected birds. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from moderate to major if it were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to these impacts.

4.6.4.6.4 Fish. The Beaufort and Chukchi Seas support at least 98 fish species, with the greatest number found in Chukchi Sea. Fish in the Arctic region must survive extended seasonal periods of frigid and harsh conditions such as reduced light, seasonal darkness, prolonged low temperatures, and ice cover. Food resources tend to be scare during winter months, so most of a fish's yearly food supply must be acquired during the brief Arctic summer. Many species found in the Beaufort and Chukchi Seas are at the northern limits of their range. Subsistence fishing has a long history in the region (commercial fishing occurred infrequently in the past). Cumulative impacts result from activities that generate lethal or sublethal impacts to individuals as well as the loss or degradation of fish habitat. Ongoing and future actions/trends that affect fish in Arctic waters include oil and gas development, noise, dredging operations, and the potential effects of climate change such as the loss of sea ice, habitat alteration, and changes in fish productivity and community structure. Cumulative impacts on fish in Arctic waters are considered to be moderate to major. The incremental contribution of routine Program activities to these impacts (primarily as a result of disturbance affecting demersal fishes) would be negligible to small, with the severity of impacts generally decreasing with distance from the disturbance.

Fish communities may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS activities as well as naturally occurring seeps. The cumulative impacts of past, present, and future oil spills on these resources would be minor to moderate. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on fish would be negligible to medium, depending on the location, timing, duration, and volume of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and could range up to moderate if they were to occur.

4.6.4.6.5 Invertebrates and Lower Trophic Levels. Invertebrates (animals without a backbone) occur in various intertidal and deepwater habitats in the Beaufort and Chukchi Seas. Benthic invertebrates are predominantly echinoderms, polychaetes, sponges, anemones, bivalves, gastropods, and bryozoans. The most common water column macroinvertebrates in the Arctic region are the copepods. Larger invertebrates tend to be sparse in much of the Beaufort Sea relative to the Chukchi Sea, where echinoderms, crabs, and shrimp are more abundant. Zooplankton productivity is highly seasonal. At the lowest trophic levels, microbes such as bacteria and protists are important in Arctic waters for breaking down and recycling nutrients and organic matter. Cumulative impacts on invertebrates and lower trophic organisms result from activities that generate lethal or sublethal impacts to individuals as well as habitat loss or degradation. Ongoing and future actions/trends that affect invertebrates and lower trophic organisms in Arctic waters include oil and gas development, dredging, trawling, and the potential effects of climate change (such as the loss of sea ice), changes in invertebrate habitat, and changes in invertebrate productivity and community structure. Cumulative impacts on invertebrates in Arctic waters are considered to be moderate to major.

Routine operations would result in negligible to moderate localized impacts primarily due to bottom-disturbing activities and platform placement and removal. The contribution of the Program to cumulative impacts (mainly due to bottom-disturbing activities) would be negligible to medium, with the severity of the impacts generally decreasing with distance from bottom-disturbing activities. Invertebrate communities may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS activities. The cumulative impacts of past, present, and future oil spills on these resources would be minor to moderate. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on invertebrates would be negligible to small, depending on the location of the spill and the season in which the spill occurred. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and could range up to moderate if they were to occur.

4.6.5 Social, Cultural, and Economic Resources

4.6.5.1 Gulf of Mexico Region

4.6.5.1.1 Areas of Special Concern. Section 4.4.8.1 identified potential effects of the Program on Areas of Special Concern in the GOM. This section identifies activities that could affect such areas in the GOM, including non-OCS activities and current and planned OCS activities that would occur during the life of the Program, and the potential incremental effects of implementing the Program.

National Marine Sanctuaries. The FGBNMS is the only National Marine Sanctuary located in the Western and Central GOM Planning Areas. The Flower Gardens Bank sanctuary is protected from direct mechanical damage due to oil and gas exploration and development by an MMS Topographic Features Stipulation, which includes a No Activity Zone (Section 4.4.6.2).

Additional OCS activities that could affect the marine sanctuaries include discharges of drilling cuttings, drilling muds, and produced waters. However, as identified in Section 4.4.6.2, the Topographic Features Stipulation does not allow discharges from OCS activities to be released within the vicinity of the FGBNMS. Consequently, it is anticipated that the sanctuary would not be affected by discharges from OCS activities.

Non-OCS activities that could affect the marine sanctuaries include fishing, diving, offshore marine transportation, and tankering. Natural events such as hurricanes could also impact the sanctuaries. Fishing and diving impacts are controlled by sanctuary guidelines regulating these activities. The distance of the Flower Garden Banks from shore (over 160 km [99 mi]) serves to reduce the number of visitors to the sanctuary, further reducing the potential for impacts from fishing and diving activities. Sanctuary regulations also prohibit collecting activities and ban anchoring within the sanctuary in order to minimize structural damage to the reef system from commercial and recreational vessels.

Climate change has the potential to profoundly affect coral communities on topographic features in several ways, including:

- Increased frequency of bleaching as a stress response to warming water temperatures (Hoegh-Guldberg et al. 2007);
- Excessive algal growth on reefs and an increase in bacterial, fungal, and viral agents (Boesch et al. 2000; Twilley et al. 2001);
- Greater frequency of mechanical damage to corals from greater severity of tropical storms and hurricanes (Janetos et al. 2008);
- Decreases in the oceanic pH and carbonate concentration are expected to reduce the reef formation rate, weaken the existing reef structure, and alter the composition of coral communities (Janetos et al. 2008); and
- Invasive species may expand their range into the GOM due to climate change.

Impacts on the marine sanctuaries could occur due to surface hydrocarbon discharges from platform spills, OCS and non-OCS tankers, or other marine traffic passing in the vicinity of the sanctuary. Discharges in the vicinity of the FGBNMS should be greatly diluted before they could reach reef features because water depths within the sanctuary are greater than 20 m (66 ft). Consequently, it is anticipated that concentrations of contaminants within such discharges would be diluted to levels unlikely to have toxic effects on reef organisms. Oil spills could also impact the Flower Garden Banks communities. The No Activity Zone mandated in the Topographic Features Stipulation and adopted as a regulation for the Flower Garden Banks precludes placement of platforms or pipelines immediately adjacent to the marine sanctuary and reduces the likelihood that oil from a pipeline leak would reach bank communities. If oil from a series of subsurface spills were to reach one of these banks, sensitive biota could be affected. Potential impacts have been discussed in Section 4.4.6.2. It is anticipated that impacts of a large oil spill reaching coral reef or hard-bottom habitat may be long-term.

National Parks, Reserves, and Refuges. As identified in Section 4.4.8.1, routine OCS activities potentially affecting parks, reserves, and refuges include placement of structures, pipeline landfalls, operational discharges and wastes, and vessel and aircraft traffic. It is assumed that pipeline landfalls, shore bases, and waste facilities would not be located in National Parks, NWRs, or National Estuarine Research Reserves because of the special status and protections afforded these areas. Consequently, there would be no direct impacts from these activities on any GOM national parks, reserves, or refuges.

It is possible that future pipeline landfalls, shore bases, and waste facilities could be located in one or more estuaries in the Western or Central GOM Planning Area that are included in the National Estuary Program. This includes Corpus Christi Bay (Coastal Bend Bays and Estuaries), Galveston Bay, Barataria-Terrebonne Estuarine Complex, and Mobile Bay. Under the cumulative scenario, it is anticipated that less than 40 new pipeline landfalls could occur in the GOM, with less than 12 of these resulting from the Program (Table 4.4.1-1). In addition, gas-processing facilities could be built in the GOM area under the cumulative scenario. It is assumed that new onshore facilities and structures would be subject to additional evaluations under the NEPA and that they would be sited to avoid national parks, reserves, and refuges and to limit impacts on estuarine and coastal habitats.

Trash and debris are a recognized problem affecting enjoyment and maintenance of recreational beaches along the GOM coast. From extensive aerial surveys conducted by NMFS over large areas of the GOM, floating offshore trash and debris was characterized by Lecke-Mitchell and Mullin (1997) as a ubiquitous, GOM-wide problem. Not surprisingly, such trash and debris frequently wash up on beaches, including those associated with Areas of Special Concern such as the Padre Island National Seashore. Trash and debris can detract from the aesthetic quality of beaches, can be hazardous to beach users and wildlife, and can increase the cost of maintenance programs.

Marine vessel wakes from a large number of vessel trips can, over time, erode shorelines along inlets, channels, and harbors. The GOM is one of the world's most concentrated shipping areas, and the Port of New Orleans supports extensive commercial shipping traffic. The GOM also supports extensive commercial fisheries as well as recreational boating. The GOM also supports training by U.S. Navy vessels as well as routine USCG activities (Section 4.3). The additional vessel activity that would occur under the Program will result in an increase in the overall potential for wakes to affect sensitive shorelines in the GOM OCS Planning Areas.

Overall, it is assumed that there could be 1,400–1,900 OCS-related vessel trips (to new facilities) per week in the GOM under the cumulative scenario; 300 to 600 of these would occur as a result of OCS activities attributable to the Program (Table 4.4.1.1-1). The majority of such vessel trips would occur in offshore waters, thereby precluding effects on shorelines associated with national parks, reserves, and refuges. Existing regulations typically limit vessel speeds in the sensitive inland waterways of Areas of Special Concern. With these measures in place, most impacts due to vessel traffic in such areas would be avoided.

Under the Program, National Parks, NWRs, National Estuarine Research Reserves, or National Estuary Program sites could be exposed to oil accidentally released from platforms, pipelines, and vessels (see Section 4.4.8.1). In addition to the potential for spills from OCS sources, storms, operator error, and mechanical failures could also result in accidental oil releases from a variety of non-OCS-related activities including domestic transportation of oil, importing foreign crude oil, and development of oil production under State programs. The potential exists for impacts to National Parks, Reserves, and Refuges that could result from both oiling of the shoreline and mechanical damage during the cleanup process. Most spills associated with the Program would be relatively small (less than 50 bbl), and most would be expected to occur in waters depths of 200 m (656 ft) or more (Table 4.4.2-1) where they are not likely to affect coastal areas. Because of the expected distribution of leasing activities, it is assumed that such spills would occur in either the Western or Central GOM Planning Area.

Based on the expected distribution of activities and facilities associated with current or proposed activities under OCS leasing programs, it is assumed that any accidental oil spills from OCS-activities would occur in either the Western or Central GOM Planning Area. In contrast, non-OCS spills could occur anywhere in the GOM. Thus, while it is considered likely that only national seashores, NWRs, national estuarine research reserves, and National Estuary Program sites in the Western or Central GOM are at risk from spills due to ongoing or proposed OCS activities, any of these types of properties located along the GOM coast has a potential to be affected by non-OCS accidental spills. Regardless of the source, oil from a large or catastrophic spill that reached the shoreline of any of these sites could have adverse effects on resources or resource values.

Hurricanes and tropical storms occur regularly in the GOM area. The natural environments that parks and refuges preserve and maintain have developed in a setting of regular occurrences of severe storms. In 2004 and 2005, however, Hurricanes Katrina, Rita, and Ivan severely impacted numerous national parks, NWRs, and national estuaries. In 2004, Hurricane Ivan damaged 10 NWRs between the Florida Panhandle and Louisiana. In 2005, Hurricane Katrina affected 16 refuges in the same area, temporarily closing all of them. Impacts included damage to beaches, dunes, vegetation and infrastructure. Breton NWR in Louisiana was reduced to about one-half its pre-Katrina size. Many impacted refuges remain impacted by huge quantities of debris and hazardous gases and liquids spread over large areas of wetlands within the sanctuaries. Should storms of similar strength and size occur during the life of the Program, long-term impacts on Areas of Special Concern in the GOM could occur.

Conclusion. Cumulative impacts on Areas of Special Concern in the GOM are considered to be negligible to moderate. In addition to OCS activities, non-OCS activities that could affect National Sanctuaries, Parks, Reserves and Refuges include fishing, diving, trash and debris, marine vessel traffic (and wakes), tankering, and oil and gas activities in State waters. Hurricanes and tropical storms also occur regularly in the GOM area potentially causing damage. Due to existing protections, it is anticipated that the FGBNMS would not be affected by OCS activities. Development of OCS onshore facilities within National Park lands is considered unlikely, making impacts from routine Program activities unlikely in these areas. Offshore construction of pipelines and platforms could contribute to cumulative effects on wildlife and on scenic values for park visitors. Impacts could also include increases to the amount of trash or debris that currently washes up on shorelines, and increases in shoreline erosion due to increased vessel traffic in inshore waters. Routine operations under the Program could result in a negligible to medium incremental increase in effects on Areas of Special Concern (see Section 4.4.8.1).

Expected oil spills (most of which are less than 1,000 bbl) that may occur during the Program could result in a negligible to small incremental contribution to cumulative impacts on Areas of Special Concern, depending on spill frequency, location, and volume; the type of product spilled; weather conditions; effectiveness of cleanup operations; and other environmental conditions at the time of the spill. Large spills (1,000 bbl and greater) or an unexpected, low-probability CDE in areas adjacent to the National Parks, NWRs, or National Forests, whether from OCS or non-OCS sources, would also depend on these factors, and could result in moderate impacts if they were to occur. Such spills could negatively impact the FGBNMS and coastal habitats and fauna, and could also affect subsistence uses, commercial or recreational fisheries, and tourism.

4.6.5.1.2 Population, Employment, and Income. Section 4.4.9.1 discusses the potential impacts from the Program on population, employment, and income in the GOM coast region. Cumulative impacts on these resources result from the incremental impacts of the Program when added to impacts from ongoing and reasonably foreseeable future OCS program activities (that are not part of the Program) and other non-OCS program activities. Specific types of impact-producing factors related to OCS program activities considered in this analysis include total employment and regional income for counties in the 23 LMAs in the five States in the GOM coast region (described in Section 3.10). Non-OCS program activities affecting the region include employment and earnings related to various other industrial sectors (e.g., construction, manufacturing, services, and State and local government) and the high unemployment rates in the five GOM coast States.

The population in the GOM coast counties increased at an average annual rate of 1.6% between 1980 and 1990, 1.2% between 1990 and 2000, and 1.5% between 2000 and 2009. During each of these periods, the greatest increases consistently occurred in Texas (with an average annual increase of 2.1% between 2000 and 2009) and Florida (with an average annual increase of 1.6% between 2000 and 2009). The components of population increase include the natural increase due to births and net positive domestic and international migration; these trends will likely continue in the GOM coast region over the next 40 to 50 years.

Although the Program would add an average of 128,150 to 196,350 direct and indirect jobs annually between 2012 and 2017, this increase is considered minor (but positive) since it would amount to between 1.2% and 1.8% of forecasted total GOM coast regional employment in 2015. The largest increases would occur in Louisiana and Texas. Likewise, direct and indirect income produced in the region would range from $6,705 million to $10,220 million, with the greatest impacts occurring in Louisiana and Texas.

Population increases of 175,473 to 261,202 would be expected in Texas on average in each year of the Program, with increases of 129,953 to 202,797 occurring in Louisiana. Smaller population increases of 16,382 to 27,519 would occur in Florida, with increases of 6,087 to 10,360 in Alabama and 4,015 to 6,669 in Mississippi. These increases also represent small changes (between 1.3% and 1.9% in the region overall in 2015), assuming a 1.5% average annual increase in population between 2009 and 2017.

Employment impacts of oil spills reaching landfall can vary considerably depending upon the total volume of oil reaching land, land area affected, and sensitivity of local environmental conditions to oil impacts. The primary impacts of oil spills would most likely fall on such coastal activities as beach recreation, diving, commercial fishing, recreational fishing, and sightseeing. Oil spills reaching land can have both short- and long-term effects on these activities. Past studies (Sorenson and McCreary 1990) have shown that there could be a one-time seasonal decline in tourist visits of 5 to 15% associated with a major oil spill. Since tourist movement to other coastal areas in the region often offsets a reduction in the number of visits to one area, the associated loss of business tends to be localized. As discussed in Section 4.4.9, the employment and regional income impact from an oil spill related to the Program would likely be greatest in Texas and Florida and this would likely continue over the next 40 to 50 years. Oil spills would generate only temporary employment (and population) increases during cleanup operations, because such operations are expected to be of short duration.

Hurricanes are recurring events in the GOM area to which the demographic and economic patterns have adjusted. In 2005, however, Hurricanes Katrina and Rita resulted in major socioeconomic changes throughout the GOM region, affecting population, employment, and regional income. Katrina-related flooding affected 49 counties in Alabama, Louisiana, and Mississippi, resulting in estimated damage of more than $155 billion (Burton and Hicks 2005). Damage or loss of hundreds of thousands of homes has resulted in the out-migration of hundreds of thousands of individuals from the region, with varying levels of long-term population displacement. Estimated declines in employment due to hurricane damage and population displacement have ranged from 150,000 to 500,000 jobs, although employment is expected to increase as reconstruction of impacted areas proceeds (Congressional Budget Office 2005). Estimated declines in the 2005 total annual personal income in the GOM range from $10 million in Texas to more than $18 million in Louisiana (Bureau of Economic Analysis 2006).

Conclusion. The cumulative impacts of ongoing and future OCS program and non-OCS program activities would be considered beneficial because these activities would increase employment and earnings in the region over the next 40 to 50 years. The Program would add to these beneficial impacts, especially in Texas and Louisiana. The incremental contribution of the Program is expected to be negligible, however, because the added employment demands are less than 2% of the total GOM coast regional employment (see Section 4.4.9.1).

In areas with a large proportion of impact-sensitive industry (such as tourism), the cumulative impacts of accidental oils spills could be moderate to major, depending on the total volume of oil reaching land, the land area affected, and the sensitivity of local environmental conditions to oil impacts. The incremental contribution of expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program would be negligible to small relative to those associated with ongoing and future OCS program and non-OCS program activities. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in minor to moderate impacts if they were to occur. In the short-term, impacts of a CDE could be large as a result of loss of employment, income, and possible shortages of commodities or services in both coastal and inland areas affected by the spill. Longer-term impacts could be smaller unless the fishing and tourism suffered as a result of real or perceived impacts of the event (see Section 4.4.9.1).

4.6.5.1.3 Land Use and Infrastructure. Localized impacts to land use and existing infrastructure are anticipated as a result of the construction of new OCS program oil and gas facilities in the GOM over the next 40 to 50 years. Depending on the location, onshore development may necessitate minimal changes of existing or potential future uses, as well as minor increases in demands on roads, utilities, and public services (MMS 2007c). Land use generally would evolve over time, with a majority of change to occur from general, regional economic, and demographic growth rather than from activities associated with ongoing and future OCS programs and/or State oil and gas development (BOEMRE 2011a).

Recently, deepwater gas production has increased while gas production along the coast has substantially decreased. These trends have combined to lower the need for new gas processing facilities along the GOM coast. As a result, BOEM has concluded that spare capacity at existing facilities is sufficient to satisfy new gas production for many years (although a new gas processing facility could be needed at some future date) (BOEMRE 2011a). With some modifications, current facilities and land use classifications would be expected to support oil and gas production associated with new OCS leases. Likewise, service-based infrastructure would be able to support offshore petroleum-related activities in both the Federal OCS and State waters (BOEMRE 2011a).

Ongoing non-OCS program activities that could affect land use and onshore infrastructure are expected to continue into the foreseeable future. These include offshore and onshore construction, the discharge of municipal and other waste effluents, and marine vessel traffic (MMS 2007c).

Activities within the GOM may be affected by post-DWH event conditions. A significant amount of information has been generated regarding the consequences of the oil spill and subsequent drilling moratorium. As the post-DWH event situation is dynamic, BOEM has been conducting ongoing monitoring of post-DWH event impacts on land use and coastal infrastructure. BOEM will continue to conduct targeted and peer-reviewed research, as long as the monitoring identifies long-term impacts of concern (BOEMRE 2011a).

Accidental oil releases may occur as a result of both OCS and non-OCS activities and from naturally occurring seeps. The extent of the impacts associated with accidental oil spills would depend on the location and size of the releases, but could include stresses of spill response on the community infrastructure, increased traffic to respond to cleanup (both onshore and offshore), and restricted access to affected lands while cleanup is conducted. In general, these releases would be expected to have only a temporary impact on land use and infrastructure (MMS 2007c).

Conclusion. Localized impacts to land use and existing infrastructure are anticipated over the next 40 to 50 years as a result of ongoing and future OCS program and non-OCS program activities in the GOM. These impacts could range from minor to major depending on the location and nature (extent and duration) of the land use change. The incremental contribution of routine operations under the Program to cumulative impacts in the GOM would be negligible to small because the existing infrastructure is considered sufficient to handle the small increases in demands for roads, utilities, and public services related to the Program. Activities within the GOM also may be affected by the post-DWH event conditions; BOEM continues to monitor the region to identify long-term impacts of concern (see Section 4.4.10.1).

Land use–related impacts resulting from expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program include stresses of spill response on community infrastructure, increased traffic in the response area (both onshore and offshore), and temporary restricted access to affected lands (while cleanup is conducted). Such spills would result in a negligible to small incremental contribution to cumulative impacts on land use and existing infrastructure. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in minor to moderate impacts if they were to occur.

4.6.5.1.4 Commercial and Recreational Fisheries.

Commercial Fisheries. Routine OCS activities over the next 40 to 50 years could harm or kill individual fishes, resulting in temporary movements of fishes away from areas where activities were being conducted. Impacts would vary depending on the nature of a particular structure, the phase of operation, the fishing method or gear, and the target species group. Impacts would be higher for drifting gear such as purse nets, bottom longlines, and pelagic longlines than for trawls and handlines (MMS 2005f). Nevertheless, areas in which commercial fishing would be affected are small relative to the entire fishing area available to surface longliners or purse seiners. Although long-term effects on populations of most fishes in the GOM as a whole are not anticipated, populations of rare fishes or those that have highly limited distributions within the GOM could be more substantially affected if activities occurred in areas with high concentrations of individuals.

Offshore oil and gas structures placed within the depth range 0 to 60 m (0 to 200 ft) would increase annual commercial fishing costs by between $1,993 and $3,819 in the Western Planning Area, while reducing costs by between $2,507 and $11,243 in the Central Planning Area. Currently, there are no data available on the placement of offshore platforms in the Eastern Planning Area; consequently, we can draw no conclusions regarding their impact on commercial fishing costs.

Depending upon the location, magnitude, and timing of accidental oil spills from OCS platforms or pipelines, lethal or sublethal toxic effects could occur, especially for species that have pelagic eggs and larvae. If spills occurred in areas with high concentrations of eggs or larvae of a particular species, the abundance of a particular year-class could be affected. The effects of spilled oil on commercial fisheries include fishing ground area closures, contaminated fish, fouled fishing gear and associated equipment, and degradation of fishing grounds. Accidental oil releases from non-OCS activities are possible anywhere on the OCS or in State waters (e.g., from vessel collisions or transfer/lightering operations); crude oil also enters the environment from naturally occurring seeps. Although such releases typically occur in deeper water, the released oil should rise to the surface relatively quickly, and although it is anticipated that most adult fish would be able to avoid the resulting plumes of oil, larvae or eggs of some fish species could be affected and commercial fishing gear could become fouled with oil. In many cases, commercial fisheries would be able to return to the area after slicks have been cleaned up or dispersed. However, shallow coastal spills could contaminate tissues of target organisms (e.g., oyster beds and shallow benthic fishes), and affected commercial fisheries could be closed for one or more seasons.

Non-OCS program activities and factors that could affect fish populations in the GOM include State oil and gas activities, commercial shipping (and other marine vessel traffic), land development, dredging and dredge-disposal operations, marine mineral mining, and water quality degradation from both point and nonpoint pollution sources. In particular, space-use conflicts resulting from exploration and delineation activities and establishment of development and production platforms could affect commercial fisheries, with some areas precluded from commercial fisheries. There are temporary exclusions from fishing in areas during exploration and delineation activities. Underwater OCS structures such as pipelines could also cause space- and gear-related conflicts, and increased vessel traffic to and from the rigs and platforms will also increase the amount of marine traffic and possible conflicts with commercial fishers. The potential for spatial preclusion also exists in both nearshore and offshore waters with increased levels of seismic survey activity.

Recreational Fisheries. While space-use conflicts with recreational fisheries caused by routine OCS operations would be minimal, there is recreational shrimp trawling for wild shrimp, and trawls could become entangled with OCS structures in the water. Deepwater recreational rod-and-reel anglers typically target oil and gas platforms because these structures usually attract target species. Noise from rig and platform installation and from seismic surveys during exploration and delineation activities could scatter target species away from some recreational fishing areas while activities are occurring and potentially for some period afterward. Temporary reductions in hook-and-line captures have been reported in some areas following seismic surveys. This may result in decreased recreational catch. Platform removal using explosives may also impact recreational fisheries. The noise would drive some fish away, some fish would be killed, and a structure that may be targeted as a fishing location by recreational anglers could be eliminated.

Oil spills from OCS or non-OCS sources could affect recreational fisheries by fouling gear with oil, tainting the catch, and degrading water quality and fishing grounds. Accidental oil releases from non-OCS activities are possible anywhere on the OCS or in State waters, and crude oil also enters the environment from naturally occurring seeps. The OCS oil spills most likely to affect recreational anglers would be shallow water spills, since recreational anglers are less likely to venture far offshore. Non-OCS oil and gas activities likely pose a greater risk in terms of potential oil spills that could affect recreational fisheries, because such activities are located closer to shore. Closure of some areas to fishing, perhaps for multiple seasons, could occur as a result of oil spills. In addition, public perception of the effects of a spill on marine life and its extent could result in a loss of revenue for the fishing-related recreation industry. Party and charter boat recreational fisheries often have losses of income because of reduced interest in fishing when a spill has occurred. Local hotels, restaurants, bait-and-tackle shops, and boat rental companies associated with recreational fisheries may experience reduced sales because of public perception related to an oil spill.

Conclusion. Cumulative impacts on commercial and recreational fisheries in the GOM as a result of ongoing and future OCS and non-OCS activities and natural phenomena are expected to be minor over the next 40 to 50 years. Non-OCS activities affecting fisheries in the GOM include State oil and gas activities, commercial shipping (and other marine vessel traffic), land development, dredging and dredge-disposal operations, marine mineral mining, and water quality degradation from both point and nonpoint pollution. The incremental contribution of routine operations under the Program to these impacts would be small since these activities would be unlikely to have population- or community-level effects on fishery resources because of the limited time frame over which most individual activities would occur and because a small proportion of habitat relative to similar available habitat would be affected during a given period. In addition, existing stipulations are in place to prevent or reduce impacts on sensitive habitats such as hard-bottom areas and topographic features. Construction of new platforms could represent a small increase in the availability of desirable recreational fishing locations for recreational anglers (see Section 4.4.11.1).

Commercial and recreational fisheries may be adversely affected by accidental oil releases from OCS and non-OCS activities (e.g., State oil and gas development, domestic transportation of oil or refined petroleum products, and commercial shipping). The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on would be medium, depending on the location, timing, and volumes of spills (among other environmental factors). Small spills are unlikely to affect a large number of fish or have a substantial effect on recreational fishing before dilution and weathering reduced concentrations of oil in the water. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be moderate if they were to occur. Spills of this scale could have significant localized effects on commercial fishing as a result of reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods, and on recreational fishing as a consequence of contamination of fish tissues, degradation of aesthetic values that attract fishers, or temporary closure of fishing areas. Large spills or a CDE have a greater potential to contact intertidal habitat and subsequently contaminate or reduce the abundance of commercial and recreational species that depend on nearshore habitat. These impacts could be long term, but are not expected to result in the long-term loss of fisheries in the GOM.

4.6.5.1.5 Tourism and Recreation. Noise from platform installation and platform removal can affect recreational fishing by temporarily disturbing fish and by causing fish kills if explosives are used to remove platforms. Platforms installed within 16 km (10 mi) of coastal recreation areas, such as beaches, parks, and wilderness areas, can affect recreational experiences by affecting ocean views. Transportation of oil and gas, combined with other commercial, industrial, and recreational vessel traffic that continues to occur within the GOM, can affect recreational experiences through increased noise, boat wake disturbances, visual intrusions, and increased trash and debris washing ashore. In addition to transportation and oil and gas, other activities contribute to the trash and debris found on the beaches including (but not limited to) beach visitors, commercial and recreational fishing, merchant shipping, naval operations, and cruise lines.

Non-OCS activities that might impact recreation and tourism include offshore construction (e.g., dredging and dredge-disposal operations, marine mineral mining, State oil and gas development, domestic transportation of oil and gas, and foreign crude oil imports), onshore construction (e.g., coastal and community development), the discharge of municipal and other waste effluents, and marine vessel traffic (e.g., commercial shipping, recreational boating, and military training and testing).

Accidental oil releases may occur as a result of both OCS and non-OCS activities, and oil is also released from naturally occurring seeps. The magnitude of the impacts would depend on the location and size of the releases, as well as their timing with respect to peak tourism seasons. These releases are expected to have a temporary impact on recreation and tourism in the GOM region. Closures of recreational areas for up to 6 weeks could occur to accommodate cleanup operations. Most of the releases identified under the Program are anticipated to be small and would occur in waters greater than 200 m (660 ft) in depth. These releases would be a small addition to releases associated with other OCS and non-OCS activities.

Severe storm events such as hurricanes have the potential to impact the recreation and tourism economy if they result in severe beach damage and/or destruction of existing public infrastructure. While hurricanes are regularly occurring events in the GOM, Hurricanes Katrina and Rita in 2005 caused unusually large amounts of damage to the tourism and recreation infrastructure in the area. These storms destroyed recreational beaches, public piers, hotels, casinos, marinas, recreational pleasure craft and charter boats, and numerous other recreational infrastructure. Almost 70% of the recreational fishing assets in Mississippi alone were damaged by Katrina (Posadas 2005). Of the 13 casino-barge structures present along the Mississippi coast prior to Katrina, most suffered severe external damage, seven broke completely free of their moorings, two partially broke free and damaged adjoining structures, one sank, and one was deposited inland by the storm surge (NIST 2006). The full extent of impacts to tourism and recreation by the hurricanes has yet to be fully quantified, but it will likely take years for tourism and recreation to return to pre-hurricane levels.

Conclusion. Cumulative impacts on tourism and recreation in the GOM as a result of ongoing and future OCS and non-OCS activities and natural phenomena are expected to be minor over the next 40 to 50 years. Non-OCS activities or phenomena affecting these resources include offshore construction (e.g., dredging and dredge-disposal operations, marine mineral mining, State oil and gas development, domestic transportation of oil and gas, and foreign crude oil imports), onshore construction (e.g., coastal and community development), the discharge of municipal and other waste effluents, and marine vessel traffic. The incremental contribution of routine operations under the Program to these impacts would be small, with potential adverse aesthetic impacts on beach recreation and sightseeing and potential positive impacts on diving and recreational fishing (see Section 4.4.12.1).

Tourism and recreation may be adversely affected by accidental oil releases from OCS and non-OCS activities (e.g., State oil and gas development, domestic transportation of oil or refined petroleum products, and commercial shipping). The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on would be negligible to small, depending on the size, location, and timing of the spill (being greatest if it occurred during the peak recreational season). Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be moderate to major if they were to occur. Short-term impacts would include beach and coastal access restrictions; restrictions on visitation, fishing, or hunting while cleanup is being conducted; and aesthetic impacts associated with the event itself and with cleanup activities. Longer-term impacts could be substantial if tourism were to suffer as a result of the real or perceived impacts of the event, or if there were substantial changes to tourism and recreation sectors in the region as a result of the event.

4.6.5.1.6 Sociocultural Systems. The GOM coastal commuting zone is ethnically and culturally diverse and includes a well-established oil and gas industry focused mainly in Louisiana and Texas (Section 3.14.1.1). For the most part, oil and gas development on the OCS will make use of existing pipelines and onshore infrastructure. Increases in activities associated with the Program are anticipated to be incremental and qualitatively similar to current patterns. However, as deepwater drilling expands, jobs that require longer, unbroken periods of offshore work will increasingly attract a more international workforce promoting sociocultural heterogeneity in coastal support communities, particularly in Texas and Louisiana.

Non-OCS program activities and processes affecting sociocultural systems are expected to continue. These include oil and gas development in State waters, coastal habitat changes, coastal land loss, regional economic changes, and recovery from storms and major oil spills. These activities and processes can lead to major impacts related to population change, job creation and loss, and changes in social institutions including family, government, politics, and education.

Accidental oil and other spills over the next 40 to 50 years could result from both OCS and non-OCS activities. The magnitude of spill impacts depends on their size, location, and timing. With the exception of major spills (such as occurred with the DWH event), oil spills are expected to have only temporary physical and economic effects and therefore should not significantly alter sociocultural systems.

The wetlands that supply subsistence resources are susceptible to oil spills. The Louisiana parishes of St. Mary, Terrebonne, and Lafourche are home to populations engaged in renewable resource harvesting, and are also areas of heavy to moderate concentrations of oil and gas industry facilities. As discussed in Section 3.7, the wetlands in coastal Louisiana are rapidly diminishing because of engineering projects to control the Mississippi River, natural subsidence, the development of the oil and gas industry, and climate change (Field et al. 2007). Because of the construction of flood-control structures, the Mississippi River no longer floods Louisiana's wetlands; these floods previously deposited new silt to offset coastal erosion. Extraction of oil and gas from coastal areas may have resulted in some subsidence of bayou lands. In many areas, Louisiana's coastal wetlands have been cut by a network of canals constructed to lay pipes bringing oil and gas to onshore refining facilities (Field et al. 2007). Cut in straight lines from the shore, these canals exacerbate the erosive force of tides and storm surges. Climate change has resulted in slowly increasing sea levels and an increased intensity of coastal storms and hurricanes. The end result has been an overall decrease in Louisiana's wetlands and a reduction in fresh and brackish wetlands and the subsistence species they support, along with an increase in salt marshes. Cumulatively, these changes constitute major impacts on a way of life that was once common along the GOM coast.

It is anticipated that global climate change will result in increased temperatures and rising relative sea levels along the GOM coast and these changes will be accompanied by an increase in severe storms in the coming decades. Rising relative sea levels and increased erosion have been observed all along the coast (Field et al. 2007). Those who rely at least in part on harvesting renewable resources from the sea, either as subsistence or commercial fishers and shrimpers, are predicted to be most vulnerable to adverse effects resulting from these changes (Nicholls et al. 2007).

Conclusion. Cumulative impacts on sociocultural systems in the GOM as a result of ongoing and future OCS and non-OCS activities and natural phenomena could be moderate over the next 40 to 50 years. Non-OCS activities or phenomena affecting these resources include oil and gas development in State waters, coastal habitat changes, coastal land loss, regional economic changes, and recovery from storms and major oil spills. In terms of subsistence and renewable resource harvesting, non-OCS activities such as flood control along the Mississippi River and natural trends such as global climate change have produced major adverse impacts on the GOM coast region. The incremental contribution of routine operations under the Program to these impacts would be small, since they are more likely to support the existing industry than to create industry growth. Any expansion of deepwater activities will result in jobs that require longer, unbroken periods of work offshore, specialized skills, and potential in-migration of part of the workforce (see Section 4.4.13.1).

Sociocultural systems may be adversely affected by accidental oil releases from OCS and non-OCS activities (State oil and gas development, domestic transportation of oil or refined petroleum products, and commercial shipping). The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program would be small to medium, especially on localized intertidal resources used by subsistence harvesters. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be moderate to major if they were to occur, especially if oil were to reach the shore. Such spills could lead to long-term closure of fisheries, resulting in social and cultural stress. GOM subsistence harvesters make up a relatively small segment of the coastal population and replacement food resources are more available than for subsistence harvesters in Alaska, so while the impact of the loss of subsistence resources would be moderate for the coastal population as a whole, it would be locally major for populations that depended on subsistence harvesting for a significant proportion of their diet.

4.6.5.1.7 Environmental Justice. Over the next 40 to 50 years, air emissions from OCS and non-OCS onshore facilities and helicopter and marine vessel traffic traversing coastal areas would be highest in States such as Texas and Louisiana that contain the greatest amounts of infrastructure. Lesser amounts of infrastructure would occur in Mississippi and Alabama. No onshore infrastructure supporting OCS operations currently exists in Florida, and none will be built as a result of the Program. It is assumed that 75% of the activity from the Program will occur in deep and ultra-deep waters, with offshore air emissions greatest in the coastal areas of Texas and Louisiana, the areas with the greatest amounts of oil and gas activity, with lesser amounts in occurring in Mississippi and Alabama. The coastal areas of Florida are located so far from OCS activities that no environmental justice issues from offshore air emissions are expected to impact the coastal parts of the State. The effects of the OCS program on air quality have been analyzed in Section 4.4.4. This analysis concluded that routine operations associated with the Program would result in NO_2, SO_2, PM_{10}, and CO levels that are well within the NAAQS. Disproportionate impacts on low-income or minority populations would be minor, because the coastal effects from offshore activities are expected to be small, based on the established and increasing trend toward movement of oil and gas activities into deeper waters of the GOM.

The Program would result in levels of infrastructure use and construction similar to those that have already occurred in the GOM coast region during previous OCS programs. These activities are not expected to expose residents to notably higher risks than currently occur. While the distribution of offshore-related activities and infrastructure indicates that some places and populations in the GOM region would continue to be of environmental justice concern, the incremental contribution of the Program is not expected to affect those places and populations.

Non-OCS activities and processes that are ongoing and expected to continue into the foreseeable future, and include non-OCS oil and gas development, coastal habitat changes, coastal land loss, economic development, regional economic changes, and recovery from storms. These activities and processes could disproportionately impact low-income and minority populations.

In addition to oil and chemical spills that could occur with the Program, oil releases and spills could also occur from other non-OCS sources such as natural oil seeps, State oil and gas activity, and petrochemical refining and processing. While the timing and location of these spills cannot be determined and some low-income and minority populations are resident in some areas of the GOM coast, in general the coasts are home to more affluent groups. Low-income and minority groups are not more likely to bear more negative impacts than are other groups.

Conclusion. In the GOM, ongoing and future OCS and non-OCS program activities in combination with the effects of storm and hurricane damage and regional economic issues would result in disproportionate moderate to major adverse cumulative impacts on low-income and minority populations. The incremental contribution of routine operations under the Program to these impacts would be negligible (see Section 4.4.14.1).

The incremental contribution of expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program would be negligible to medium because of the movement of oil and gas activities farther away from coastal areas and the demographic pattern of more affluent groups (and fewer low-income and minority populations) living in coastal areas. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in moderate to major impacts, depending on the location, size, and timing of the event.

4.6.5.1.8 Archeological and Historic Resources. Section 4.4.1.5 discusses the direct and indirect impacts from the Program in onshore and offshore environments in the GOM. Cumulative impacts on archeological and historic resources result from the incremental impacts of the Program when added to impacts from ongoing and reasonably foreseeable future OCS program activities (that are not part of the Program) and other non-OCS program activities. Table 4.6.1-2 presents the exploration and development scenario for the GOM cumulative case (encompassing the Program and other OCS program activities). Specific types of impact-producing factors related to OCS program activities considered in this analysis include drilling rig and platform emplacement, pipeline emplacement, anchoring, new onshore facilities, ferromagnetic debris associated with OCS activities, and oil spills. Non-OCS program activities include trawling, sport diving, commercial treasure hunting, and channel dredging. Natural phenomena such as waves, currents, and tropical storms are also considered.

Prehistoric Resources. Offshore development could result in an interaction between a drilling rig, platform, pipeline, or anchors and an inundated prehistoric site. This direct physical contact with a site could destroy artifacts or site features and could disturb the stratigraphic context of the site. The result would be the loss of archaeological data on prehistoric migrations, settlement patterns, subsistence strategies, and archaeological contacts for the Americas and the Caribbean.

Since 1973 when the Environment Studies Program (ESP) was initiated, the USDOI has required that an archaeological survey be conducted prior to development of mineral leases determined to have potential for cultural resources including prehistoric archaeological sites. High-probability areas for the occurrence of prehistoric sites in the GOM include the region of the OCS shoreward of the 45-m (50-ft) isobath. Although an archaeological survey would identify most of the cultural resources in the APE for the project and routine operations related to OCS program activities would avoid all known cultural resources, it is likely that impacts to prehistoric resources have already occurred as a result of OCS program and non-program activities that took place before implementation of the 1973 archaeological survey requirement.

Onshore development could result in direct physical contact between the construction of new onshore facilities or pipeline trenches and previously unidentified prehistoric sites. This direct physical contact with a prehistoric site could cause physical damage to or complete destruction of information on the prehistory of the region and North America. Federal and State laws and regulations initiated in the 1960s began requiring archaeological surveys prior to permitting any activity that might disturb a significant archaeological site. Therefore, it can be assumed that, since the introduction of the archaeological resource protection laws, most coastal archaeological sites have been located, evaluated, and mitigated prior to construction. However, impacts to coastal prehistoric resources may have already occurred as a result of various onshore construction activities prior to enactment of the archaeological resource protection laws.

Trawling activity in the GOM affects only the uppermost portion of the sediment column (Garrison et al. 1989). This zone would already have been disturbed by natural factors relating to the destructive effects of marine transgression and continuing effects of wave and current action. Therefore, the effect of future trawling on most prehistoric archaeological sites is expected to be minor.

Tropical storms and hurricanes are yearly occurrences in the GOM and may be increasing in intensity as a result of global climate change (Section 3.3.1). Past storm events have affected all areas of the GOM, from west Texas to south Florida, and broad areas are affected by each storm (DeWald 1980). Prehistoric sites in shallow waters or coastal beach sites are exposed to the destructive effects of wave action and scouring currents during these events. Under such conditions, it is highly likely that artifacts would be dispersed and the site context disturbed, resulting in the loss of archaeological information. Overall, a significant loss of data from nearshore and coastal prehistoric sites may have occurred, and will continue to occur, from the effects of tropical storms and hurricanes. It is assumed that some of the data lost have been significant and/or unique, resulting in a moderate to major level of impact.

Most channel dredging occurs at the entrances to bays, harbors, and ports. These areas have a high probability for prehistoric archaeological sites, as they are associated with drowned river valleys, which are known to have a high probability for prehistoric sites. It is assumed that some of the archaeological data that have been lost as a result of dredging have been significant and unique; therefore, the impact to prehistoric archaeological sites as a result of past channel dredging activities has probably been moderate to major. In many areas, the USACE now requires remote-sensing surveys prior to dredging activities to minimize such impacts (Espey, Huston & Associates 1990).

An accidental oil spill could affect coastal prehistoric archaeological sites, but the direct impact of oil on most sites is uncertain. Protection of such sites during an oil spill event requires specific knowledge of its location, condition, nature, and extent prior to impact; however, the GOM coastline has not been systematically surveyed for archaeological sites. Existing information indicates that, in coastal areas of the GOM, prehistoric sites occur frequently along the barrier islands and mainland coast and along the margins of bays and bayous. Thus, any spill that contacts land would involve potential impacts on prehistoric sites.

Heavy oiling of a coastal area could conceal intertidal sites that may not be recognized until they are inadvertently damaged during cleanup (Whitney 1994). Crude oil may also contaminate organic material used in ^{14}C dating, and, although there are methods for cleaning contaminated ^{14}C samples, greater expense is incurred (Dekin et al. 1993). The major source of potential impacts from oil spills is the harm that could result from unmonitored shoreline cleanup activities. Unauthorized collecting of artifacts by cleanup crew members is also a concern, albeit one that can be mitigated with effective training and supervision. Damage or loss of significant archaeological information could result from the contact between an oil spill and a prehistoric archaeological site; therefore, cumulatively the level of impacts from oil spills (past, present, and future) to prehistoric archaeological sites ranges from moderate to high.

Historic Resources. Direct physical contact between a routine activity and a shipwreck site could destroy fragile ship remains, such as the hull and wooden or ceramic artifacts, and could disturb the site context. The result would be the loss of archaeological data on ship construction, cargo, and the social organization of the vessel's crew, and the concomitant loss of information on maritime culture for the time period from which the ship dates.

Since 1973 when the ESP was initiated, the USDOI has required archaeological (historical) surveys be conducted prior to development of mineral leases determined to have potential for historic-period shipwrecks. The high-probability areas for the occurrence of historic-period shipwrecks in the GOM consist of nearshore areas, port vicinities, and ship-specific polygons. Based on experience from the last 10 years (as reported by Church and Warren [2008]; Ford et al. [2008]; Atauz et al. [2006]), archaeological surveys are now also being requested for the APE that includes any potential bottom-disturbing activities in deepwater areas that could be affected by a project. Although an archaeological survey would identify most of the cultural resources in the area of potential effect (APE) for the project and routine operations related to OCS program activities would avoid all known cultural resources, it is likely that impacts on historic-period shipwrecks may have already occurred as a result of OCS program and non-program activities that took place before implementation of the archaeological survey requirement in 1973.

Onshore development could result in direct physical contact between the construction of new onshore facilities or pipeline trenches and previously unidentified historic sites. Federal and State laws and regulations initiated in the 1960s began requiring archaeological surveys prior to permitting any activity that might disturb a significant archaeological site. Therefore, it can be assumed that, since the introduction of the archaeological resource protection laws, most coastal archaeological sites have been located, evaluated, and mitigated prior to construction. However, impacts to coastal historic sites may have already occurred as a result of various onshore construction activities prior to enactment of the archaeological resource protection laws.

Trawling activities in the GOM only affect the uppermost portion of the sediment column (Garrison et al. 1989). On many wrecks, this zone would already have been disturbed by natural factors and would contain only artifacts of low specific gravity (e.g., ceramics and glass) which have lost all original contexts. Therefore, the effect of future trawling on most historic shipwreck sites would be minor.

Sport diving and commercial treasure hunting are significant factors in the loss of historic data from shipwreck sites. While commercial treasure hunters generally affect wrecks having intrinsic monetary value, sport divers may collect souvenirs from all types of shipwrecks. It is assumed that some of the data lost have been significant and/or unique. The known extent of these activities suggests that they have resulted in a major impact to historic-period shipwrecks.

Tropical storms and hurricanes are yearly occurrences in the GOM and may be increasing as a result of global climate change (Section 3.3.1). Past storms have affected all areas of the GOM, from west Texas to south Florida, and broad areas are affected by each storm (DeWald 1980). Shipwrecks in shallow waters and coastal historic sites are exposed to greatly intensified longshore currents and high-energy waves during tropical storms (Clausen and Arnold 1975). Under such conditions, it is highly likely that artifacts of low specific gravity would be dispersed. Some of the original information contained in the site would be lost in this process, but a significant amount of information may also remain. BOEM-sponsored studies conducted specifically to examine the effect of hurricanes on shipwrecks in the GOM found that storm effects on wrecks varied, with some wrecks being damaged, some unaffected, and others protected because the storm caused sediment to be deposited on the wreck (Gearhart et al. 2011).

Overall, a significant loss of data from historic sites has probably occurred, and will continue to occur, from the effects of tropical storms and hurricanes. It is assumed that some of the data lost has been significant and/or unique, resulting in a moderate to major level of impact.

Most channel dredging occurs at the entrances to bays, harbors, and ports. These areas have a high probability for historic shipwrecks, and the greatest concentrations of historic wrecks are likely to be associated with these features (Garrison et al. 1989). Assuming that some of the data lost have been unique, the impact to historic sites as a result of past channel dredging activities has probably been moderate to major. In many areas, the USACE requires remote-sensing surveys prior to dredging activities, to minimize such impacts (Espey, Huston & Associates 1990).

Past, present, and future oil and gas exploration and development on the OCS will result in the deposition of tons of ferromagnetic debris on the seafloor. This modern marine debris tends to mask the magnetic signatures of historic shipwrecks, particularly in areas that were developed prior to requiring archaeological surveys. Such masking of the signatures characteristic of historic shipwrecks increases the potential that significant or unique historic information may be lost. However, BOEM requires avoidance or investigation of any unidentified magnetic anomaly that could be related to a shipwreck site prior to permitting bottom-disturbing activities. The impacts to historic shipwrecks from magnetic masking could range from minor to moderate.

An accidental oil spill could affect a coastal historic site, but the direct impact of oil on most historic sites is uncertain. The primary source of potential impacts from oil spills is unmonitored shoreline cleanup activities (Bittner 1996; see Section 4.4.15.1.2). Unauthorized collecting of artifacts by cleanup crew members is also a concern, albeit one that can be mitigated with effective training and supervision. Damage or loss of significant historic information could result from oil spill cleanup activities; therefore, the cumulative impact from oil spills (past, present, and future) on historic sites could range from moderate to major.

Conclusion. The cumulative impacts of ongoing and future OCS and non-OCS program activities on prehistoric and historic archaeological sites in the GOM are currently unknown, but could range from minor to moderate, mainly because activities occurring on the OCS prior to the USDOI's survey requirement (in effect since 1973) may already have affected significant archaeological sites. Other important impact-producing factors that likely have had, and will continue to have, an impact on both prehistoric and historic archaeological sites are channel dredging, tropical storms, and hurricanes. Commercial treasure hunting and sport diving may also result in a loss of artifacts at historic-period shipwreck sites. The incremental contribution of routine operations under the Program is expected to be negligible to large, depending on whether significant resources are located in the area of effect. Archaeological surveys that would identify significant cultural resources to be avoided could reduce these impacts (see Section 4.4.15.1).

Cumulative impacts on prehistoric and historic archaeological sites due to expected accidental oil spills and related cleanup activities could range from negligible to major, depending on the location of the spill in relation to sensitive resources. The incremental contribution of oil spills associated with the Program could be small to large relative to those associated with ongoing and future OCS and non-OCS program activities. Impacts associated with an unexpected, low-probability CDE would also depend on location, and could range from minor to major if it were to occur. There is a greater likelihood that more of the resources would be affected at a major level during a CDE. A more detailed discussion of the effects of oil spills on archaeological and historic resources in the GOM is presented in Section 4.4.15.1.

4.6.5.2 Alaska – Cook Inlet

4.6.5.2.1 Areas of Special Concern. Section 4.4.8.2 identifies potential impacts that could result from routine activities or accidents related to the proposed leasing program on Areas of Special Concern adjacent to and in the Cook Inlet Planning Area. In considering the potential cumulative effects of OCS activities on these areas, the level of routine activities and the potential for accidental spills under the Program must be considered with other past, present, and reasonably foreseeable future actions that would occur during the 40-year life of the proposed program. Overall cumulative impacts on these Areas of Special Concern in Cook Inlet consider impacts from both OCS and non-OCS activities.

National Park Service Lands. As identified in Section 4.4.8.2, NPS lands are potentially susceptible to cumulative impacts from activities related to OCS oil and gas development as a consequence of the proposed 5-year leasing program in Cook Inlet. The potentially affected lands include the Lake Clark National Park and Preserve and the Katmai National Park and Preserve and Aniachak National Monument. Kenai Fjords National Park is east of Cook Inlet on the GOA, but it could be affected by an oil spill associated with OCS activities in Cook Inlet.

Impacts from routine OCS operations could come from facilities developed to support oil drilling and production, and could include effects from pipeline landfalls, dredging, air pollution, and the construction of roads and new facilities. Onshore oil facilities are permissible only on private acreage within each National Park. All of these National Parks, Monuments, and Preserves contain privately held acreage, and development of onshore oil support facilities is possible in these areas. Because of the more confined nature of Cook Inlet, OCS construction of facilities within the Cook Inlet Planning Area could have some negative effects on scenic values for some users if the facilities were visible from shore or air during flightseeing. It is assumed that pipeline landfalls, shore bases, and waste facilities would not be located in National Parks, because of the special status and protections afforded these areas.

Increased traffic (i.e., land, sea, and air) and development within the vicinity of NPS lands could also contribute to cumulative impacts on these areas. Because the amount of traffic is restricted and activities within the parks regulated, traffic would likely create a minor addition to cumulative impacts on the NPS lands. It is anticipated that noise generated by OCS offshore construction activities would be at low levels and intermittent, and would not persist for more than a few months at any one time. It is considered unlikely that these additional activities would noticeably affect wildlife or park user values compared to current (non-OCS) activities within the considered planning areas. Increased traffic may also affect air quality (see Section 4.4.4.2 and Section 4.6.2.1.2). Air quality in Alaska is expected to remain good, with pollutant concentrations associated with offshore and onshore emission sources well within applicable State and Federal standards. The contribution of OCS program activities to cumulative air quality impacts would be small. Air quality impacts from oil spills and fires would be localized and short in duration.

Impacts on these areas could occur due to accidental releases of oil spilled from onshore facilities and offshore drilling rigs (Table 4.6.1-3). Non-OCS activities, such as oil and gas development in State waters, the domestic transportation of oil or refined petroleum products including LNG from Cook Inlet and the Alaska Peninsula, the production and storage of petroleum products and LNG, and commercial shipping, could also result in accidental spills that could affect park lands. In addition to affecting the National Parks mentioned above, oil spills from tankering to and from Valdez could also affect Kenai Fjords NP and Wrangell St Elias NPP. Naturally occurring seeps may also be a source of crude oil introduced into nearshore waters (Kvenvolden and Cooper 2003). An oil spill would have the greatest effect if it came into contact with shoreline habitats. Impacts would depend primarily on the spill location, size, and time of year. In general, directly affected coastal fauna could include invertebrates; marine mammals; fishes that reproduce in, inhabit, or migrate through coastal areas; terrestrial mammals that feed on these fishes; and marsh birds and seabirds. Spilled oil could also affect subsistence harvests in those parks in which subsistence hunting and fishing are allowed (see Section 4.6.5.2) and could affect the number of park visitors.

National Wildlife Refuges. NWRs in the vicinity of Cook Inlet are identified in Section 3.9.2.2. NWRs potentially affected by OCS activities in the Cook Inlet Planning Area include the Alaska Peninsula NWR, Becharof NWR, Kodiak NWR, Kenai NWR, and Izembek NWR. These refuges could be contaminated by oil spilled from offshore projects or could be subject to negative effects from routine operations associated with the development of onshore oil and gas support facilities. They could also be affected by non-OCS activities within or adjacent to refuges, including oil and gas development in State waters, the domestic transportation of oil or refined petroleum products including LNG from Cook Inlet and the Alaska Peninsula, the production and storage of petroleum products and LNG, and commercial shipping. Numerous refuge lands have been conveyed to private owners and Native corporations. Section 22(g) of ANCSA requires that new development on these lands must be in accordance with the purpose for which the refuge was formed. Thus, while development of onshore oil and gas support facilities is technically possible, such development would be subject to intensive review (as would any other development).

The potential cumulative effects of routine operations and accidental events on these NWRs are essentially the same as those discussed above for the NPS lands. In addition, subsistence hunting and fishing are permitted on all refuges in Alaska and could, therefore, be affected by accidents and routine operations in the immediate vicinity of refuge properties.

National Forests. The only National Forest within the vicinity of the Cook Inlet Planning Area is the Chugach National Forest, which is located mainly on the eastern side of the Kenai Peninsula (Figure 3.9.2-1). Because there would be no OCS-related development, such as pipelines or other onshore facilities, within the Chugach National Forest, it would not be affected by routine OCS activities associated with lease sales in the Cook Inlet Planning Area. Because of the forest location, oil spills from OCS platforms or pipelines within the Cook Inlet Planning Area would not be expected to affect shoreline areas or other resources within Chugach National Forest.

The Chugach National Forest is adjacent to the Gulf of Alaska. It also borders Prince William Sound and is close to Valdez. The Chugach National Forest is, therefore, potentially susceptible to cumulative effects of routine oil-related operations from transport and tanker loading of oil produced (OCS and non-OCS) in other regions (e.g., the Beaufort Sea Planning Area) and transported by pipeline to the Port of Valdez. Potential effects include increased noise and air pollution from tanker traffic.

Additional, non-OCS-related cumulative impacts in the National Forest could result from mining operations (e.g., for gold or gravel/stone), hunting, flightseeing, ski resorts, trains, and tourism. However, the impacts of these activities are regulated through a permitting process following an approved resource use plan.

The Chugach National Forest would be potentially susceptible to oil (mostly non-OCS) spilled from tankers that utilize the loading facilities at the Port of Valdez. Oil spills that reached the coastline could affect coastal fauna; subsistence, recreational, and commercial fishing; and tourism. Impacts would depend on the size and timing of a spill and would be expected to be minor to moderate.

Other Areas of Special Concern. There are multiple State parks and State recreation areas near the Cook Inlet Planning Area, many of which border Cook Inlet or are located in areas that could be contacted by accidental oil spills. Such areas include Captain Cook State Recreation Area, Clam Gulch State Recreation Area, Chugach State Park, Kachemak Bay State Park and State Wilderness Park, and Ninilchik State Recreation Area. In addition, the Kachemak Bay National Estuarine Research Reserve is located in Cook Inlet on the southern end of the Kenai Peninsula. Cumulative impacts from offshore activities would be similar to those described above for National Parks and Refuges. Existing protections and restrictions on uses should limit the direct terrestrial cumulative impacts from OCS and non OCS activities on these areas. There is existing oil and gas infrastructure in State waters of Cook Inlet and the addition of OCS infrastructure and activities could have negative effects on scenic values for some users if the facilities were visible from shore or the air during flightseeing. It is assumed that pipeline landfalls, shore bases, and waste facilities would not be located in the State parks and recreation areas. Increased traffic (i.e., land, sea, and air) and development within the vicinity of State parks lands could also contribute to cumulative impacts on these areas. It is anticipated that noise generated by OCS offshore construction activities would be at low levels, intermittent, and would not persist for more than a few months at any one time. It is considered unlikely that these additional activities would noticeably affect wildlife or park user values compared to current (non-OCS) activities within the considered planning areas.

As described above, impacts on State parks and recreational areas could occur due to accidental releases of oil spilled from onshore facilities and offshore drilling rigs. An oil spill contacting shoreline habitats could affect subsistence harvests in those parks in which recreation and subsistence hunting and fishing are allowed and could affect the number of park visitors. Impacts would depend primarily on the spill location, size, and time of year.

Conclusion. Cumulative impacts on Areas of Special Concern in Cook Inlet are considered to be negligible to moderate. Routine operations under the Program could result in negligible to medium incremental increases in effects on National Sanctuaries, Parks, Refuges, and Estuarine Research Reserves (see Section 4.4.8.2). Development of onshore facilities within NPS lands in the vicinity of the areas included in the Program is considered unlikely, thereby making impacts from routine Program activities unlikely in these areas. Offshore construction of pipelines and platforms could contribute to cumulative effects on wildlife and on scenic values for park visitors due to noise and activity levels, particularly in the vicinity of Cook Inlet. However, such effects would be localized, intermittent, and temporary.

Expected oil spills (most of which are less than 1,000 bbl) that occur during the Program could result in a negligible to small incremental contribution to cumulative impacts on Areas of Special Concern, depending on spill frequency, location, and volume; the type of product spilled; weather conditions; effectiveness of cleanup operations; and other environmental conditions at the time of the spill. Large spills (1,000 bbl and greater) or an unexpected, low-probability CDE in areas adjacent to the National Parks, NWRs, or National Forests, whether from OCS or non-OCS sources, would also depend on these factors, and could result in moderate impacts if they were to occur. Such spills could negatively impact coastal habitats and fauna, and could also affect subsistence uses, commercial or recreational fisheries, and tourism.

4.6.5.2.2 Population, Employment, and Income. Section 4.4.9 discusses the potential impacts from the Program on population, employment, and income in the south-central Alaska region. Cumulative impacts on these resources result from the incremental impacts of the Program when added to impacts from reasonably foreseeable future OCS program activities (there are no ongoing OCS program activities) and ongoing and future non-OCS program activities. Specific types of impact-producing factors related to OCS program activities considered in this analysis include total employment and regional income for the south Alaska region, which corresponds to the Cook Inlet Planning Area (described in Section 3.10). Non-OCS program activities affecting the region include employment and earnings related to various other industrial sectors (e.g., construction, manufacturing, services, and State and local government).

The population in the Cook Inlet Planning Area increased at an average annual rate of 3.2% between 1980 and 1990, 1.3% between 1990 and 2000, and 1.2% between 2000 and 2009. During each of these periods, the greatest increases consistently occurred on the Kenai Peninsula (with an average annual increase of 1.1% between 2000 and 2009) and in Anchorage (also with an average annual increase of 1.1% between 2000 and 2009). The components of population increase include the natural increase due to births and net positive domestic and international migration; these trends would likely continue in south central Alaska over the next 40 to 50 years.

Although the Program would add an average of 1,372 to 3,792 direct and indirect jobs annually in Alaska between 2012 and 2017, this increase is considered minor (but positive) since it would amount to less than 2% of total Alaska employment. Likewise, direct and indirect income produced in the region would range from $87 million to $256 million annually in south central Alaska, which constitutes less than 2% of income in Alaska overall.

Employment impacts of oil spills reaching landfall can vary considerably depending upon the total volume of oil reaching land, the land area affected, and the sensitivity of local environmental conditions to oil impacts. The primary impacts of oil spills would most likely fall on such activities as beach recreation, commercial fishing, recreational fishing, and sightseeing. Oil spills reaching land can have both short- and long-term effects on these recreational coastal activities. Past studies (Sorenson 1990) have shown that there could be a one-time seasonal decline in tourist visits of 5% to 15% associated with a major oil spill. Since tourist movement to other coastal areas in the region often offsets a reduction in the number of visits to one area, the associated loss of business tends to be localized. Although an oil spill could occur anywhere in the lease sale area, cleanup-related employment would likely occur in the area directly affected, generally in locations remote from communities. Oil spills will generate only temporary employment (and population) increases during cleanup operations, because such operations are expected to be of short duration.

Conclusion. The cumulative impacts of future OCS program and ongoing and future non-OCS program activities would be considered beneficial because these activities would increase employment and earnings in the region over the next 40 to 50 years. The Program would add to these beneficial impacts, especially on the Kenai Peninsula and in Anchorage. The incremental contribution of the Program is expected to be small, however, because the added employment demands are less than 2% of total Alaska employment (see Section 4.4.9.2).

In areas with a large proportion of impact-sensitive industry (such as commercial and recreational fishing), the cumulative impacts of accidental oils spills could be moderate to major, depending on the total volume of oil reaching land, the land area affected, and the sensitivity of local environmental conditions to oil impacts. The incremental contribution of expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program would be negligible to small relative to those associated with future OCS program and ongoing and future non-OCS program activities. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in minor to moderate impacts. In the short term, impacts of a CDE could be large as a result of loss of employment, income, and property value; increased traffic congestion; increased cost of service provision; and possible shortages of commodities or services. Longer-term impacts could be smaller unless the fishing and tourism suffered as a result of real or perceived impacts of the event (see Section 4.4.9.1).

4.6.5.2.3 Land Use and Infrastructure. Localized impacts to land use and existing infrastructure are anticipated as a result of the construction of new OCS program oil and gas facilities in Cook Inlet over the next 40 to 50 years. Impact-producing factors from OCS program activities would include increased aircraft traffic (e.g., helicopter trips); modifications to current land use designations to incorporate new facilities, if they are needed; and some infrastructure expansion. Ongoing non-OCS program activities affecting land use and onshore infrastructure are expected to continue into the foreseeable future. These include offshore construction, onshore construction, and marine vessel traffic. Where land is largely undeveloped and no established oil and gas infrastructure is present, development could result in land use impacts, such as the conversion of existing land use (e.g., undeveloped, residential, or commercial) to industrial land use to accommodate oil and gas production (MMS 2007e).

Accidental oil releases may occur as a result of both OCS and non-OCS activities, and oil is also released from naturally occurring seeps. The extent of the impacts would depend on the location and size of the releases, but could include stresses of spill response on the community infrastructure, increased traffic to respond to cleanup, and restricted access to particular lands while cleanup is conducted. In general, these releases would be expected to have a temporary impact on land use and infrastructure (MMS 2007c).

Conclusion. Localized impacts to land use and existing infrastructure are anticipated over the next 40 to 50 years as a result of future OCS and ongoing and future non-OCS program activities in Cook Inlet. These impacts could range from minor to major depending on the location and nature (extent and duration) of the land use change. The incremental contribution of routine operations under the Program to cumulative impacts in Cook Inlet would be negligible to small because the Program would not introduce new kinds of activities that would alter existing land uses (see Section 4.4.10.2).

Land use–related impacts resulting from expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program include stresses of spill response on community infrastructure, increased traffic in the response area (both onshore and offshore), and temporary restricted access to affected lands (while cleanup is conducted). Such spills would result in a small incremental contribution to cumulative impacts on land use and existing infrastructure. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in moderate impacts if they were to occur.

4.6.5.2.4 Commercial Fisheries and Recreational Fisheries. Some OCS exploration, development, and production activities have the potential to result in space-use conflicts with fishing activities over the next 40 to 50 years. In some cases, fishing vessels could be excluded from normal fishing grounds for safety reasons during construction periods or after facilities are in place. In other instances, fishery crews or anglers could decide to avoid certain areas to reduce the potential for gear loss. Such conflicts can sometimes be avoided by conducting construction activities or seismic surveys during closed fishing periods or seasons. A potential also exists for loss of gear or loss of access to fishing areas when floating drill rigs used for exploration are being moved and during other vessel operations.

Offshore construction of platforms or artificial islands could infringe on commercial fishing activities by excluding commercial fishing from adjacent areas due to safety considerations. Drilling discharges associated with exploration activities would likely affect only a small area near drilling platforms or islands, and are not expected to interfere with commercial fishing. During development and production phases, potential effects of such discharges would cease because all muds, cuttings, and produced waters would be discharged into wells instead of being released to open waters. Potential effects of platform construction and operation are expected to be highly localized. Because only a very small area of the individual planning areas would be affected, interference with commercial fisheries is expected to be small.

The impacts of oil and gas development on commercial fishing costs would vary considerably by placement depth. In the Kodiak area, the largest cost increases would occur with structures located in water between 300 and 1,500 m (984 and 4,921 ft) deep, with an annual increase of $43 in costs from a single structure; a single structure in each depth range would increase annual costs by $44. In the Cook Inlet area, the largest increase would come with a single structure placed in water between 150 and 300 m (492 and 984 ft), with an overall increase in costs of $57 per year. Cost impacts in the Gulf of Alaska area would be the largest, at $93 per year with a structure in each depth range, the largest cost increases occurring with a structure placed at between 300 to 1,500 m (984 and 4,921 ft). In each of the areas, single structures would have relatively insignificant impacts compared to fishery revenues in each depth range.

Various non-OCS activities, including State oil and gas programs, dredging and dredge-disposal operations, logging operations, and commercial or sport fishing activities, could also contribute to cumulative impacts on fisheries. Drilling of wells under State oil and gas programs would also require construction of pipelines and artificial islands or platforms in Alaskan waters. Potential effects on fishery resources and on space-use conflicts from State oil and gas activities would be similar to those described above for OCS program oil and gas activities. Dredging and marine disposal activities would involve excavation of nearshore sediments and subsequent disposal in offshore or nearshore areas, thereby disturbing seafloor habitats in some areas and burying benthic organisms that help to support fishery resources. Logging operations have a potential to contribute to cumulative effects on fishery resources by degrading riverine habitats that are important for salmon reproduction and the rearing of juveniles.

Non-OCS activities, such as State oil and gas development, domestic transportation of oil or refined petroleum products, and commercial shipping (and other marine vessel traffic), may also result in accidental spills that could affect fisheries within the waters of the south central Alaska region. Fisheries resources could become exposed to oil as a consequence of accidental oil spills, which could cause declines in subpopulations of some species inhabiting the affected planning areas. It is anticipated that there would be no long-term effects on overall fish populations in Alaskan waters as a result of such spills. However, even localized decreases in stocks of fish could have effects on some fisheries by reducing catches or increasing the amount of effort or the distances that must be traveled to obtain adequate catches.

Even if fish stocks are not reduced as a consequence of a spill, specific fisheries could be closed due to actual or perceived contamination of fish or shellfish. It is anticipated that most small to medium spills would have limited effects on fisheries because of the relatively small areas likely to be exposed to high concentrations of hydrocarbons and the short period of time during which oil slicks would persist. In the event of a large spill, commercial, recreational, or subsistence fisheries for shellfish in nearshore subtidal and intertidal areas that become oiled are likely to be affected. Fisheries for shellfish that occur in deeper waters, where oil concentrations would likely be too low to cause direct effects on biota, are less likely to be affected. Regardless, even shellfish from deeper areas could become commercially unacceptable for market due to actual or perceived contamination and tainting.

Oil spills that enter nearshore waters could also damage setnet fisheries, as evidenced by the *Exxon Valdez* oil spill of 1989. While only a relatively small volume of weathered oil entered the lower Cook Inlet region as a result of that spill, the commercial salmon fishery was closed to protect both gear and harvest from possible contamination. Within the Cook Inlet Planning Areas, a spill the size of the assumed largest OCS spill could result in temporary closures to commercial and subsistence setnet fishing until cleanup operations or natural processes reduced oil concentrations to levels considered safe.

Although pelagic fishes likely would be less affected than fishes in shallow subtidal or intertidal areas, spilled oil could contaminate gear used for pelagic fishing, such as purse seines and drift nets. A large oil spill before or during the season when such fishing gears are in use could result in closures of some short-period, high-value commercial fisheries in order to protect gear or harvests from potential contamination. Lines from longline fisheries for halibut, Pacific cod, black cod, and other fish species in the Cook Inlet Planning Area could also be affected by oil. Some lines and buoys fouled with small amounts of oil could be unfit for future use. Although it is unlikely that a trawler would be operating in an oiled area, the trawl catches could be contaminated by oil and rendered unfit for consumption and unprofitable if passed through such an area.

Conclusion. Cumulative impacts on commercial and recreational fisheries in Cook Inlet as a result of ongoing and future OCS and non-OCS activities and natural phenomena are expected to be minor over the next 40 to 50 years. Non-OCS activities affecting fisheries in the inlet include State oil and gas programs, dredging and dredge-disposal operations, logging operations, and commercial or sport fishing activities. The incremental contribution of routine Program activities to these impacts would be small. Routine operations under the Program would be unlikely to have population-level effects on fishery resources or result in long-term loss of fishery resources (see Section 4.4.11.2).

Commercial and recreational fisheries may be adversely affected by accidental oil releases from OCS and non-OCS activities (e.g., State oil and gas development, domestic transportation of oil or refined petroleum products, and commercial shipping). The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on would be negligible to medium, depending on the location, timing, and volumes of spills (among other environmental factors). Small spills are unlikely to affect a large number of fish or have a substantial effect on recreational fishing before dilution and weathering reduced concentrations of oil in the water. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be moderate if they were to occur. Large spills or a CDE could have significant localized effects on commercial fishing as a result of reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods, and on recreational fishing as a consequence of contamination of fish tissues, degradation of aesthetic values that attract fishers, or temporary closure of fishing areas. Large spills or a CDE have a greater potential to contact intertidal habitat and subsequently contaminate or reduce the abundance of commercial and recreational species that depend on nearshore habitat. These impacts could be long-term, but are not expected to result in the long-term loss of fisheries in Cook Inlet.

4.6.5.2.5 Tourism and Recreation. Platform, pipeline, causeway, and facility construction and vessel traffic could interfere with water-based recreational activities (fishing, boating, sightseeing, cruise ships) and could result in some disruption to land-based activities (hiking, picnicking, hunting, visiting Native communities, camping, wildlife viewing, and sightseeing), depending on the location of recreational activities relative to proposed development; increases in amounts of trash and debris from OCS activities; and possible competition between workers and tourists for local services, such as air transport, hotel accommodations, and other visitor services. Non-OCS activities that could have an impact on tourism and recreation include offshore construction (e.g., State oil and gas development, domestic transportation of oil and gas), onshore construction (e.g., coastal and community development), and marine vessel traffic (e.g., commercial shipping, recreational boating, military training and testing).

Non-OCS activities and proposed and future OCS activities represent a continuation of existing onshore and offshore oil and gas construction trends close to the Cook Inlet Planning Area. Substantial infrastructure for related oil and gas development already exists in this area (especially in the upper inlet), including platforms, exploration and production wells, pipelines to transport oil from offshore platforms to common-carrier pipeline systems onshore, and processing facilities. Therefore, there should not be additional visual disruption for the tourists in these areas. Pipeline construction would present a temporary disruption to tourism and recreation due to workers competing with tourists for short-term housing (hotels) and air transport; aesthetic impacts (visual and auditory) associated with construction sites; and possible temporary prevention of access to some recreational or wilderness areas. In addition, the new pipeline in the Arctic region could create road access into previously undeveloped lands used primarily for subsistence, creating a potential conflict between subsistence practices and recreational hunting or other possible tourist activities.

Oil spills associated with OCS and non-OCS activities, as well as oil from naturally occurring seeps, could also affect recreation and tourism, and could result in both short-term and long-term effects, depending on public perception and reaction. Potential cumulative impacts include direct land impacts (e.g., oil contamination of a national wildlife refuge or recreational port); aesthetic impacts of the spill and associated cleanup; increased traffic to respond to cleanup operations; and restricted access to particular lands while cleanup is being conducted.

Conclusion. Cumulative impacts on tourism and recreation in Cook Inlet as a result of ongoing and future OCS and non-OCS activities and natural phenomena would be minor over the next 40 to 50 years. Non-OCS activities or phenomena affecting these resources include offshore construction (e.g., State oil and gas development, domestic transportation of oil and gas), onshore construction (e.g., coastal and community development), and marine vessel traffic. The incremental contribution of routine operations under the Program to these impacts would be small, with potential adverse aesthetic impacts on sightseeing, boating, fishing, and hiking activities in the inlet (see Section 4.4.12.1).

Tourism and recreation may be adversely affected by accidental oil releases from OCS and non-OCS activities (e.g., State oil and gas development, domestic transportation of oil or refined petroleum products, and commercial shipping). The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program would be negligible to small, depending on the size, location, and timing of the spill (being greatest if it occurred during the peak recreational season). Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be minor to moderate if they were to occur. Short-term impacts would include beach and coastal access restrictions; restrictions on visitation, fishing, or hunting while cleanup is being conducted; and aesthetic impacts associated with the event itself and with cleanup activities. Longer-term impacts could be substantial if tourism were to suffer as a result of the real or perceived impacts of the event, or if there were substantial changes to tourism and recreation sectors in the region as a result of the event.

4.6.5.2.6 Sociocultural Systems. The area surrounding the Cook Inlet Planning Area is demographically diverse and includes relatively remote Native villages that rely on subsistence harvesting, towns that rely on commercial fishing, and ethnically diverse cities (Section 3.14.1.2). Future non-OCS activities affecting sociocultural systems include oil and gas development on State submerged lands, changes in commercial fishing patterns and maritime shipping, and limited industrialization; these activities are expected to continue in the foreseeable future.

The Cook Inlet Planning Area is already the location of offshore oil and gas development (in State waters). Supporting infrastructure and a trained workforce are already available in relative proximity. As part of this industrial mix, development of the OCS is likely to have minor cumulative impacts relative to development in the region. No new shore bases are planned and only one new pipeline is projected under the Program (Table 4.6.1-3).

Oil spills can cause damage to resources important to subsistence harvesters, affect fish populations important to commercial fishers, and have sociological impacts in affected communities. Most spills projected to result from exploration and development of the OCS would be a relatively minor component of the existing mix of impacts from oil and gas development and commercial shipping. However, as the *Exxon Valdez* event has shown, coastal communities are susceptible to sociocultural disruption as the result of large-scale spills that disrupt commercial fishing and subsistence harvesting.

OCS program development could temporarily displace fish and sea mammal populations harvested by subsistence hunters and fishers. Helicopter flights associated with development could disturb nesting and roosting sites of birds that are harvested, and temporarily and locally disturb terrestrial game animals.

Conclusion. Cumulative impacts on sociocultural systems in Cook Inlet as a result of ongoing and future OCS and non-OCS activities and natural phenomena could be minor to moderate over the next 40 to 50 years. Important impacting factors include the displacement of fish and sea mammal populations and the disturbance of nesting and roosting sites and terrestrial game animals (e.g., by noise). Non-OCS activities or phenomena affecting these resources include oil and gas development in State waters, changes in commercial fishing patterns and maritime shipping, air traffic, and limited industrialization. The incremental contribution of routine Program activities to these impacts would be small, since they would not introduce new kinds of activities that would alter existing socioeconomic systems. In addition, the relatively small number of new residents that would come into the area because of the Program should likewise not alter existing sociocultural systems (see Section 4.4.13.2).

Sociocultural systems may be adversely affected by accidental oil releases from OCS and non-OCS activities. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on would be small to large, especially in intertidal and estuarine zones used by subsistence harvesters. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be major if they were to occur, especially if resources important to subsistence harvesters, including intertidal resources, migrating fishes, and fishes with strong ties to the shore, were affected.

4.6.5.2.7 Environmental Justice. Although no new pipe yards, pipeline landfalls, or gas processing facilities would be built as a result of the proposed 5-year OCS program, additional offshore construction could include increased noise and traffic, air and water pollution, impacts to residential property values, and land use changes. Much of the Alaska Native population resides in the coastal areas of Alaska. New offshore infrastructure resulting from this program could be located near areas where subsistence hunting occurs. The OCS program would result in levels of infrastructure use and construction similar to what is occurring in south central Alaska. These activities are not expected to expose residents to notably higher risks than currently occur.

Any adverse environmental impacts to fish and mammal subsistence resources from installation of infrastructure and routine operations of these facilities could have disproportionately higher health or environmental impacts to Alaska Native populations. OCS activities could potentially disrupt marine mammal harvests (primarily walrus, seals, and beluga whales) by diverting marine migrations or by causing other behavioral changes such as increased wariness.

Air emissions from onshore facilities and helicopter and vessel traffic traversing coastal areas will be highest in areas containing the greatest amounts of infrastructure. It is assumed that the majority of the activity from the Program would occur in deep waters, with offshore air emissions greatest in the coastal areas with the greatest amounts of oil and gas activity, with lesser amounts occurring elsewhere. The effects of the OCS program on air quality have been analyzed in Section 4.4.4.2. This analysis concluded that routine operations associated with the proposed 5-year program would result in NO_2, SO_2, PM_{10}, and CO levels that are well within the NAAQS. Disproportionate impacts on low-income or minority populations of the inlet would be minor, because coastal effects from offshore activities are expected to be small, based on the established and increasing trend toward movement of oil and gas activities into deeper waters of the inlet.

Oil spill events in the region and related cleanup activities pose the greatest potential for cumulative effects on low-income and minority population groups. It is reasonable to expect that most of these spills will occur in deepwater areas located away from the coast, based on the established trend for oil and gas activity to move into deep waters located for the most part at a substantial distance from the coast. The magnitude of impacts from such spills cannot be predicted, should they contact the coast, and depends on their location, size, and timing. While the location of possible oil spills cannot be determined and while low-income and minority populations are resident in some areas of the coast, in general, the coasts are home to more affluent groups. Low-income and minority groups are not more likely to bear more negative impacts than are other groups.

Conclusion. In the Cook Inlet Planning Area, future OCS program and ongoing and future non-OCS program activities in combination with the effects of onshore and offshore construction, increased marine vessel and helicopter traffic, and land use changes would result in disproportional moderate to major adverse cumulative impacts on low-income and minority populations (especially those dependent on subsistence harvesting and fishing). The incremental contribution of routine operations under the Program to these impacts would be small (see Section 4.4.14.2).

The incremental contribution of expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program would be negligible to small. Large spills (1,000 bbl or greater) and unexpected CDEs could result in moderate to major impacts on the Alaska Native population, especially if subsistence resources were diminished or tainted as a result of the spill. Mitigation measures, cooperative agreements between Native and industry groups, and government-to-government consultations are designed to limit the effects from oil spills and routine operations.

4.6.5.2.8 Archeological and Historic Resources. Section 4.4.15.2 discusses the indirect and direct impacts from the Program (OCS program activities from 2012 to 2017) on archeological and historic resources in the Cook Inlet Planning Area. Cumulative impacts on archeological and historic resources result from the incremental impacts of the Program when added to impacts from existing and reasonably foreseeable future OCS program activities (that are not part of the Program) and other non-OCS program activities. Table 4.6.1-3 presents the exploration and development scenario for the Cook Inlet cumulative case (encompassing the Program and future OCS program activities). Specific types of impact-producing factors related to OCS program activities considered in this analysis include drilling rig and platform emplacement, pipeline emplacement, new onshore facilities, and oil spills. Non OCS-program activities (e.g., oil and gas industry in State waters) and natural geologic processes such as ice gouging and erosion due to high-energy waves/currents and thermokarst collapse are also considered.

Archeological Resources. Offshore development could result in an interaction between a drilling rig, platform, pipeline, or anchors and an inundated prehistoric site. This direct physical contact with a site could destroy artifacts or site features and could disturb the stratigraphic context of the site. The result would be the loss of archaeological data on prehistoric migrations, settlement patterns, subsistence strategies, and archaeological contacts between northeast Asia and the Americas.

Since 1973 when the ESP was initiated, the USDOI has required that an archaeological survey be conducted prior to development of mineral leases determined to have potential for cultural resources, including prehistoric archaeological sites. Relative sea-level data, which are used to define the portion of the continental shelf having potential for prehistoric sites, suggest that the portion of the continental shelf shoreward of about the 60-m (200-ft) isobath would have potential for prehistoric sites. Although an archaeological survey would identify most of the cultural resources in the APE for the project and routine operations related to OCS program activities would avoid all known cultural resources, it is likely that impacts to prehistoric resources have already occurred as a result of non-OCS program activities prior to the implementation of the 1973 archaeological survey requirement.

Onshore development could result in direct physical contact between the construction of new onshore facilities or pipeline trenches and previously unidentified prehistoric sites. This direct physical contact with a prehistoric site could cause physical damage to or complete destruction of information on the prehistory of the region and North America. Federal and State laws and regulations initiated in the 1960s began requiring archaeological surveys prior to permitting any activity that might disturb a significant archaeological site. Therefore, it can be assumed that, since the introduction of the archaeological resource protection laws, most coastal archaeological sites have been located, evaluated, avoided, or mitigated prior to construction. However, impacts to coastal prehistoric resources may have already occurred as a result of various onshore construction activities prior to enactment of the archaeological resource protection laws.

Trawling activity in Cook Inlet only affects the uppermost portion of the sediment column (Krost et al. 1990). This zone would already be disturbed by natural factors relating to the destructive effects wave and current action (Cook Inlet is a high-energy wave environment; see Section 4.2.3.2.2). Therefore, the effect of trawling on most prehistoric archaeological sites would be minor.

Most channel dredging occurs at the entrances to bays, harbors, and ports. These areas have a high probability for prehistoric archaeological sites, as they are often associated with drowned river valleys, which are known to have a high probability for prehistoric sites. It is assumed that some of the archaeological data that have been lost as a result of dredging have been significant and unique; therefore, the impact to prehistoric archaeological sites as a result of past channel dredging activities has probably been moderate to major. In many areas, the USACE now requires remote-sensing surveys prior to dredging activities to minimize such impacts (Espey, Huston & Associates 1990).

Natural geologic processes such as ice gouging and thermokarst erosion may affect prehistoric archaeological sites associated with Cook Inlet. No specific studies examining the effects of geological processes on archaeological sites have been conducted in Cook Inlet. However, coastal prehistoric sites are exposed to the erosional effects of high-energy waves and thermokarst erosion. These natural processes could cause artifacts to be dispersed and the site context to be disturbed or even completely destroyed, resulting in the loss of archaeological information. Cook Inlet is a high-energy area affected by strong tidal movements. The seafloor of lower Cook Inlet contains characteristics such as lag gravels, sand ribbons, and sand wave fields (MMS 2003a). These features are formed only in areas of high energy. High-energy water movement may have removed the potential for archaeological resources to be present. Additional research is needed to determine the extent of the disturbance. Studies conducted in the Beaufort Sea indicate that seafloor sediments have been affected by ice gouging and by increased river flows resulting from glaciation (Darigo et al. 2007). It is likely that similar processes have operated in Cook Inlet and that they have affected the integrity of archaeological sites. Overall, some loss of data from submerged and coastal prehistoric sites has probably occurred, and will continue to occur, from the effects of natural geologic processes. It is assumed that some of the data lost have been significant and/or unique, resulting in a major level of impact. Additional studies specifically addressing these topics are required.

An accidental oil spill could affect coastal prehistoric archaeological sites, but the direct impact of oil on most sites is uncertain. Protection of such sites during an oil spill requires specific knowledge of their location, condition, nature, and extent prior to impact; however, the Cook Inlet coastline has not been systematically surveyed for archaeological sites.

Heavy oiling of a coastal area could conceal intertidal sites that may not be recognized until they are inadvertently damaged during cleanup (Whitney 1994). Crude oil may also contaminate organic material used in ^{14}C dating, and although there are methods for cleaning contaminated ^{14}C samples, greater expense is incurred (Dekin et al. 1993). The major source of potential impact from oil spills is the harm that could result from unmonitored shoreline cleanup activities. Unauthorized collecting of artifacts by cleanup crew members is also a concern, albeit one that can be mitigated with effective training and supervision. Damage or loss of significant archaeological information could result from the contact between an oil spill and a prehistoric archaeological site; therefore, cumulatively the level of impacts from oil spills (past, present, and future) to prehistoric archaeological sites ranges from moderate to high.

Historic Resources. Direct physical contact between a routine activity and a shipwreck site could destroy fragile ship remains, such as the hull and wooden or ceramic artifacts, and could disturb the site context. The result would be the loss of archaeological data on ship construction, cargo, and the social organization of the vessel's crew, and the concomitant loss of information on maritime culture for the time period from which the ship dates.

Since 1973 when the ESP was initiated, the USDOI has required archaeological (historical) surveys be conducted prior to development of mineral leases when a historic-period shipwreck is reported to lie within or adjacent to the lease area. Although an archeological survey would identify most of the cultural resources in the APE for the project and routine operations related to OCS activities would avoid all known cultural resources, it is likely that impacts on historic-period shipwrecks may have already occurred as a result of non-OCS program activities that took place before implementation of the 1973 archaeological survey requirement.

Onshore development could result in direct physical contact between the construction of new onshore facilities or pipeline trenches and previously unidentified historic sites. Federal and State laws and regulations initiated in the 1960s began requiring archaeological surveys prior to permitting any activity that might disturb a significant archaeological site. Therefore, it can be assumed that, since the introduction of the archaeological resource protection laws, most coastal archaeological sites that would have been impacted have been located, evaluated, avoided, or mitigated prior to construction. However, impacts to coastal historic sites may have resulted from onshore construction activities prior to enactment of the archaeological resource protection laws, but the magnitude of this possible impact is impossible to quantify.

Trawling activity in south central Alaska affects only the uppermost portion of the sediment column (Krost et al. 1990). On many wrecks, this zone would already be disturbed by natural factors and would contain only artifacts of high specific gravity which have lost all original context. Therefore, the effect of trawling on most historic shipwreck sites would be minor.

Most channel dredging occurs at the entrances to bays, harbors, and ports. These areas have a high probability for historic shipwrecks. Assuming that some of the data lost have been unique, the impact on historic sites as a result of past channel dredging activities has probably been moderate to major. In many areas, the USACE now requires remote-sensing surveys prior to dredging activities to minimize such impacts (Espey, Huston & Associates 1990).

Natural geologic processes such as ice gouging and erosion due to high-energy waves/currents and thermokarst collapse affect historic sites in Cook Inlet. No specific studies addressing this topic have been undertaken. Coastal historic sites are exposed to the erosional effects of wave energy and thermokarst erosion, which can cause artifacts to be dispersed and the site context to be disturbed or even completely destroyed. Cook Inlet is a high-energy area affected by strong tidal movements. The seafloor of lower Cook Inlet contains seafloor characteristics such as lag gravels, sand ribbons, and sand wave fields (MMS 2003a). These features are only formed in areas of high energy. High-energy water movement may have removed the potential for historic resources to be present. Additional research is needed to determine the extent of the disturbance. Overall, a significant loss of data from submerged and coastal historic sites may have already occurred from the effects of natural geologic processes. It is assumed that some of the data lost have been significant and/or unique, resulting in a major level of impact. Additional studies specifically addressing these topics are required.

An accidental oil spill could affect a coastal historic site, but the direct impact of oil on most historic sites is uncertain. The primary source of potential impacts from oil spills is unmonitored shoreline cleanup activities (Bittner 1996; see Section 4.4.14.2.2). Unauthorized collecting of artifacts by cleanup crew members is also a concern, albeit one that can be mitigated with effective training and supervision. Damage or loss of significant historic information could result from oil spill cleanup activities; therefore, the cumulative impact of oil spills (past, present, and future) on historic sites could range from moderate to major.

Conclusion. The cumulative impacts of future OCS program and ongoing and future non-OCS program activities on prehistoric and historic archaeological sites in Cook Inlet are currently unknown, but could range from minor to moderate, mainly because activities occurring on the OCS prior to the USDOI's survey requirement (in effect since 1973) may already have affected significant archaeological sites. Other important impacting factors that have had, and will continue to have, an impact on both prehistoric and historic archaeological sites are channel dredging and geologic processes, such as ice gouging and erosion due to high-energy waves/currents and thermokarst collapse. Commercial treasure hunting and sport diving may also result in a loss of artifacts at historic-period shipwreck sites. The incremental contribution of routine operations under the Program is expected to be negligible to large, depending on the presence of significant resources in the area of potential effect. Archaeological surveys that would identify significant cultural resources to be avoided could reduce these impacts (see Section 4.4.15.2).

Cumulative impacts on prehistoric and historic archaeological sites due to expected accidental oil spills and related cleanup activities could range from negligible to major. The incremental contribution of oil spills associated with the Program could be negligible to large relative to those associated with future OCS program and ongoing and future non-OCS program activities. Impacts associated with an unexpected, low-probability CDE would also depend on location, and could range from minor to major if they were to occur. There is a greater likelihood that more of the resources would be affected at a major level during a CDE. A more detailed discussion of the effects of oil spills on archaeological and historic resources in Cook Inlet is presented in Section 4.4.15.2.

4.6.5.3 Alaska Region – Arctic

4.6.5.3.1 Areas of Special Concern. Cumulative impacts to these Areas of Special Concern include impacts from both OCS and non-OCS activities. Section 4.4.8.3 identifies potential impacts that could result from routine activities or accidents related to the proposed leasing program on Areas of Special Concern adjacent to and in the Beaufort Sea and Chukchi Sea Planning Areas.

National Park Service Lands. In the Arctic, activities associated with the Red Dog Mine and its port facility south of Kivalina on the Chukchi Sea would contribute to cumulative impacts on the Cape Krusenstern National Monument. The road from the mine (located just outside the monument) to the port crosses the northern boundary of the monument. Impacts from this facility, such as habitat loss or disturbance, are expected to be minor due to the limited activity associated with the mine.

There is minor land and air traffic in the Arctic and most visitors would arrive by sea. Because the amount of traffic is restricted and activities within the parks regulated, traffic would likely create a minor addition to cumulative impacts on the NPS lands. It is anticipated that noise generated by OCS offshore construction activities would be at low levels, intermittent, and would not persist for more than a few months at any one time. It is considered unlikely that these additional activities would noticeably affect wildlife or park user values compared to current (non-OCS) activities within the Beaufort and Chukchi Sea Planning Areas.

Impacts on these areas could occur due to accidental releases of oil spilled from onshore facilities and offshore drilling rigs. Non-OCS activities, such as oil and gas development in State waters, the domestic transportation of oil or refined petroleum products, the production and storage of petroleum products, and commercial shipping (tanker traffic) could also result in accidental spills that could affect park lands. Naturally occurring seeps may also be a source of crude oil introduced into nearshore waters (Kvenvolden and Cooper 2003). Noatak National Preserve, Kobuuk River National Preserve, Cape Krusenstern National Monument, and Bering Land Bridge National preserve all have coastlines on or near the Chukchi Sea and could potentially be affected by spills from tanker traffic. Although not an NPS land, the National Petroleum Reserve is managed by BLM and has a large shoreline component that borders the Chukchi Sea. An oil spill would have the greatest effect if it came into contact with shoreline habitats. Impacts would depend primarily on the spill location, size, and time of year. In general, directly affected coastal fauna could include marine mammals; fishes that reproduce in, inhabit, or migrate through coastal areas; terrestrial mammals that feed on these fishes; and marsh birds and seabirds. Spilled oil could also affect subsistence harvests in those parks in which subsistence hunting and fishing are allowed and could affect the number of park visitors.

National Wildlife Refuges. NWRs in the vicinity of the Beaufort Sea and Chukchi Sea Planning Areas are identified in 3.9.3.2 for the Beaufort and Chukchi Seas. NWRs (including three units of the Alaska Maritime NWR) potentially affected by OCS activities include the Arctic National Wildlife Refuge (ANWR) and the Alaska Maritime NWR (Chukchi Sea Unit, Gulf of Alaska Unit, Alaska Peninsula Unit).

Oil drilling and facility development are prohibited in the ANWR and are discretionary on all other refuges; however, refuges could potentially be affected by OCS oil and gas development from adjacent regions under the cumulative case scenario. These refuges could be contaminated by oil spilled from offshore projects, or could be subject to negative effects from routine operations associated with the development of onshore oil and gas support facilities. They could also be affected by non-OCS activities within or adjacent to refuges including State oil and gas development, the domestic transportation of oil or refined petroleum products, the production and storage of petroleum products and LNG, and commercial shipping. Numerous refuge lands have been conveyed to private owners and Native corporations. Section 22(g) of the Arctic Native Claims Settlement Act (1971) requires that new development on these lands must be in accordance with the purpose for which the refuge was formed. Thus, while development of onshore oil and gas support facilities is technically possible, such development would be subject to intensive review (as would any other development).

The potential cumulative effects of routine operations and accidental events on these NWR's are essentially the same as those discussed above for the NPS lands. In addition, subsistence hunting and fishing are permitted on all refuges in Alaska and could, therefore, be affected by accidents and routine operations in the immediate vicinity of refuge properties.

National Forests. There are no National Forests in the Beaufort Sea and Chukchi Sea Planning Areas.

Conclusion. Cumulative impacts on Areas of Special Concern in Arctic waters are considered to be negligible to moderate. Routine operations under the Program could result in negligible to medium incremental increases in effects on National Parks and Wildlife Refuges (see Section 4.4.8.3). Development of onshore facilities within NPS lands in the vicinity of the areas included in the Program is considered unlikely, thereby making impacts from routine Program activities unlikely in these areas. Offshore construction of pipelines and platforms could contribute to cumulative effects on wildlife and on scenic values for park visitors due to noise and activity levels. However, such effects would be localized, intermittent, and temporary. It is anticipated that lease stipulations applied at the lease sale stage could minimize the potential for cumulative impacts from routine operations on these areas.

Expected accidental oil spills (most of which are less than 1,000 bbl) that occur during the Program could result in a negligible to medium incremental contribution to cumulative impacts on Areas of Special Concern, depending on spill frequency, location, and volume; the type of product spilled; weather conditions; effectiveness of cleanup operations; and other environmental conditions at the time of the spill. Large spills (1,000 bbl and greater) or an unexpected CDE in areas adjacent to the National Parks or NWRs, whether from OCS or non-OCS sources, would also depend on these factors, and could result in moderate impacts if they were to occur. Such spills could also negatively impact coastal habitats and fauna, and could also affect subsistence uses.

4.6.5.3.2 Population, Employment, and Income. Section 4.4.9.2 discusses the potential impacts from the Program on population, employment, and income in the Arctic region. Cumulative impacts on these resources result from the incremental impacts of the Program when added to impacts from reasonably foreseeable future OCS program activities (there are no ongoing OCS program activities) and ongoing and future non-OCS program activities. Specific types of impact-producing factors related to OCS program activities considered in this analysis include total employment and regional income for the North Slope Borough, which corresponds to the Beaufort Sea and Chukchi Sea Planning Areas (described in Section 3.10). Non-OCS program activities affecting the region include employment and earnings related to various other industrial sectors (e.g., construction, manufacturing, services, and State and local government).

The population in the Beaufort Sea and Chukchi Sea Planning Areas is concentrated in Barrow. It increased at an average annual rate of 3.6% between 1980 and 1990, and 2.1% between 1990 and 2000; it decreased by 1.0% between 2000 and 2009. The components of population increase include the natural increase due to births and net positive domestic migration; the population trend is uncertain over the next 50 years and will likely depend on the availability of jobs. Most communities in the borough have a high percentage of American Indian or Alaska Natives.

The Program would add an average of 3,457 to 12,665 direct and indirect jobs in Alaska annually between 2012 and 2017, an increase that is considered moderate (but positive) since it would amount to less than 6% of total Alaska employment. Likewise, direct and indirect income produced in Alaska would range from $233 million to $904 million annually, which constitutes less than 6% of income in Alaska overall. Most of the workers directly associated with OCS oil and gas activities would work offshore or onshore in worker enclaves separated from local communities, and most workers will likely commute to work sites from Alaska's larger population centers or from outside the immediate area. While OCS jobs would be available to the local populations in all areas, rural Alaskan employment in the petroleum industry, especially among Alaska Natives, would likely remain relatively low. However, a contingent of Alaska Natives from the Fairbanks area and members of the Doyon Corporation do work in the oil fields of the North Slope, and these jobs are important to them.

Employment impacts of oil spills reaching landfall can vary considerably depending upon the total volume of oil reaching land, the land area affected, and the sensitivity of local environmental conditions to oil impacts. The primary impacts of oil spills would most likely fall on such activities as beach recreation, commercial fishing, recreational fishing, and sightseeing. Oil spills reaching land can have both short- and long-term effects on these recreational coastal activities. Although an oil spill could occur anywhere in the lease sale area, cleanup-related employment would likely occur in the area directly affected, generally in locations remote from communities. The hiring of cleanup workers would have a regional and State of Alaska emphasis. Oil spills will generate only temporary employment (and population) increases during cleanup operations, because such operations are expected to be of short duration. Employment generated by spills will be a function of the size and frequency of spills.

Conclusion. The cumulative impacts of future OCS program and ongoing and future non-OCS program activities would be considered beneficial because these activities would increase employment and earnings in the region over the next 40 to 50 years (although rural Alaskan employment in the petroleum industry, especially among Alaska Natives, would likely remain relatively low). The Program would add to these beneficial impacts. The incremental contribution of routine operations under the Program is expected to be small, however, because the added employment demands are less than 10% of total Alaska employment (see Section 4.4.9.3).

The cumulative impacts of accidental oil spills could be minor to major, depending on the total volume of oil reaching land, the land area affected, and the sensitivity of local environmental conditions to oil impacts. The incremental contribution of expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program would be negligible to small relative to those associated with ongoing and future OCS program and non-OCS program activities. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in minor to moderate impacts if they were to occur. In the short term, impacts of a CDE could be large as a result of loss of employment, income, and possible shortages of commodities or services in both coastal and inland areas affected by the spill. Longer-term impacts could be smaller unless recreational activities and tourism suffered as a result of real or perceived impacts of the event (see Section 4.4.9.1).

4.6.5.3.3 Land Use and Infrastructure. Localized impacts to land use and existing infrastructure are anticipated as a result of the construction of new oil and gas facilities in the Beaufort Sea and Chukchi Sea Planning Areas over the next 40 to 50 years. Impact-producing factors from OCS program activities would include increased vehicular traffic (e.g., helicopter trips); modifications to current land use designations to incorporate new facilities, if they are needed; and some infrastructure expansion.

Ongoing non-OCS program activities that could affect land use and onshore infrastructure are expected to continue into the foreseeable future. These include offshore construction, onshore construction, and vessel traffic. Where land is largely undeveloped and no established oil and gas infrastructure is present, development could result in land use and infrastructure impacts, such as the conversion of existing land use (e.g., undeveloped, residential, or commercial) to industrial land use to accommodate oil and gas production (MMS 2007e).

Accidental oil releases may occur as a result of both OCS and non-OCS activities. The extent of impacts would depend on the location and size of the releases, but could include stresses of spill response on the community infrastructure, increased traffic to respond to cleanup, and restricted access to particular lands while cleanup is conducted. In general, these releases would be expected to have a temporary impact on land use and infrastructure (MMS 2007c).

Conclusion. Localized impacts to land use and existing infrastructure are anticipated over the next 40 to 50 years as a result of future OCS program and ongoing and future non-OCS program activities in the Beaufort and Chukchi Seas. These impacts could range from minor to major depending on the nature (extent and duration) of the land use change. The incremental contribution of routine operations under the Program in the Arctic to cumulative impacts would be small to medium because the existing infrastructure is considered sufficient to handle the land use changes needed for new onshore pipeline construction and transportation network (see Section 4.4.10.3).

Land use–related impacts resulting from expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program include stresses of spill response on community infrastructure, increased traffic in the response area (both onshore and offshore), and temporary restricted access to affected lands (while cleanup is conducted). Such spills would result in a small incremental contribution to cumulative impacts on land use and existing infrastructure. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in moderate to major impacts if they were to occur.

4.6.5.3.4 Commercial and Recreational Fisheries. There currently is no commercial fishing and little data on recreational fishing in the Beaufort or Chukchi Sea (although the North Pacific Fishery Management Council has concluded that there are few recreational fisheries in these waters). Sport fishing likely occurs in coastal areas of larger population centers such as Barrow. Subsistence fishing is widespread in coastal areas of the Arctic. Given the importance of this fishing to local villages in the Arctic region, any impacts from the Program may directly affect the local economy by causing declines in salmon availability for harvest. Greater declines in the harvest would lead to greater impacts on local communities. However, it is anticipated that impacts from routine OCS operations would be minor as a result of adherence to mitigation measures and compliance with Federal, State, and local requirements.

The Program would represent a small increment to the potential for overall cumulative effects on fishing by local villages in the Arctic region. Routine OCS program activities would be unlikely to have cumulative population- or community-level effects on local fishery resources because of the limited time frame over which most individual activities would occur; because a small proportion of habitat, relative to similar available habitat, could be affected during a given period; and because of existing stipulations that are in place to avoid impacts to sensitive habitats such as hard bottom areas and topographic features. Non-OCS activities, including State oil and gas development and sportfishing, could also contribute to cumulative effects on local fisheries.

Depending on specific conditions during a large oil spill, there could be substantial economic losses for commercial fisheries as a consequence of reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods. Non-OCS sources of spills, including State oil and gas production, have a potential to cause similar effects. The occurrence of a catastrophic spill, such as could occur from a tanker accident, could have substantially greater effects on fisheries.

Conclusion. Cumulative impacts on fisheries in the Beaufort and Chukchi Seas as a result of ongoing and future OCS and non-OCS activities and natural phenomena could be moderate to major over the next 40 to 50 years. Non-OCS activities affecting fisheries include State oil and gas development and sportfishing. The incremental contribution of routine operations under the Program to these impacts would be small, since these activities would not occur in the immediate area where fisheries are located (see Section 4.4.11.3).

Fisheries may be adversely affected by accidental oil releases from OCS and non-OCS activities (e.g., State oil and gas development, domestic transportation of oil or refined petroleum products, and commercial shipping). The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on would be medium, depending on the location, timing, and volumes of spills (among other environmental factors). Small spills are unlikely to affect a large number of fish or have a substantial effect on fishing before dilution and weathering reduced concentrations of oil in the water. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be moderate if they were to occur. Large spills or a CDE could have significant localized effects on fishing as a result of reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods, and on recreational fishing as a consequence of contamination of fish tissues, degradation of aesthetic values that attract fishers, or temporary closure of fishing areas. Large spills or a CDE have a greater potential to contact intertidal habitat and subsequently contaminate or reduce the abundance of commercial and recreational species that depend on nearshore habitat. These impacts could be long term, but are not expected to result in the long-term loss of fisheries in Arctic waters.

4.6.5.3.5 Tourism and Recreation. Platform, pipeline, causeway, and facility construction and vessel traffic could interfere with water-based recreational activities (fishing, boating, sightseeing, cruise ships); cause some disruption to land-based activities (hiking, picnicking, hunting, visiting Native communities, camping, wildlife viewing, and sightseeing), depending on the location of recreational activities relative to proposed development; increase amounts of trash and debris from OCS activities; and cause possible competition between workers and tourists for local services, such as air transport, hotel accommodations, and other visitor services. Non-OCS activities that could have an impact on tourism and recreation include offshore construction (e.g., State oil and gas development, domestic transportation of oil and gas), onshore construction (e.g., coastal and community development), and vessel traffic (e.g., commercial shipping, recreational boating, military training and testing).

Non-OCS activities and proposed and future OCS activities represent a continuation of existing onshore and offshore oil and gas construction trends in the Beaufort Sea and Chukchi Sea Planning Areas. Substantial infrastructure for related oil and gas development already exists in both of these areas, including platforms, exploration and production wells, pipelines to transport oil from offshore platforms to common-carrier pipeline systems onshore, and processing facilities; therefore, there should not be additional visual disruption for the tourists in these areas. Pipeline construction would present a temporary disruption to tourism and recreation due to workers competing with tourists for short-term housing (hotels) and air transport; aesthetic impacts (visual and auditory) associated with construction sites; and possible temporary prevention of access to some recreational or wilderness areas. In addition, the new pipeline in the Arctic region could create road access into previously undeveloped lands used primarily for subsistence, creating a potential conflict between subsistence practices and recreational hunting or other possible tourist activities.

Oil spills associated with OCS and non-OCS activities, as well as oil releases from naturally occurring seeps, could also affect recreation and tourism, and could result in both short-term and long-term effects, depending on public perception and reaction. Potential cumulative impacts include direct land impacts (e.g., oil contamination of a National Wildlife Refuge); aesthetic impacts of the spill and associated cleanup; increased traffic to respond to cleanup operations; and restricted access to particular lands while cleanup is being conducted.

Conclusion. Cumulative impacts on tourism and recreation in the Beaufort Sea and Chukchi Sea Planning Areas as a result of ongoing and future OCS and non-OCS activities and natural phenomena could be moderate to major over the next 40 to 50 years because they would be noticeable to the recreation and tourism community, as no similar infrastructure yet exists in that region, and competition for accommodations and air transport may slow tourism for a time. Non-OCS activities or phenomena affecting these resources include offshore construction (State oil and gas development, domestic transportation of oil and gas), onshore construction (e.g., coastal and community development), and marine vessel traffic. The incremental contribution of routine operations under the Program to these impacts would be small, with potential adverse aesthetic impacts on sightseeing, hiking, and rafting activities (see Section 4.4.12.1).

Tourism and recreation may be adversely affected by accidental oil releases from OCS and non-OCS activities. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on would be negligible to small, depending on the size, location, and timing of the spill (being greatest if it occurred during the peak recreational season). Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be minor to moderate if they were to occur. Short-term impacts would include beach and coastal access restrictions; restrictions on visitation, fishing, or hunting while cleanup is being conducted; and aesthetic impacts associated with the event itself and with cleanup activities. Longer-term impacts could be substantial if tourism were to suffer as a result of the real or perceived impacts of the event, or if there were substantial changes to tourism and recreation sectors in the region as a result of the event.

4.6.5.3.6 Sociocultural Systems. Small, primarily Alaska Native communities along the Arctic coast are heavily dependent on subsistence harvesting of sea mammals, fish, and terrestrial fauna Enclaves of workers at Prudhoe Bay and nearby oil fields are employed by the oil and gas industry. They commute from mostly south-central Alaska, Fairbanks, and States outside of Alaska. For the most part, these two communities (Alaska Native communities and worker enclaves) have had little interaction because of the physical distance that separates them. The exception is Nuiqsuit. Further development of the oil and gas industry, increases in marine shipping as a result of the diminishing polar ice caps, and the effects of climate change coupled with development of oil and gas resources on the OCS could contribute to cumulative effects on the subsistence harvesting and sociocultural structure of the region.

A primary concern of Alaska Natives is the health and accessibility of sea mammals including whales, walrus, and seals, which could be affected by the cumulative effects of climate change, increased industrial activity, and increased shipping along the northern coast of Alaska. Warming climatic conditions have resulted in the early retreat of the polar ice pack, less shore-fast ice, and more young ice. Ice flow haulouts used by seals and walrus are thus farther from shore, increasing the effort required for subsistence hunters to harvest them. Young ice is less thick and less able to support hunting and whale butchering, making the subsistence harvest more difficult. More ice-free lanes along the coast have resulted in an increase in marine traffic, including cargo shipping and tourist cruise ships, through the Bering Strait and the Chukchi and Beaufort Seas, a pattern that is likely to continue. Increased commercial and tourist shipping added to increased vessel traffic supporting new oil and gas development would likely exacerbate adverse effects on subsistence resources. Noise from increased shipping would disturb bowhead and beluga whale migration patterns, already affected by the noise of seismic survey vessels during oil and gas exploration and to a lesser extent drilling and operation of wells. Increased shipping could increase the number of ship strikes on marine mammals; the risk of introduction of alien aquatic nuisance species from bilge water and other discharges; and chances of spills of fuel and other hazardous materials from shipping accidents. Eco-tourists seek many of the same species as subsistence hunters and can make them more wary and more difficult to hunt. The effects of increased shipping would be particularly acute in narrow ice-free corridors along the Beaufort and Chukchi coast and in narrow passages, such as the Bering Strait, where migrating sea-mammals and Arctic shipping would share the same narrow waterway. In addition, the likely concomitant increase in the use of ice breakers has the potential for disrupting Native travel across the ice in pursuit of marine mammals, potentially cutting them off from the shore, and leading whales following open water farther offshore (Arctic Council 2009). The whale harvest is central to Alaska Native culture in terms of the food it provides, the inter-community ties built on barter and exchange of whale products, and its association with Native cultural identity and spirituality. Oil and gas exploration and development combined with increased shipping and the effects of climate change would have an adverse cumulative effect on subsistence harvesting.

Warming temperatures have also reduced the amount of permafrost underlying Arctic communities, resulting in increased coastal erosion and less stable sediments, rendering traditional ice cellars cut into the permafrost useless, further stressing the subsistence harvest through loss of storage facilities, and in some cases requiring villages to move back from the coast (USGCRP 2003).

The construction and operation of linear features such as oil and gas pipelines and roads can deflect migration patterns of terrestrial mammals such as caribou that are an important part of the subsistence harvest. As onshore oil and gas development expands from Prudhoe Bay, Native communities such as Nuiqsut feel increasingly cut off from traditional subsistence resource harvesting areas. To the extent that offshore oil development requires onshore support infrastructure, it contributes to a cumulative negative impact on onshore access to subsistence resources. As the distance between Native communities and oil and gas worker enclaves decreases, the interaction between these two groups is likely to increase, raising the potential for cross-cultural conflicts and changes in traditional culture.

Conclusion. Cumulative impacts on sociocultural systems in the Arctic Planning Areas as a result of ongoing and future OCS and non-OCS activities and natural phenomena could be moderate over the next 40 to 50 years. Important impacting factors include early retreat of the polar ice pack (due to warming climate conditions), increased marine shipping (due to more ice-free lanes along the coast), and increased noise (due to increased shipping, increased tourism, seismic surveys and other oil and gas activities) — all of which could disturb sea mammals and their migration patterns. Some factors, such as the loss of polar ice are beyond the control of local communities, BOEM, or oil and gas developers and may be considered unavoidable at the local community level. They would require some adjustment in subsistence harvesting patterns, a moderate effect. Effects would only be major if a subsistence resource were eliminated or rendered unavailable. The effects of other factors, such as increased shipping and ice breaking, can be mitigated through conflict avoidance agreements and regulation of coastal shipping. The incremental contribution of routine operations under the Program to these impacts would range from small to medium, especially if subsistence-related activities, central to the well-being of Alaska Natives who inhabit the area, are affected. Many of these potential effects are mitigatable (see Section 4.4.13.3).

Onshore linear features (e.g., pipelines and roads) affect the migration patterns of terrestrial mammals. Because of the high level of dependence on subsistence harvesting, the incremental contribution of the Program to cumulative impacts on subsistence activities near the Beaufort and Chukchi Seas would be expected to be small to medium (see Section 4.4.13.3). It is likely that onshore subsistence harvesting practices would have to be adjusted. Effects would be major only if important resources were eliminated or made unavailable. Design stipulations and operational procedures could reduce the impact of onshore development.

Sociocultural systems may be adversely affected by accidental oil releases from OCS and non-OCS activities. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program would be small to medium, depending on the location, volume, and timing (i.e., season) of the spill. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be major if they were to occur, especially if they disrupt sea mammal harvest or resulted in the IWC reducing or eliminating whale quotas in the Alaska Arctic. A CDE would prove challenging for existing response capacity and capability, especially if the spill were under ice or in broken ice. The cleanup process itself has the potential to cause displacement of subsistence resources and subsistence hunters, and would have major impacts in the short term depending on the timing and duration of the displacement. The associated influx of cleanup workers would likely overwhelm the resources of local communities and could result in cross-cultural conflicts.

4.6.5.3.7 Environmental Justice. Additional offshore construction under the Program could include increased noise and traffic, air and water pollution, impacts on residential property values, and land use changes. Much of the Alaska Native population resides in the coastal areas of Alaska. New offshore infrastructure resulting from this program could be located near areas where subsistence hunting occurs. The proposed 5-year program will result in levels of infrastructure use and construction similar to what has occurred in the south Alaska region during previous programs. These activities are not expected to expose residents to notably higher risks than currently occur.

Any adverse environmental impacts on fish and mammal subsistence resources could have disproportionately higher health or environmental impacts on Alaska Native populations. OCS activities could potentially disrupt marine mammal harvests (primarily walrus, seals, and beluga whales) by diverting marine migrations or by causing other behavioral changes, such as increased wariness or having to go further from shore because of the diminishing polar ice cap, and whales migrating further from shore or the synergistic effects of all these factors combined.

Air emissions from onshore facilities and helicopter and vessel traffic traversing coastal areas will be highest in areas containing the greatest amounts of infrastructure. It is assumed that the majority of the activity from the proposed 5-year program will occur in waters no more than 100 m (30 ft) deep, with the most offshore air emissions occurring in the coastal areas with the greatest amounts of oil and gas activity and with fewer emissions occurring elsewhere. The effects of the OCS program on air quality have been analyzed in Section 4.4.4. This analysis concluded that routine operations associated with the proposed 5-year program would result in NO_2, SO_2, PM_{10}, and CO levels that are well within the NAAQS. Coastal effects from offshore activities are expected to be small, based on the established and increasing trend toward movement of oil and gas activities into deeper waters.

Oil spill events in the region, and related cleanup activities, pose the greatest potential for impacts on low-income and minority population groups. It is reasonable to expect that most of these spills would occur in deepwater areas located away from the coast, based on the established trend for oil and gas activities to move into deep waters located for the most part at a substantial distance from the coast. The magnitude of impacts from such spills cannot be predicted, should they contact the coast, and depends on their location, size, and timing. However, according to MMS (2002b), the probability that an offshore oil spill occurring and impacting coastal populations is low. While the location of possible oil spills cannot be determined, low-income and minority populations are resident in some areas of the coast. Low-income and minority groups could bear more negative impacts than other population groups.

Conclusion. In the Beaufort Sea and Chukchi Sea Planning Areas, OCS and non-OCS program activities in combination with the effects of increased marine traffic and climate change could result in moderate to major adverse cumulative impacts on human health and the environment, especially if a large oil spill were to occur, because oil spill contamination of subsistence foods is the main concern regarding potential effects on Native health. Impacts on marine and terrestrial ecosystems in the region (described in Section 4.6.4) could affect subsistence resources, traditional culture, and community infrastructure; indigenous communities that are subsistence-based would likely experience disproportionate, highly adverse environmental and health effects. However, the incremental change due to impacts from Program activities is expected to be small.

The incremental contribution of expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program would be negligible to small. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in moderate to major impacts on the Alaska Native population, especially if subsistence resources were diminished or tainted as a result of the spill. Mitigation measures, cooperative agreements between Native and industry groups, and government-to-government consultations are designed to limit the effects from oil spills and routine operations.

4.6.5.3.8 Archeological and Historic Resources. Section 4.4.15.3 discusses the potential impacts from the Program on onshore and offshore environments in the Beaufort Sea and Chukchi Sea Planning Areas. Cumulative impacts on archeological and historic resources result from the incremental impacts of the Program when added to impacts from ongoing and reasonably foreseeable future OCS program activities (that are not part of the proposed action) and other non-OCS program activities. Table 4.6.1-3 presents the exploration and development scenario for the Arctic region cumulative case (encompassing the proposed and future OCS program activities). Specific types of impact-producing factors related to OCS program activities considered in this analysis include drilling rig and platform emplacement, pipeline emplacement, new onshore facilities, and oil spills. Non-OCS program activities (e.g., oil and gas industry in State waters) and natural geologic processes such as ice gouging and thermokarst erosion are also considered (see also Section 4.2.2.2).

Archeological Resources. Offshore development could result in an interaction between a drilling rig, platform, pipeline, or anchors and an inundated prehistoric site. This direct physical contact with a site could destroy artifacts or site features and could disturb the stratigraphic context of the site. The result would be the loss of archaeological data on prehistoric migrations, settlement patterns, subsistence strategies, and archaeological contacts between northeast Asia and the Americas.

Since 1973 when the ESP was initiated, the USDOI has required that an archaeological survey be conducted prior to development of mineral leases determined to have potential for cultural resources, including prehistoric archaeological sites. Relative sea-level data, which are used to define the portion of the continental shelf having potential for prehistoric sites, suggest that the portion of the continental shelf shoreward of about the 60-m (200-ft) isobath would have potential for prehistoric sites. Although an archaeological survey would identify all cultural resources in the APE for the project and routine operations related to OCS program activities would avoid all known cultural resources, it is likely that impacts to prehistoric resources may have already occurred as a result of non-OCS program activities prior to the implementation of the archaeological survey requirement.

Onshore development could result in direct physical contact between the construction of new onshore facilities or pipeline trenches and previously unidentified prehistoric sites. This direct physical contact with a prehistoric site could cause physical damage to or complete destruction of information on the prehistory of the region and North America. Federal and State laws and regulations initiated in the 1960s began requiring archaeological surveys prior to permitting any activity that might disturb a significant archaeological site. Therefore, it can be assumed that, since the introduction of the archaeological resource protection laws, most coastal archaeological sites have been located, evaluated, avoided, or mitigated prior to construction. However, impacts to coastal prehistoric resources may have already occurred as a result of various onshore construction activities prior to enactment of the archaeological resource protection laws.

Trawling activity in the Arctic region affects only the uppermost portion of the sediment column (Krost et al. 1990). This zone would already be disturbed by natural factors relating to the destructive effects of ice gouging and scouring (see Section 4.2.2). Therefore, the effect of trawling on most prehistoric archaeological sites would be minor.

Most channel dredging occurs at the entrances to bays, harbors, and ports. These areas have a high probability for prehistoric archaeological sites, as they are often associated with drowned river valleys, which are known to have a high probability for prehistoric sites. It is assumed that some of the archaeological data that have been lost as a result of dredging have been significant and unique; therefore, the impact to prehistoric archaeological sites as a result of past channel dredging activities has probably been moderate to major. In many areas, the USACE now requires remote-sensing surveys prior to dredging activities to minimize such impacts (Espey, Huston & Associates 1990).

Natural geologic processes such as ice gouging and thermokarst erosion have caused and will continue to cause a significant loss of prehistoric archaeological data in the Alaska region. For example, ice gouges on the Beaufort Sea shelf can create a furrow up to 67 m (220 ft) wide and 4 m (13 ft) deep; however, the average ice gouge is about 8 m (26 ft) wide and 0.5 m (1.6 ft) deep (Barnes 1984). Coastal prehistoric sites are exposed to the destructive effects of thermokarst erosion. These natural processes would cause artifacts to be dispersed and the site context to be disturbed or even completely destroyed, resulting in the loss of archaeological information. Overall, a significant loss of data from submerged and coastal prehistoric sites has probably occurred, and will continue to occur, from the effects of natural geologic processes. It is assumed that some of the data lost have been significant and/or unique, resulting in a major level of impact.

An accidental oil spill could affect coastal prehistoric archaeological sites, but the direct impact of oil on most sites is uncertain. Protection of such sites during an oil spill requires specific knowledge of their location, condition, nature, and extent prior to impact; however, the Beaufort Sea and Chukchi Sea coastlines have not been systematically surveyed for archaeological sites.

Heavy oiling of a coastal area could conceal intertidal sites that may not be recognized until they are inadvertently damaged during cleanup (Whitney 1994). Crude oil may also contaminate organic material used in ^{14}C dating, and, although there are methods for cleaning contaminated ^{14}C samples, greater expense is incurred (Dekin et al. 1993). The major source of potential impact from oil spills is the harm that could result from unmonitored shoreline cleanup activities. Unauthorized collecting of artifacts by cleanup crew members is also a concern, albeit one that can be mitigated with effective training and supervision. Damage or loss of significant archaeological information could result from the contact between an oil spill and a prehistoric archaeological site; therefore, the cumulative impact from oil spills to prehistoric archaeological sites could range from moderate to major.

Historic Resources. Direct physical contact between a routine activity and a shipwreck site could destroy fragile ship remains, such as the hull and wooden or ceramic artifacts, and could disturb the site context. The result would be the loss of archaeological data on ship construction, cargo, and the social organization of the vessel's crew, and the concomitant loss of information on maritime culture for the time period from which the ship dates.

Since 1973 when the ESP was initiated, the USDOI has required archaeological (historical) surveys be conducted prior to development of mineral leases when a historic-period shipwreck is reported to lie within or adjacent to the lease area. Although an archeological survey would identify all cultural resources in the APE for the project and routine operations related to OCS activities would avoid all known cultural resources, it is likely that impacts to historic-period shipwrecks may have already occurred as a result of non-OCS program activities that took place before implementation of the 1973 archaeological survey requirement.

Onshore development could result in direct physical contact between the construction of new onshore facilities or pipeline trenches and previously unidentified historic sites. Federal and State laws and regulations initiated in the 1960s began requiring archaeological surveys prior to permitting any activity that might disturb a significant archaeological site. Therefore, it can be assumed that, since the introduction of the archaeological resource protection laws, most coastal archaeological sites that would have been impacted have been located, evaluated, avoided, or mitigated prior to construction. However, impacts to coastal historic sites may have resulted from onshore construction activities prior to enactment of the archaeological resource protection laws.

Trawling activity in the Alaska subregion only affects the uppermost portion of the sediment column (Krost et al. 1990). On many wrecks, this zone would already be disturbed by natural factors and would contain only artifacts of high specific gravity which have lost all original context. Therefore, the effect of trawling on most historic shipwreck sites would be minor.

Most channel dredging occurs at the entrances to bays, harbors, and ports. These areas have a high probability for historic shipwrecks. Assuming that some of the data lost have been unique, the impact to historic sites as a result of past channel-dredging activities has probably been moderate to major. In many areas, the USACE now requires remote-sensing surveys prior to dredging activities to minimize such impacts (Espey, Huston & Associates 1990).

Natural geologic processes such as ice gouging and thermokarst erosion may cause a loss of historic data in the Beaufort and Chukchi Seas (see study conducted in the Beaufort Sea by Darigo et al. [2007]). For example, ice gouges on the Beaufort Sea shelf can create furrows up to 67 m (220 ft) wide and 4 m (13 ft) deep; however, the average ice gouge is about 8 m (26 ft) wide and 0.5 m (1.6 ft) deep (Barnes 1984). Darigo et al. (2007) suggest that areas close to islands and the shore may be protected from the effects of ice gouging. Coastal historic sites are exposed to the erosional effects of wave energy and thermokarst erosion, which would cause artifacts to be dispersed and the site context to be disturbed or even completely destroyed. No specific studies have examined the effect of geological processes on site integrity. Overall, a significant loss of data from submerged and coastal historic sites may have already occurred from the effects of natural geologic processes. It is possible that some of the data lost may have been significant and/or unique, resulting in a major level of impact. Additional studies are needed to assess the effect of geological processes on cultural resources.

An accidental oil spill could affect a coastal historic site, but the direct impact of oil on most historic sites is uncertain. The primary source of potential impact from oil spills is unmonitored shoreline cleanup activities (Bittner 1996; see Section 4.4.15.3.2). Unauthorized collecting of artifacts by cleanup crew members is also a concern, albeit one that can be mitigated with effective training and supervision. Damage or loss of significant historic information could result from oil spill cleanup activities; therefore, the cumulative impact from oil spills (past, present, and future) on historic sites could range from moderate to major.

Conclusion. The cumulative impacts of future OCS program and ongoing and future non-OCS program activities on prehistoric and historic archaeological sites in the Beaufort and Chukchi Seas are currently unknown, but could range from minor to moderate, mainly because activities occurring on the OCS prior to BOEM's survey requirement (in effect since 1973) may already have affected significant archaeological sites. Other important impact-producing factors that likely have had, and will continue to have, an impact on both prehistoric and historic archaeological sites are channel dredging and geologic processes, such as ice gouging and thermokarst erosion. Commercial treasure hunting and sport diving may also result in a loss of artifacts at historic-period shipwreck sites. The incremental contribution of routine operations under the Program is expected to be negligible to large. Archaeological surveys that would identify significant cultural resources to be avoided could reduce these impacts (see Section 4.4.15.3).

Cumulative impacts on prehistoric and historic archaeological sites due to expected accidental oil spills and related cleanup activities could range from negligible to major, depending on the location of the spill in relation to sensitive resources. The incremental contribution of oil spills associated with the Program could be small to large relative to those associated with future OCS program and ongoing and future non-OCS program activities. Impacts associated with an unexpected, low-probability CDE would also depend on location, and could range from minor to major if they were to occur. There is a greater likelihood that more of the resources would be affected at a major level during a CDE. A more detailed discussion of the effects of oil spills on archaeological and historic resources in Arctic waters is presented in Section 4.4.15.3.

4.6.5.4 Summary for Gulf of Mexico Region

4.6.5.4.1 Areas of Special Concern. In the GOM, Areas of Special Concern are federally managed areas such as marine protected areas, National Marine Sanctuaries, National Parks, and National Wildlife Refuges. In addition to these areas, a number of locations have been given special designations by Federal, State, and nongovernmental organizations. These include the National Estuarine Research Reserves, National Estuary Program Sites, and the Military and NASA Use Areas. Cumulative impacts on these resources result from activities that could potentially cause damage to or degradation of fauna or habitats within these areas. Ongoing and future activities or trends that affect Areas of Special Concern in/near the GOM include fishing, diving, dredging operations, marine vessel traffic (and wakes), tankering, trash and debris accumulation (from various sources), onshore infrastructure (e.g., roads and vehicle traffic), and oil and gas development and infrastructure (e.g., pipeline landfalls and onshore facilities). Extreme weather events such as hurricanes and tropical storms also occur regularly in the GOM region and potentially cause damage by increasing shoreline erosion. Climate change has the potential to profoundly affect coral communities within these areas (e.g., in the FGBNMS, the only marine sanctuary in the GOM). Cumulative impacts on Areas of Special Concern in the GOM are considered to be negligible to moderate. The impacts of activities taking place within the Areas of Special Concern located onshore, such as National Parks and National Forests, are regulated through permitting processes. The cumulative impacts from spills would be minor to major, depending on spill frequency, location, and size; the type of product spilled; weather conditions; effectiveness of cleanup operations; and other environmental conditions at the time of the spill.

Routine operations under the Program could result in a negligible to medium incremental increase in effects on Areas of Special Concern. Expected oil spills (most of which are less than 1,000 bbl) that may occur during the Program could result in a small incremental contribution to cumulative impacts on Areas of Special Concern, depending on spill frequency, location, and volume; the type of product spilled; weather conditions; effectiveness of cleanup operations; and other environmental conditions at the time of the spill. Impacts associated with large spills (1,000 bbl and greater) or an unexpected, low-probability CDE in areas adjacent to the National Parks, NWRs, or National Forests, whether from OCS or non-OCS sources, would also depend on these factors, and could result in moderate impacts if they were to occur. Such spills could negatively impact the FGBNMS and coastal habitats and fauna, and could also affect subsistence uses, commercial or recreational fisheries, and tourism.

4.6.5.4.2 Population, Employment, and Income. Population in counties of the GOM coastal region has been steadily increasing since 1980, with the highest growth occurring in Texas. Most of the employment (and earnings) in the region is concentrated in Florida and Texas, which together provide about 81% of the employment in the GOM region. The largest employing sectors are in services, retail and wholesale trade, and State and local government. Cumulative economic impacts result from direct employment and income created through the development of offshore oil and gas resources, and the indirect employment and income produced through the spending of wages and salaries, and from the procurement of materials and services in the Gulf coast region. In-migration of workers and their families into the region produces population impacts. Oil and gas development has created employment and income in the coastal economies of the GOM coast, and this has led to rapid increases in population. Small incremental increases in employment, income, and population are expected with the development of offshore oil and gas resources in the GOM under the Program.

The cumulative impacts of ongoing and future OCS program and non-OCS program activities would be considered beneficial because these activities would increase employment and earnings in the region over the next 40 to 50 years. The Program would add to these beneficial impacts, especially in Texas and Louisiana. The incremental contribution of the Program is expected to be negligible, however, because the added employment demands are less than 2% of the total GOM coast regional employment. In areas with a large proportion of impact-sensitive industry (such as tourism), the cumulative impacts of accidental oil spills could be moderate to major, depending on the total volume of oil reaching land, the land area affected, and the sensitivity of local environmental conditions to oil impacts. The incremental contribution of expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program would be negligible to small relative to those associated with ongoing and future OCS program and non-OCS program activities. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in minor to moderate impacts if they were to occur. In the short term, impacts of a CDE could be large as a result of loss of employment, income, and possible shortages of commodities or services in both coastal and inland areas affected by the spill.

4.6.5.4.3 Land Use and Infrastructure. Most of the equipment and facilities supporting offshore oil and gas operations are located in the western and central GOM. Currently, there are hundreds of onshore facilities that support offshore industry. These include ports, refineries, and waste management facilities, among others. Cumulative impacts on land use and infrastructure result from demands on roads, utilities, and public services and the need to develop additional onshore facilities to accommodate ongoing and future activities in the GOM. Oil spill response also places stresses on community infrastructure and increases traffic in the affected area. Cumulative impacts on land use and onshore resources from ongoing and future activities in the GOM could range from minor to major depending on the nature and location of demands. Most of these impacts are expected to be temporary.

The incremental contribution of routine operations under the Program to cumulative impacts in the GOM would be negligible to small because the existing infrastructure is considered sufficient to handle the small increases in demands for roads, utilities, and public services related to the Program. Activities within the GOM also may be affected by the post-DWH event conditions; BOEM continues to monitor the region to identify long-term impacts of concern. Land use–related impacts resulting from expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program include stresses of spill response on community infrastructure, increased traffic in the response area (both onshore and offshore), and temporary restricted access to affected lands (while cleanup is conducted). Such spills would result in a negligible to small incremental contribution to cumulative impacts on land use and existing infrastructure. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in minor to moderate impacts if they were to occur.

4.6.5.4.4 Commercial and Recreational Fisheries. Commercial fisheries are very important to the economies of the GOM coast States; in 2009, commercial fishery landings in the GOM reached almost 649,000 metric tons, worth more than $629 million. When related processor, wholesale, and retail businesses are included, the GOM seafood industry supports more than 200,000 jobs, with related income impacts of $5.5 billion. In 2009, Louisiana led the States in total landings and value, followed by Mississippi, Texas, and Florida. Recreational fishing is also important to the region. In 2010, more than 4.5 million people engaged in some form of recreational fishing. Most recreational fishing in the region is done on private/rental boats (about 60%), followed by fishing from shore, then fishing from charter vessels. Angling trips are also made in inland waters. The majority of recreational fish landings in 2010 were in Florida, followed by Louisiana, Alabama, and Mississippi. Cumulative impacts on commercial and recreational fishing result from changes in commercial fishing costs with the development of offshore oil and gas resources in the GOM coast region, and changes in accessibility of fisheries resources. Ongoing oil and gas development has affected commercial fishing costs both positively and negatively in the GOM coast through the effect offshore infrastructure placement has on the concentration of fisheries resources, and disused platforms have enhanced recreational fisheries. The cumulative effects of ongoing and future GOM activities on commercial and recreational fisheries are considered to be minor.

The incremental contribution of routine Program activities to cumulative impacts in the GOM would be small, since these activities would be unlikely to have population- or community-level effects on fishery resources because of the limited time frame over which most individual activities would occur and because a small proportion of habitat relative to similar available habitat would be affected during a given period. In addition, existing stipulations are in place to prevent or reduce impacts on sensitive habitats such as hard-bottom areas and topographic features. Construction of new platforms could represent a small increase in the availability of desirable recreational fishing locations for recreational anglers. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on would be medium, depending on the location, timing, and volumes of spills (among other environmental factors). Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be moderate if they were to occur. Large spills or a CDE could have significant localized effects on commercial fishing as a result of reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods, and on recreational fishing as a consequence of contamination of fish tissues, degradation of aesthetic values that attract fishers, or temporary closure of fishing areas. Large spills or a CDE have a greater potential to contact intertidal habitat and subsequently contaminate or reduce the abundance of commercial and recreational species that depend on nearshore habitat.

4.6.5.4.5 Tourism and Recreation. The GOM coastal zone is one of the major recreational regions of the United States, with marine fishing and beach-related recreation being particularly popular. The coasts in GOM States offer diverse natural and developed landscapes and seascapes, and the beaches, barrier islands, estuarine bays and sounds, river deltas, and tidal marshes are visited by residents and tourists throughout the year. In 2000, Florida was the most important destination for marine recreation, with more than 22 million people participating in the State. Cumulative impacts on tourism and recreation therefore result when there are changes in the accessibility of beach and offshore resources for recreational use, and from increases in marine vessel and aircraft traffic in the vicinity of recreational resources. Oil and gas development has had an important impact on tourism and recreation in the GOM coast through the effect of offshore infrastructure placement and the proximity of platform servicing traffic to recreational resources, as well as the visibility of offshore platforms from onshore recreational areas. Given the existence of offshore oil and gas developments and other ongoing activities in the GOM, however, cumulative impacts on tourism and recreation from ongoing and future OCS and non-OCS activities are expected to be minor.

The incremental contribution of routine operations under the Program to cumulative impacts in the GOM would be small, with potential adverse aesthetic impacts on beach recreation and sightseeing and potential positive impacts on diving and recreational fishing. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program would be small to medium, depending on the size, location, and timing of the spill (being greatest if it occurred during the peak recreational season). Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be minor to moderate if they were to occur. Short-term impacts would include beach and coastal access restrictions; restrictions on visitation, fishing, or hunting while cleanup is being conducted; and aesthetic impacts associated with the event itself and with cleanup activities. Longer-term impacts could be substantial if tourism were to suffer as a result of the real or perceived impacts of the event, or if there were substantial changes to tourism and recreation sectors in the region as a result of the event.

4.6.5.4.6 Sociocultural Systems. The counties along the GOM coast are home to a large and heterogeneous mix of cultures, subcultural groups, and populations. Within the coastal region, the effects of the offshore oil and gas industry are felt most directly by populations living within the coastal community commuting zone where industry support facilities and the people who work in them are located. Coastal estuaries provide a wealth of wild resources for subsistence harvesting. Although many of the subsistence activities in the GOM region are practiced recreationally, some Native American groups, such as the United Houma Nation and the federally-recognized Chittimacha Tribe in southern Louisiana, depend on fishing, hunting, and gathering for at least part of their domestic subsistence. Commercial Vietnamese fishers also retain a quarter of their catch for family use and barter. Cumulative impacts to sociocultural systems occur when ongoing and future actions (OCS and non-OCS program) cause changes in local populations and social institutions or when jobs are lost or created. Subsistence practices have already been stressed by natural trends associated with climate change (e.g., flood control along the Mississippi River). Cumulative impacts on sociocultural systems in the GOM as a result of ongoing and future OCS and non-OCS activities and natural phenomena could be moderate over the next 40 to 50 years.

The incremental contribution of routine operations under the Program to cumulative impacts in the GOM would be small, since they are more likely to support the existing industry than to create industry growth. Any expansion of deepwater activities will result in jobs that require longer, unbroken periods of work offshore, specialized skills, and potential in-migration of part of the workforce. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program would be small to medium, especially on localized intertidal resources used by subsistence harvesters. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be moderate to major if they were to occur, especially if oil from a CDE were to reach the shore. Such spills could lead to long-term closure of fisheries, resulting in social and cultural stress. GOM subsistence harvesters make up a relatively small segment of the coastal population and replacement food resources are more available than for subsistence harvesters in Alaska, so while the impact of the loss of subsistence resources would be moderate for the coastal population as a whole, it would be locally major for populations that depended on subsistence harvesting for a significant proportion of their diet.

4.6.5.4.7 Environmental Justice. In general, environmental justice impacts occur when any activity or trend (OCS program- or non-OCS program-related) results in adverse health or environmental impacts that are significantly high and disproportionately affect minority and low-income populations. A large number of minority and low-income individuals are located in the LMA counties along the GOM coast. In this region, the adverse effects of several hurricanes over the past decade are still being felt; these events have had high and disproportionate effects on minority and low-income populations, especially in terms of property damage and loss of income. These effects are considered to be long-term, if not irreversible, and will likely persist into the foreseeable future. Cumulative impacts could result from changes in the proximity of onshore oil and gas infrastructure and to marine vessel and aircraft traffic, especially when these changes occur in counties where there are minority and low-income populations composing 50% or more of the total county population, or are more than 20 percentage points higher than the State average. Ongoing and future oil and gas development would continue to affect low-income and minority populations in some regions of the GOM coast by increasing the proximity to existing oil and gas infrastructure and associated health, environmental, and visibility impacts. It is likely that hurricanes in the region will increase in frequency and increase in the coming decades. Given all these factors, cumulative impacts on minority and low-income populations are considered to be moderate to major.

Because of the long-established and well-developed oil and gas industry present in the GOM and the fact that an estimated 75% of activity from the Program would occur in deep and ultra-deep waters, routine operations under the Program are not expected to cause additional environmental justice concerns; their contribution to cumulative impacts on low-income and minority populations therefore would be negligible. The incremental contribution of expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program would be negligible to medium because of the movement of oil and gas activities farther away from coastal areas and the demographic pattern of more affluent groups (and fewer low-income and minority populations) living in coastal areas. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in moderate to major impacts, depending on the location, size, and timing of the event.

4.6.5.4.8 Archaeological and Historical Resources. Onshore cultural resources are highly varied in coastal areas of the GOM. Prehistoric cultural resources range from small, temporary-use sites to substantial permanent settlements, some from the earliest known human occupation of the areas, about 12,000 years ago. Based on current water levels, it is likely that sites older than 3,000 years could be located underwater in the region. Offshore cultural resources mainly consist of shipwrecks dating from as early as the sixteenth century; however, other structures, such as the Ship Shoal Lighthouse, can also be found offshore. Studies have indicated that two-thirds of all shipwrecks in the northern GOM are located within 1.5 km (0.9 mi) of the shore, with the highest concentration of ships occurring in areas that experienced high-volume marine traffic. Shipwrecks are also thought to be concentrated in the open sea of the eastern GOM. To date, shipwrecks have been found in water depths of up to 1,981 m (6,500 ft). Cumulative impacts to these resources occur when operations involving bottom-disturbing activities (e.g., channel dredging) come into physical contact with artifacts or their site context, or as a result of natural phenomena such as waves, currents, and tropical storms. The cumulative impacts of ongoing and future activities (OCS and non-OCS) are not currently known, but could range from minor to moderate, mainly because activities occurring on the OCS prior to USDOI's survey requirement, which went into effect in 1973, may already have affected (i.e., damaged or destroyed) significant sites.

Routine operations under the Program could affect significant archaeological and historic resources, especially offshore resources, with construction activities such as platform and pipeline construction, and dredging, potentially damaging or destroying affected resources. Onshore impacts include resource damage or loss, or visual effects and are possible from pipeline landfall, onshore pipeline, and road construction. Anchor drags could adversely affect shipwrecks. Impacts could range from negligible to major, depending on the presence of significant archaeological or historic resources in the area of potential effect. The incremental contribution of routine operations under the Program could be negligible to large, depending on the presence of significant archaeological or historic resources in the area of potential effect. Archaeological surveys that would identify significant cultural resources to be avoided could reduce these impacts.

The incremental contribution of expected accidental oil spills associated with the Program (most of which are less than 1,000 bbl) to cumulative impacts on archaeological and historical resources in the GOM would be negligible to large, depending on the presence of significant resources in the area of potential effect and the spill location, timing, duration, and size. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from minor to major if it were to occur.

4.6.5.5 Summary for Alaska – Cook Inlet

4.6.5.5.1 Areas of Special Concern. The Alaska National Interest Lands Conservation Act of 1980 designated certain public lands in Alaska as National Parks, Wildlife Refuges, Wild and Scenic Rivers, for the National Wilderness Preservation and National Forest Systems. Many of these occur in the Cook Inlet region. Other Areas of Special Concern include MPAs, National Estuarine Research Reserves, National Estuary Program Areas, MUAs, and NOAA-designated HCAs. In addition, there are several State parks and recreation areas bordering Cook Inlet. Cumulative impacts on these resources result from activities that could potentially cause damage to or degradation of fauna or habitats within these areas. Ongoing and future activities or trends that affect Areas of Special Concern in or near Cook Inlet include fishing, diving, dredging operations, marine vessel traffic (and wakes), tankering, trash and debris accumulation (from various sources), onshore infrastructure (e.g., roads and vehicle traffic), and oil and gas development and infrastructure (e.g., pipeline landfalls and onshore facilities). Cumulative impacts on Areas of Special Concern in the Cook Inlet would be negligible to moderate. The impacts of activities taking place within the Areas of Special Concern located onshore, such as National Parks and National Forests, are regulated through permitting processes. The cumulative level of impacts from spills would be minor to major, depending on spill frequency, location, and size; the type of product spilled; weather conditions; effectiveness of cleanup operations; and other environmental conditions at the time of the spill.

Routine operations under the Program could result in negligible to medium incremental increases in effects on National Sanctuaries, Parks, Refuges, and Estuarine Research Reserves. Expected oil spills (most of which are less than 1,000 bbl) that occur during the Program could result in a negligible to small incremental contribution to cumulative impacts on Areas of Special Concern, depending on spill frequency, location, and volume; the type of product spilled; weather conditions; effectiveness of cleanup operations; and other environmental conditions at the time of the spill. Large spills (1,000 bbl and greater) or an unexpected, low-probability CDE in areas adjacent to the National Parks, NWRs, or National Forests, whether from OCS or non-OCS sources, would also depend on these factors, and could result in moderate impacts if they were to occur. Such spills could negatively impact coastal habitats and fauna, and could also affect subsistence uses, commercial or recreational fisheries, and tourism.

4.6.5.5.2 Population, Employment, and Income. Between 2005 and 2009, the Municipality of Anchorage had a population of 280,389, about 45% of the total population in Alaska. Employment is concentrated in Anchorage, which provides about 83% of employment in the region. The largest employing sectors in 2008 were in services, wholesale and retail trade, and State and local government. Oil and gas employment is concentrated in Anchorage, with a total of 8,636 workers employed directly in oil and gas extraction activities, pipeline and refinery activities, and support activities in 2007. Cumulative economic impacts result from direct employment and income created through the development of offshore oil and gas resources and the indirect employment and income produced through the spending of wages and salaries and from the procurement of materials and services in the region. Oil and gas development has created large increases in employment and income in the economy of Alaska as a whole, and has led to rapid increases in population. In-migration of workers and their families into the region produces population impacts. Small incremental increases in employment, income, and population are expected with the development of offshore oil and gas resources in the Cook Inlet region under the Program.

The cumulative impacts of future OCS program and ongoing and future non-OCS program activities would be considered beneficial because these activities would increase employment and earnings in the region over the next 40 to 50 years. The Program would add to these beneficial impacts, especially on the Kenai Peninsula and in Anchorage. The incremental contribution of the Program is expected to be small, however, because the added employment demands are less than 5% of baseline levels in Alaska. In areas with a large proportion of impact-sensitive industry (such as commercial and recreational fishing), the cumulative impacts of accidental oils spills could be moderate to major, depending on the total volume of oil reaching land, the land area affected, and the sensitivity of local environmental conditions to oil impacts. The incremental contribution of expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program would be negligible to small relative to those associated with future OCS program and ongoing and future non-OCS program activities. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in minor to moderate impacts if they were to occur. In the short-term, impacts of a CDE could be large as a result of loss of employment, income, and property value; increased traffic congestion; increased cost of service provision; and possible shortages of commodities or services.

4.6.5.5.3 Land Use and Infrastructure. Anchorage is the State center for scheduled aircraft and the regional center for chartered aircraft. It has a cargo facility served by a railroad connecting it to Alaska's interior and the port of Seward and two military bases (Joint Base Elmendorf-Richardon). It is also the center for the State's overall road network. Much of the on-land infrastructure around Cook Inlet supports offshore oil and gas development; facilities/complexes include the Trading Bay production facility, the Tesoro Refinery, the Drift River Terminal, and the Nikiski complex (Agrium and ConocoPhillips LNG). Cumulative impacts on land use and infrastructure result from demands on roads, utilities, and public services and the need to develop additional onshore facilities to accommodate ongoing and future activities in the inlet. Oil spill response also places stresses on community infrastructure and increases traffic in the affected area. Cumulative impacts on land use and onshore resources could range from minor to major, depending on the nature and location of demands. These impacts are generally considered temporary.

The incremental contribution of routine operations of the Program to cumulative impacts in Cook Inlet would be small to medium because land use changes would be needed for new onshore pipeline construction and transportation network. Land use–related impacts resulting from expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program include stresses of spill response on community infrastructure, increased traffic in the response area (both onshore and offshore), and temporary restricted access to affected lands (while cleanup is conducted). Such spills would result in a small incremental contribution to cumulative impacts on land use and existing infrastructure. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in moderate impacts if they were to occur.

4.6.5.5.4 Commercial and Recreational Fisheries. Commercial fisheries of Cook Inlet and the Gulf of Alaska target groundfish, Pacific halibut, Pacific salmon, herring, crab, shrimp, clams, scallops, sea urchins, and sea cucumbers. The groundfish fisheries accounted for the largest share ($640 million, or about 48%) of the ex-vessel value of all commercial fisheries in Alaska in 2009. Recreational fishing in the Cook Inlet region includes marine sport fishing, freshwater fishing, and shellfish gathering activities, which contribute substantially to the area's economy. On the western bank of upper Cook Inlet, there are recreational fisheries for razor clams, several species of hardshell clams, and crab. Cumulative impacts on commercial and recreational fishing result from changes in commercial fishing costs with offshore oil and gas development and changes in accessibility of fishery resources. The cumulative impacts on commercial and recreational fisheries in Cook Inlet are considered to be minor.

The incremental contribution of routine operations under the Program to cumulative impacts in Cook Inlet would be small since these would be unlikely to have population-level effects on fishery resources or result in long-term loss of fishery resources. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on would be negligible to medium, depending on the location, timing, and volumes of spills (among other environmental factors). Small spills are unlikely to affect a large number of fish or have a substantial effect on recreational fishing before dilution and weathering reduced concentrations of oil in the water. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be moderate if they were to occur. Large spills or a CDE could have significant localized effects on commercial fishing as a result of reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods, and on recreational fishing as a consequence of contamination of fish tissues, degradation of aesthetic values that attract fishers, or temporary closure of fishing areas. Large spills or a CDE have a greater potential to contact intertidal habitat and subsequently contaminate or reduce the abundance of commercial and recreational species that depend on nearshore habitat.

4.6.5.5.5 Tourism and Recreation. Opportunities for recreational activities such as hunting, hiking, boating, wildlife viewing, and sightseeing are abundant in the Cook Inlet region. Visitors reach the area via tour ships and ferries, as well as helicopters, small aircraft, and fishing charters. The Kenai Peninsula and Prince William Sound receive the heaviest recreational use by residents and nonresidents, and are in close proximity to Cook Inlet and Anchorage. The Chugach National Forest attracts hikers, campers, and other users. Cumulative impacts on tourism and recreation result from changes in accessibility of beach and offshore resources for recreational use, and from increases in marine vessel and aircraft traffic in the vicinity of recreational resources; these impacts are expected to be minor.

The incremental contribution of routine operations under the Program to cumulative impacts in Cook Inlet would be small, with potential adverse aesthetic impacts on sightseeing, boating, fishing, and hiking activities in the inlet. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program would be negligible to small, depending on the size, location, and timing of the spill (being greatest if it occurred during the peak recreational season). Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be minor to moderate if they were to occur. Short-term impacts would include beach and coastal access restrictions; restrictions on visitation, fishing, or hunting while cleanup is being conducted; and aesthetic impacts associated with the event itself and with cleanup activities. Longer-term impacts could be substantial if tourism were to suffer as a result of the real or perceived impacts of the event, or if there were substantial changes to tourism and recreation sectors in the region as a result of the event.

4.6.5.5.6 Sociocultural Systems. The region surrounding Cook Inlet includes economically complex cities such as Anchorage and its suburbs, the largest urban community in the State; towns such as Kenai, Soldotna, and Nikiski that are centers of the oil and gas industry; smaller towns such as Port Lions that depend on commercial fishing; and small predominantly Alaska Native communities. Subsistence harvesting plays some role in communities of all types. Cumulative impacts to sociocultural systems occur when ongoing and future actions (OCS and non-OCS programs) cause changes in local populations and social institutions or when jobs are lost or created. Subsistence harvesting could also be affected by activities that affect marine fauna, such as increases in airborne or subsea noise (e.g., aircraft or marine vessel traffic, seismic surveys, drilling) or degradation of water quality (e.g., fuel or oil spills, chemical releases, or dredging operations that increase turbidity), or that necessitate changes in subsistence fishing practices. Cumulative impacts on sociocultural systems in Cook Inlet as a result of ongoing and future OCS and non-OCS activities and natural phenomena could be minor to moderate over the next 40 to 50 years.

The incremental contribution of routine Program activities to cumulative impacts would be small, since they would not introduce new kinds of activities that would alter existing socioeconomic systems. In addition, the relatively small number of new residents that would come into the area because of the Program should likewise not alter existing sociocultural systems. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on would be small to large, especially in intertidal and estuarine zones used by subsistence harvesters. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be major if they were to occur, especially if resources important to subsistence harvesters, including intertidal resources, migrating fishes, and fishes with strong ties to the shore, were affected.

4.6.5.5.7 Environmental Justice. In general, environmental justice impacts occur when any activity or trend (OCS program- or non-OCS program-related) results in adverse health or environmental impacts that are significantly high and disproportionately affect minority and low-income populations. A large number of minority and low-income individuals live in the south-central Alaska region; however, the number of minority individuals in each of the local boroughs does not exceed 50% of the population and does not exceed the State average by 20 percentage points or more in any of the boroughs. Thus, there is no minority population in south central Alaska. Likewise, there are no low-income populations in any of the boroughs around Cook Inlet. Subsistence hunting and fishing are an important part of the economies in rural communities. Although there are no environmental justice concerns here, cumulative impacts on local communities could result from changes in the proximity of onshore oil and gas infrastructure and to marine vessel and aircraft traffic. Ongoing and future oil and gas development would continue to affect populations in some regions of Cook Inlet by increasing the proximity to existing oil and gas infrastructure and associated health, environmental, and visibility impacts. Given these factors, cumulative impacts on local populations are considered to be moderate to major.

The incremental contribution of routine operations under the Program to cumulative impacts in Cook Inlet would be small, depending on the proximity of onshore pipelines and offshore infrastructure to communities and their subsistence harvest areas, but are not expected to cause additional environmental justice concerns; their contributions to cumulative impacts on low-income and minority populations therefore would be negligible. The incremental contribution of expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program would be negligible to small. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in moderate to major impacts on the Alaska Native population, especially if subsistence resources were diminished or tainted as a result of the spill. Mitigation measures, cooperative agreements between Native and industry groups, and government-to-government consultations are designed to limit the effects from oil spills and routine operations.

4.6.5.5.8 Archaeological and Historic Resources. Onshore archaeological and historic resources occur along the shoreline surrounding Cook Inlet; the predominant types of prehistoric features are house pits containing household and subsistence artifacts like stone lamps, sinkers, and arrowheads. Historic sites onshore consist of early Russian houses, churches, roadway inns, fish camps, and mining camps. Little research has been done to characterize prehistoric resources in the offshore waters of Cook Inlet; however, it is likely that high-energy tidal movement has removed at least some resources from their original resting place. The best-preserved shipwrecks are likely to be found on the OCS, because wave action and ice are less likely to contribute to the breakup of ships in deeper waters. Cumulative impacts to these resources occur when operations involving bottom-disturbing activities (e.g., channel dredging) come into physical contact with artifacts or their site context, or as a result of natural phenomena such as high-energy waves and currents, ice gouging, and thermokarst collapse. The cumulative impacts of future OCS and ongoing and future non-OCS activities are not currently known, but could range from minor to moderate, mainly because activities occurring on the OCS prior to USDOI's survey requirement, which went into effect in 1973, may already have affected (i.e., damaged or destroyed) significant sites.

Routine operations could affect significant archaeological and historic resources, especially offshore resources, with construction activities such as platform and pipeline construction potentially damaging or destroying affected resources. Onshore impacts include resource damage or loss, or visual effects and are possible from pipeline landfall, onshore pipeline, and road construction. Anchor drags could adversely affect shipwrecks. The incremental contribution of routine operations under the Program is could be negligible to large, depending on the presence of significant resources in the area of potential effect. Archaeological surveys that would identify significant cultural resources to be avoided could reduce these impacts.

The incremental contribution of expected accidental oil spills associated with the Program (most of which are less than 1,000 bbl) to cumulative impacts on archaeological and historical resources in Cook Inlet would be negligible to large, depending on the presence of significant resources in the area of potential effect and the spill location, timing, duration, and size. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from minor to major if they were to occur.

4.6.5.6 Summary for Alaska – Arctic

4.6.5.6.1 Areas of Special Concern. The Alaska National Interest Lands Conservation Act of 1980 designated certain public lands in Alaska as National Parks, Wildlife Refuges, Wild and Scenic Rivers, and as designated for the National Wilderness Preservation and National Forest Systems. Some of these occur in the Arctic region. Other Areas of Special Concern include MPAs; there are no MUAs, National Estuarine Research Reserves, National Estuary Program Areas, or NOAA-designated HCAs in or adjacent to the Beaufort Sea or Chukchi Sea Planning Area. Cumulative impacts on these resources result from activities that could potentially cause damage to or degradation of fauna or habitats within these areas. Ongoing and future activities or trends that affect Areas of Special Concern in or near Arctic waters include fishing, diving, dredging operations, marine vessel traffic (and wakes), tankering, trash and debris accumulation (from various sources), onshore infrastructure (e.g., roads and vehicle traffic), and oil and gas development and infrastructure (e.g., pipeline landfalls and onshore facilities). Cumulative impacts on Areas of Special Concern in Arctic waters would be negligible to moderate. The impacts of activities taking place within the Areas of Special Concern located onshore, such as National Parks and National Forests, are regulated through permitting processes. The cumulative level of impacts from spills would be minor to major, depending on spill frequency, location, and size; the type of product spilled; weather conditions; effectiveness of cleanup operations; and other environmental conditions at the time of the spill.

Routine operations under the Program could result in negligible to medium incremental increases in effects on National Parks and Wildlife Refuges. Expected oil spills (most of which are less than 1,000 bbl) that occur during the Program could result in a negligible to small incremental contribution to cumulative impacts on Areas of Special Concern, depending on spill frequency, location, and volume; the type of product spilled; weather conditions; effectiveness of cleanup operations; and other environmental conditions at the time of the spill. Large spills (1,000 bbl and greater) or an unexpected, low-probability CDE in areas adjacent to the National Parks, NWRs, or National Forests, whether from OCS or non-OCS sources, would also depend on these factors, and could result in moderate impacts if they were to occur. Such spills could negatively impact coastal habitats and fauna, and could also affect subsistence uses.

4.6.5.6.2 Population, Employment, and Income. Population in the North Slope Borough is concentrated in Barrow, with a population of 4,078 between 2005 and 2009. Unemployment, especially in smaller villages, is high, especially during the winter when there is little alternate market-based activity; however, subsistence-related transactions play a key role in the economic well-being of those living in these communities. The largest employing sectors in 2008 were mining (including oil and gas), services, and State and local government. Oil and gas employment is relatively small, mainly because large numbers of oil and gas workers in the Arctic region reside in other parts of Alaska and the United States, relocating temporarily to work locations in the Arctic, as needed. The oil and gas industry employed about 7,540 workers who were employed directly in oil and gas extraction activities, pipeline and refinery activities, and support activities in 2007. Cumulative economic impacts result from direct employment and income created through the development of offshore oil and gas resources and the indirect employment and income produced through the spending of wages and salaries and from the procurement of materials and services in Alaska as a whole. In-migration of workers and their families into the region produces population impacts. Oil and gas development has created large increases in employment and income in the economy of Alaska as a whole, and has led to rapid increases in population. Small incremental increases in employment, income, and population in Alaska as a whole are expected with the development of offshore oil and gas resources in the Arctic region under the Program.

The cumulative impacts of future OCS program and ongoing and future non-OCS program activities would be considered beneficial because these activities would increase employment and earnings in the region over the next 40 to 50 years (although rural Alaskan employment in the petroleum industry, especially among Alaska Natives, would likely remain relatively low). The Program would add to these beneficial impacts. The incremental contribution of routine operations under the Program is expected to be small, however, because the added employment demands are less than 10% of total Alaska employment. The cumulative impacts of accidental oil spills could be minor to major, depending on the total volume of oil reaching land, the land area affected, and the sensitivity of local environmental conditions to oil impacts. The incremental contribution of expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program would be negligible to small relative to those associated with ongoing and future OCS program and non-OCS program activities. Large spills (1,000 bbl or greater) or an unexpected CDE could result in minor to moderate impacts. In the short-term, impacts of a CDE could be large as a result of loss of employment, income, and possible shortages of commodities or services in both coastal and inland areas affected by the spill.

4.6.5.6.3 Land Use and Infrastructure. Land use in much of the Arctic region is not intense, with oil and gas-related development (onshore and offshore in State waters) and subsistence being the predominant uses. There are only a few small communities in the area, the largest of which is Barrow. Barrow is the economic, transportation, and administrative center for the North Slope Borough. Transportation-related infrastructure is minimal, but concentrated in the Prudhoe Bay oil field area. Marine shipping to North Slope communities is by barge and by lightering of cargo to shore because of the shallow coastal waters and the lack of dredging and heavy-lift equipment. Paved and unpaved roads are generally limited to the area within communities. During the winter, many residents travel by snowmobile. Airports and related service facilities are also limited. Most of the oil and gas-related infrastructure in the Arctic region is along the Beaufort Sea coastline. The Prudhoe Bay/Kuparuk oil field infrastructure is served by about 480 km (300 mi) of interconnected gravel roads, 640 km (400 mi) of pipeline routes, and related processing and distribution facilities. Cumulative impacts on land use and infrastructure result from demands on roads, utilities, and public services and the need to develop additional onshore facilities to accommodate ongoing and future activities in the region. Oil spill response also places stresses on community infrastructure and increases traffic in the affected area. Cumulative impacts on land use and onshore resources could range from minor to major, depending on the nature and location of demands. These impacts are generally considered temporary.

The incremental contribution of routine operations under the Program to cumulative impacts in the Arctic region would be small to medium because of land use changes needed for new onshore pipeline construction and transportation network. Land use–related impacts resulting from expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program include stresses of spill response on community infrastructure, increased traffic in the response area (both onshore and offshore), and temporary restricted access to affected lands (while cleanup is conducted). Such spills would result in a small incremental contribution to cumulative impacts on land use and existing infrastructure. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in moderate to major impacts.

4.6.5.6.4 Commercial and Recreational Fisheries. There currently is no commercial fishing and little data on recreational fishing in the Beaufort or Chukchi Seas (although the North Pacific Fishery Management Council has concluded that there are few recreational fisheries in these waters). Sport fishing likely occurs in coastal areas of larger population centers such as Barrow. Subsistence fishing is widespread in coastal areas of the Arctic; fisherman target Pacific herring, Dolly Varden char, whitefish, Arctic cod, and sculpin. Given the importance of fishing to local communities in the Arctic region, the most important cumulative impacts would result from any activities that cause a decline in fish availability for subsistence harvest. The cumulative impacts on recreational (and subsistence) fisheries in Arctic waters are considered to be moderate to major.

The incremental contribution of routine Program activities to cumulative impacts would be small, since routine operations under the Program would not occur in the immediate area where fisheries are located. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program would be medium, depending on the location, timing, and volumes of spills (among other environmental factors). Small spills are unlikely to affect a large number of fish or have a substantial effect on fishing before dilution and weathering reduced concentrations of oil in the water. Impacts associated with large spills (1,000 bbl or greater) and unexpected, low-probability CDEs could be moderate if they were to occur. Large spills or an unexpected, low-probability CDE could have significant localized effects on fishing as a result of reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods, and on recreational fishing as a consequence of contamination of fish tissues, degradation of aesthetic values that attract fishers, or temporary closure of fishing areas. Large spills or a CDE have a greater potential to contact intertidal habitat and subsequently contaminate or reduce the abundance of commercial and recreational species that depend on nearshore habitat.

4.6.5.6.5 Tourism and Recreation. Tour groups to the North Slope Borough make up most of the nonresidential recreational activity. Most visitors stay in Barrow or Deadhorse. Travel to these areas is primarily by air, although bus tours occasionally arrive via the Dalton Highway. Hikers and river rafters also visit the Arctic National Wildlife Refuge and other areas using scheduled or chartered airplanes for access. An increasing number of cruise ships are entering the Chukchi and Beaufort Seas. Cumulative impacts on tourism and recreation result from disruptions to land-based activities, increases in the trash and debris accumulation, and competition between workers and tourists for local services, such as air transport and hotel accommodations; these impacts are expected to be moderate to major.

The incremental contribution of routine operations under the Program to cumulative impacts would be small, with potential adverse aesthetic impacts on sightseeing, hiking, and rafting activities. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program would be negligible to small, depending on the size, location, and timing of the spill (being greatest if it occurred during the peak recreational season). Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be minor to moderate if they were to occur. Short-term impacts would include beach and coastal access restrictions; restrictions on visitation, fishing, or hunting while cleanup is being conducted; and aesthetic impacts associated with the event itself and with cleanup activities. Longer-term impacts could be substantial if tourism were to suffer as a result of the real or perceived impacts of the event, or if there were substantial changes to tourism and recreation sectors in the region as a result of the event.

4.6.5.6.6 Sociocultural Systems. Most of the sparsely populated rural lands in the Arctic region are inhabited by indigenous Alaskans. Barrow is the largest permanent community on the North Slope and serves as the administrative and commercial hub of the region. The Alaska Natives living in communities along the coast of the Beaufort and Chukchi Seas are primarily Iñupiaq Eskimo. Alaska Native communities along the Arctic coast are heavily dependent on subsistence harvesting of sea mammals, fish, and terrestrial fauna. Enclaves of workers at Prudhoe Bay and nearby oil fields are employed by the oil and gas industry. They commute from mostly south central Alaska, Fairbanks, and States outside of Alaska. For the most part, these two communities (Alaska Native communities and worker enclaves) have had little interaction because of the physical distance that separates them. Cumulative impacts to sociocultural systems occur when ongoing and future actions (OCS and non-OCS program) cause changes in local populations and social institutions or when jobs are lost or created. Subsistence harvesting could also be affected by activities that affect marine fauna, such as increases in airborne or subsea noise (e.g., aircraft or marine vessel traffic, seismic surveys, drilling) or degradation of water quality (e.g., fuel or oil spills, chemical releases, or dredging operations that increase turbidity), or that necessitate changes in subsistence fishing practices. Cumulative impacts on sociocultural systems in the Arctic Planning Areas as a result of ongoing and future OCS and non-OCS activities and natural phenomena could be moderate over the next 40 to 50 years.

The incremental contribution of routine operations under the Program to cumulative impacts would range from small to medium, especially if subsistence-related activities, central to the well-being of Alaska Natives who inhabit the area, are affected. Many of these potential effects are mitigatable. Onshore linear features (e.g., pipelines and roads) affect the migration patterns of terrestrial mammals. Because of the high level of dependence on subsistence harvesting, the incremental contribution of the Program to cumulative impacts on subsistence activities near the Beaufort and Chukchi Seas would be expected to be small to medium. Effects would be major only if important resources were eliminated or made unavailable. Design stipulations and operational procedures could reduce the impact of onshore development.

The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on would be small to medium, depending on the location, volume, and timing (i.e., season) of the spill. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be major if they were to occur, especially if they disrupt sea mammal harvest or resulted in the IWC reducing or eliminating whale quotas in the Alaska Arctic. A CDE would prove challenging for existing response capacity and capability, especially if the spill were under ice or in broken ice. The cleanup process itself has the potential to cause displacement of subsistence resources and subsistence hunters, and would have major impacts in the short term depending on the timing and duration of the displacement. The associated influx of cleanup workers would likely overwhelm the resources of local communities and could result in cross-cultural conflicts.

4.6.5.6.7 Environmental Justice. In general, environmental justice impacts occur when any activity or trend (OCS program or non-OCS program related) results in adverse health or environmental impacts that are significantly high and disproportionately affect minority and low-income populations. A large number of minority and low-income individuals are located in the Arctic region, although the number of low-income individuals does not exceed 50% of the total population (thus there is no low-income population in the region). Subsistence hunting and fishing are an important part of the economies in Arctic communities. Cumulative impacts on local communities could result from changes in the proximity of onshore oil and gas infrastructure and to marine vessel and aircraft traffic. Ongoing and future oil and gas development would continue to affect populations in some regions along the Beaufort and Chukchi Seas by increasing the proximity to existing oil and gas infrastructure and associated health, environmental, and visibility impacts. Given these factors, cumulative impacts on local populations are considered to be moderate to major.

The incremental contribution of routine operations under the Program to cumulative impacts in the Arctic region would be negligible small, depending on the proximity of onshore pipelines and offshore infrastructure to communities and their subsistence harvest areas, but are not expected to cause additional environmental justice concerns; their contribution to cumulative impacts on low-income and minority populations therefore would be small. The incremental contribution of expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program would be negligible to small. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in moderate to major impacts on the Alaska Native population, especially if subsistence resources were diminished or tainted as a result of the spill. Mitigation measures, cooperative agreements between Native and industry groups, and government-to-government consultations are designed to limit the effects from oil spills and routine operations.

4.6.5.6.8 Archaeological and Historic Resources. At the height of the late Wisconsinan glacial advance, about 19,000 years ago, the global sea level was much lower than at present, which created land bridges between the North American and Asian continents. During this time, large expanses of the OCS were exposed as dry land and shorelines shifted depending on the location of ice. These relict shorelines (and other relevant landforms) are currently inundated. Some studies indicate that ice gouging may have altered the seafloor in the Arctic region, removing all archaeological evidence of the first peoples; however, the extent of the disturbance is not known. To date, studies have been done in the Beaufort Sea, but more will be needed to fully understand the potential for significant artifacts to be present. Numerous shipwrecks have been documented in the Beaufort and Chukchi Seas. Most of these were associated with commercial whaling that occurred in the region between 1849 and 1921. Most of the shipwrecks are likely to be in State waters. There are significant onshore historic sites in the Arctic region; these include Cold War–era outposts, radar stations, and missile sites, and the Ipiutak Site National Historic Landmark at Point Hope, among others. Cumulative impacts to these resources occur when operations involving bottom-disturbing activities (e.g., channel dredging) come into physical contact with artifacts or their site context, or as a result of natural phenomena such as high-energy waves and currents, ice gouging, and thermokarst collapse. The cumulative impacts of future OCS and ongoing and future non-OCS activities are not currently known, but could range from minor to moderate, mainly because activities occurring on the OCS prior to USDOI's survey requirement, which went into effect in 1973, may already have affected (i.e., damaged or destroyed) significant sites.

Routine operations could affect significant archaeological and historic resources, especially offshore resources, with construction activities such as platform and pipeline construction potentially damaging or destroying affected resources. Onshore impacts include resource damage or loss, or visual effects, and are possible as a result of pipeline landfall, onshore pipeline, and road construction. Anchor drags could adversely affect shipwrecks. Impacts could range from negligible to major, depending on the presence of significant archaeological or historic resources in the area of potential effect. The incremental contribution of routine operations under the Program could be negligible to large, depending on the presence of resources in the area of potential effect. Archaeological surveys that would identify significant cultural resources to be avoided could reduce these impacts.

The incremental contribution of expected accidental oil spills associated with the Program (most of which are less than 1,000 bbl) to cumulative impacts on archaeological and historical resources in Arctic waters would be small to large, depending on the presence of significant resources in the area of potential effect and the spill location, timing, duration, and size. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from minor to major if they were to occur.

4.6.6 Cumulative Impacts Summary Tables

Anticipated trends and conclusions concerning cumulative impacts for the GOM, Cook Inlet, and Arctic regions, and the Program's incremental contribution to cumulative impacts in these regions, are summarized in Tables 4.6.6-1 (GOM), 4.6.6-2 (Cook Inlet), and 4.6.6-3 (Arctic region). Impact conclusions for potential cumulative impacts on each resource or system are provided in the second column of these tables using the same four-level classification scheme (negligible, minor, moderate or major) as was used for the direct/indirect impacts analyses (see Section 4.1.4). The incremental contribution of the 2012-2017 Program to cumulative impacts on a given resource or system, presented in the third column, is characterized in terms of small, medium, and large. The incremental contribution only takes into account effects from routine operations and expected accidental events and spills under the Program. A potential CDE that may occur in the future (an unexpected, low-probability event) from operations associated with past or future 5-year programs or other cumulative actions is described principally in terms of its direct and indirect impact (if it were to occur) in the body of analysis and is not incorporated into the overall effects or incremental contribution conclusions. In the case of the GOM, the 2010 DWH event has been accounted for in the cumulative impacts analysis as part of the existing baseline.

TABLE 4.6.6-1 Summary of Cumulative Impacts and Incremental Contributions of the Program – Gulf of Mexico

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Water Quality	There are many factors affecting the water quality in the GOM currently and all of these factors are expected to continue into the foreseeable future. In general, these include marine vessel traffic, wastewater discharge, dredging and marine disposal, oil and gas production (in State waters and on the OCS), military operations, LNG terminal operations, LOOP operations, and natural oil seepage along the continental slope. Coastal waters are also affected by numerous other factors, including river inflows, urbanization, agricultural practices, municipal waste discharges, and coastal industry. Climate change is also expected to affect water quality in the coming decades, especially in terms of surface temperature, salinity, vertical stratification, and pH. Another issue of importance to water quality in the GOM concerns an area known as the hypoxic zone, a zone of oxygen depletion (due to high nutrient loads) which is located at the bottom of the continental shelf of Louisiana and Texas. Cumulative impacts on water quality are attributed to a combination of all these factors and, overall, are considered to be **moderate**.	The incremental contribution of routine operations under the Program would be **small** to **medium**. Compliance with NPDES permits and USCG regulations would reduce the magnitude of most impacts. The effects of expected accidental oil spills (most of which are less than 1,000 bbl) would depend upon weather and sea conditions at the spill site, the type of oil spilled, the depth of the spill event, and the volume and rate of spillage; therefore, the incremental contribution of expected oil spills to cumulative water quality impacts could range from **small** to **large**. Water quality impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from **moderate** to **major** if it were to occur. Spill response and cleanup activities could also contribute to water quality impacts.
Air Quality	The ambient air quality in coastal counties along the GOM is relatively good. Coastal counties are in attainment for all criteria pollutants except 8-hr ozone (in some areas of Texas and Louisiana). Most of the human-caused visibility degradation is attributed to sulfate particles, but also to organic or elemental carbon particles, and nitrate particles. The effects of various USEPA regulations and standards are expected to result in a steady, downward trend in future air emissions in the coming decades. Cumulative impacts on air quality in the GOM region are attributed to both offshore and onshore activities. Offshore activities in the GOM are mainly associated with the oil and gas industry, but also include various marine vessel traffic (shipping, fishing, cruise ships), tanker lightering, and military operations. Onshore emission sources include power generation, industrial processing, manufacturing, refineries, commercial and home heating, on-road	The incremental contribution of routine operations under the Program would be **small**, because they would not cause exceedance of the NAAQS in public access areas or affect visibility. The effects of expected accidental oil spills (most of which are less than 1,000 bbl) would be localized and temporary due to dispersion; therefore, the incremental contribution of expected oil spills to cumulative air impacts could range from **small** to **medium**. Air quality impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could be **moderate** if it were to occur. Spill response and cleanup activities could also contribute to air quality impacts.

TABLE 4.6.6-1 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Air Quality (Cont.)	vehicles, and non-road engines (e.g., aircraft, locomotives, and construction equipment). Cumulative impacts on air quality in the GOM over the next 40 to 50 yr are expected to be **minor** to **moderate**.	
Acoustic Environment	Sources of ambient noise in the GOM include wind and wave activity, precipitation (rain and hail), lightening, biological noise, and distant marine vessel traffic. The main sources of anthropogenic noise in the GOM are numerous and include marine vessel traffic, dredging, construction, oil and gas activities (exploration, development, and production), marine mineral mining, geophysical survey, sonar, explosions, and ocean science studies. The quality of the acoustic environment in the GOM would continue to be adversely affected by ongoing and future OCS and non-OCS activities. The magnitude of cumulative impacts on the GOM acoustic environment is time- and location-specific and could range from **minor** to **major**, depending on the ambient acoustic conditions and the nature and combination of noise sources from all OCS and non-OCS activities in the GOM. See also Marine Mammals (this table).	The contribution of routine operations under the Program to cumulative impacts would vary with time and location could range from **small** to **medium** and would depend on the characteristics of the noise sources present. The incremental increase in adverse acoustic environmental impacts from expected accidental oil spills in GOM waters (mainly due to noise sources associated with response and cleanup) would be localized and temporary; therefore, the incremental contribution of expected oil spills (most of which are less than 1,000 bbl) to cumulative noise-related impacts would be **small**. Noise-related impacts associated with an unexpected, low-probability CDE could range from **minor** to **moderate** if it were to occur.
Coastal and Estuarine Habitats		
Barrier Beaches and Dunes	Cumulative impacts result from factors that reduce sediment input to downdrift areas and increase erosion of beaches and dunes. Past actions such as channelization and diversion of Mississippi River flows (through dams and reservoirs) and beach stabilization projects (using groins, jetties, and seawalls) have contributed to sediment deprivation and submergence of coastal lands, and these actions are expected to continue into the foreseeable future. Ongoing and future actions/trends that affect barrier beaches and dunes include those related to oil and gas development in State waters, coastal development (onshore industry and wastewater discharge), marine vessel traffic, recreation, and climate change. Cumulative impacts on barrier beaches and dunes are expected to be **moderate** to **major**.	Routine operations under the Program would result in minor localized impacts primarily due to facility construction, pipeline trenching and landfalls, channel dredging, and vessel traffic. The contribution of the Program to cumulative impacts on beaches and dunes therefore would generally be **small** to **medium**. The incremental impacts of expected accidental oil spills associated with the Program would be **negligible** to **large**, depending on the location, timing, duration, and size of the spill; the proximity of the spill to particular habitats; and the timing and nature of spill containment and cleanup activities. The majority of these spills would be small (less than 50 bbl) and most of them would not likely contact and affect coastal and estuarine habitats.

TABLE 4.6.6-1 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Barrier Beaches and Dunes (Cont.)		Large oil spills (1,000 bbl or greater) or an unexpected, low-probability CDE have the greatest potential to affect extensive areas of shoreline and coastal and estuarine habitats. Although these are rare events, the impacts of such releases on coastal and estuarine habitats could range from **moderate** to **major** if they were to occur.
Wetlands	Cumulative impacts result from direct elimination of wetland habitat by excavation or filling, reduction of sediment inputs, erosion of wetland substrates, and degradation of wetland communities (by reduced water quality or hydrologic changes). Losses of coastal wetlands have been occurring along the GOM coast for decades (especially in Louisiana) and are expected to continue into the foreseeable future. Ongoing and future actions/trends that affect wetlands include those related to oil and gas development in State waters, coastal development (onshore industry and wastewater discharge), marine vessel traffic, dredging/disposal operations, and climate change. Cumulative impacts on coastal wetlands are expected to be **moderate** to **major**.	Same as for barrier beaches and dunes.
Seagrass Beds	Most seagrass beds are in the Eastern GOM where there are no past or present OCS activities and none proposed as part of the Program. The distribution of seagrass beds in coastal waters of Western and Central GOM has diminished in recent decades, possibly due to increased turbidity caused by marine vessel traffic in shallow waters. Ongoing and future actions/trends that affect seagrass habitats include onshore development, commercial and recreational fishing (trawling and anchoring), marine vessel traffic (anchoring), recreation (diving), and climate change. Cumulative impacts on seagrass beds are expected to be **moderate** to **major**.	Same as for barrier beaches and dunes.

TABLE 4.6.6-1 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Benthic and Pelagic Habitats	Cumulative impacts on benthic and pelagic habitats result from activities that disturb ocean bottom or marine habitats, increase sediment suspension (turbidity), degrade water quality, or affect the food supply of biota depending on these resources. Ongoing and future actions/trends that affect these habitats include oil and gas activities in State waters, commercial shipping (including tankers), dredging/disposal operations, anchoring, and climate change. Cumulative impacts on benthic and pelagic habitats are considered to be **moderate** to **major**.	Routine operations under the Program in the GOM could result in mainly temporary and localized impacts from ground disturbance during drilling and pipeline and platform placement, as well as the discharge of drilling muds and cuttings and produced water (sensitive habitats could have long term affects depending on their proximity to these activities). The incremental contribution to cumulative impacts on marine benthic habitats would range from **negligible** to **medium** and would be limited by existing mitigation measures. The incremental impacts of expected accidental oil spills on benthic habitats (most of which are less than 1,000 bbl) would range from **negligible** to **small**, depending on the size, duration, timing, and location of the spill, and the nature (i.e., sensitivity) of the benthic habitat contacted by oil. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and could range from **minor** to **moderate** if they were to occur. Major impacts to coral reef habitats could occur if the Flower Gardens Banks are heavily oiled and high mortality occurs.
Essential Fish Habitat	Cumulative impacts on EFH result from any activities that kill managed fish species, disturb ocean bottom habitats, increase sediment suspension (turbidity), degrade water quality, or affect the food supply for fishery resources. Ongoing and future actions/trends that affect EFH include commercial fishing, commercial shipping (and other marine vessel traffic), land development, water quality degradation, dredge/fill and disposal operations, the construction of channel stabilization structures, and climate change. Cumulative impacts on EFH are considered to be **moderate** to **major**.	Routine operations under the Program in the GOM could result in moderate short- and long-term impacts to EFH and managed species, mainly as a result of bottom disturbance during the placement of pipelines and production platforms. The incremental contribution to cumulative impacts on EFH would be **negligible** to **medium** and would be limited by specific lease stipulations. The incremental impacts of expected accidental oil spills on EFH (most of which are less than 1,000 bbl) would range from **negligible** to **medium** depending on the size of the spill, its location, environmental factors, and the uniqueness of the affected EFH. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could result in **moderate** to **major** impacts if they were to occur.

TABLE 4.6.6-1 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Marine and Coastal Fauna		
Marine Mammals	All marine mammals in U.S. waters are protected under the *Marine Mammal Protection Act of 1972*. In the GOM, there are 21 species of cetaceans and one species of Sirenian. Their distribution and abundance is influenced by oceanographic circulation patterns (which is largely wind-driven, but with localized effects from freshwater discharge). Ongoing and future activities or phenomena that affect marine mammals include oil and gas development in State waters, natural phenomena (e.g., hurricanes and diseases), vessel traffic, commercial fishing, pollution, military operations, catastrophes, climate change, and invasive species. Cumulative impacts on marine mammals are considered to be **minor** to **moderate**.	Routine oil and gas-related activities (e.g., seismic surveys, facility construction, normal operations, and, eventually, decommissioning) would result in minor to moderate impacts on marine mammals. Impacts on marine mammals from these activities could include physical injury or death; behavioral disturbances; lethal or sublethal toxic effects; and loss of reproductive, nursery, feeding, and resting habitats. The contribution of Program activities to cumulative impacts on marine mammals would be **negligible** to **medium**. The incremental impacts of expected accidental oil spills (most of which are less than 1,000 bbl) would be **small** to **large**, depending on the location, timing, and volume of the spills; the environmental settings of the spills; and the species exposed to the spills. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from **moderate** to **major** if it were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to these impacts.
Terrestrial Mammals	The terrestrial mammals considered here are federally endangered GOM coast beach mouse subspecies and the federally endangered Florida salt marsh vole. Present beach mice habitat is no longer of optimal quality because of historical beach erosion, habitat loss and fragmentation from beach front development, and tropical storm damage. Ongoing and future activities or phenomena that affect terrestrial mammals include oil and gas development in State waters, natural phenomena (e.g., hurricanes and tropical storms), industrial and residential development, vehicle traffic, recreation, trash and debris, artificial lighting, climate change (including sea-level rise), and invasive and feral species. Cumulative impacts on terrestrial mammals are considered to be minor to moderate. Cumulative impacts on terrestrial mammals are considered to be **minor** to **moderate**.	Routine oil and gas-related activities (e.g., facility construction, normal operations, and, eventually, decommissioning) are not expected to significantly affect the four federally endangered beach mouse subspecies and the federally endangered Florida salt marsh vole. Negligible to minor impacts may result from consumption of or entanglement in beach trash and debris originating from Program activities. The contribution of the Program activities to cumulative impacts therefore would be **negligible** to **medium**. The incremental impacts of expected accidental oil spills (most of which are less than 1,000 bbl) on these terrestrial mammals would be **small** to **large**, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding

TABLE 4.6.6-1 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Terrestrial Mammals (Cont.)		and other important habitats; the timing and nature of spill containment; and the status of the affected animals. An unexpected, low-probability CDE has a greater potential to affect the habitats of beach mice and the Florida salt marsh vole; therefore, impacts could range from **moderate** to **major** if it were to occur. Oil impacts on beach mice would be more likely if a storm surge transports the oil over foredunes.
Marine and Coastal Birds	The GOM is an important pathway for migratory birds. Most migrant birds either directly cross the GOM or move north or south by traversing the GOM or the Florida peninsula. There is a diverse range of habitats that support migratory and resident bird species along the northern GOM coast. Cumulative impacts result from direct injury or mortality of marine and coastal birds due to collisions with onshore and offshore structures, ingestion of trash or debris, or exposure to discharges or emissions; loss or degradation of habitat due to coastal development, climate change, or construction and operations activities; and behavioral disturbance due to commercial and recreational boating and small aircraft traffic. Many bird species are currently experiencing a loss or degradation of habitat due to land development and climate change and these impacts are expected to continue into the foreseeable future. Ongoing and future actions/trends that affect marine and coastal birds include those related to oil and gas development in State waters, coastal development, vessel traffic, dredging operations, and climate change. Cumulative impacts on marine and coastal birds are considered to be **moderate**.	Routine operations may result in localized short-term impacts due to infrastructure construction and marine vessel and aircraft traffic. The contribution of Program activities to cumulative impacts on marine and coastal birds therefore would be **negligible** to **medium**. The incremental contribution of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on marine and coastal birds would be **small** to **large**, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and nesting areas; the timing and nature of spill containment; and the status of the affected birds. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from **moderate** to **major** if it were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to these impacts.

TABLE 4.6.6-1 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Fish	Fish in the northern GOM live in the water column (pelagic) and on the seafloor or near bottom waters (demersal) along the gradient from the continental shelf to the abyssal plain. Demersal species are much more abundant and diverse in the hard-bottom habitats found in the eastern GOM. Some fish migrate between saltwater and freshwater habitats. For example, anadromous species (such as the Gulf sturgeon and striped bass) spend most of their adulthood in saltwater but spawn in freshwater; catadromous species (such as the American eel) live primarily in freshwater and spawn in saltwater. Cumulative impacts result from OCS and non-OCS activities that generate lethal or sublethal impacts to individuals as well as habitat loss or degradation. Ongoing and future actions/trends that affect fish include oil and gas development in State and Federal waters, commercial and recreational fishing, noise, dredging and trawling operations, explosive platform removal, land loss, and coastal hypoxia. Climate change is also expected to affect fish habitat, productivity, and community structure. Cumulative impacts on fish are considered to be **moderate** to **major**.	The incremental contribution of routine Program activities to these impacts (primarily as a result of disturbance affecting demersal fishes) would be **negligible** to **small**, with the severity of impacts generally decreasing with distance from the disturbance (and a **negligible** contribution to impacts on threatened or endangered fish species). The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on fish would be **negligible** to **medium**, depending on the location, timing, duration, and volume of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range up to **moderate** if it were to occur.
Reptiles	Five species of sea turtles are known to inhabit the GOM. The federally protected American crocodile also lives in the eastern GOM, along Florida's southern coast (in mangrove swamps, brackish bays, and inshore freshwater habitats). Hurricanes in 2005 adversely affected sea turtle nesting sites; and the DWH event caused sea turtle mortality and fouling of habitats. Cumulative impacts on sea turtles result from OCS and non-OCS activities that generate lethal and sublethal impacts that alter or eliminate habitat required for reproduction, feeding, and early life stage development. Ongoing and future actions/trends that affect sea turtles and crocodiles in the GOM include climate change, OCS activities and non-OCS activities such oil and gas development in State and Federal waters, marine vessel traffic, coastal development, dredging, commercial fishing, and land loss. Cumulative impacts on sea turtles are considered to be **moderate** to **major**.	The incremental contribution of routine Program activities to these impacts would be **small** to **medium**, because population-level impacts are not expected. Expected accidental oil spills under the Program (most of which are less than 1,000 bbl) would result in a **negligible** to **medium** incremental increase in the overall impact of exposure to oil from other anthropogenic activities (such as spills from foreign tankers) because such spills are relatively easy to contain and would only affect small areas of habitat (and few individuals). However, large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could potentially result in population-level effects. Although such spills are rare events, impacts could be **major** and long-term if multiple individuals and their habitat (especially nesting habitat) are exposed to oil.

TABLE 4.6.6-1 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Lower Trophic Levels and Invertebrates	Invertebrates (animals without a backbone) occupy multiple habitat types from the intertidal zone to the deep sea. Benthic invertebrates burrow into bottom sediments or move along the sediment surface; pelagic invertebrates either drift with the current or actively swim. In the GOM, invertebrates and lower trophic level organisms include prokaryotes, viruses, protozoa, sponges, jellyfish, worms, mollusks (bivalves, squid, octopi), echinoderms (sea urchins and sea star), and crustaceans (barnacles, crabs, shrimp) among others. Cumulative impacts on invertebrates and lower trophic organisms result from activities that generate lethal or sublethal impacts on individuals as well as habitat loss or degradation. Cumulative impacts result from OCS and non-OCS activities that generate lethal or sublethal impacts to individuals as well as habitat loss or degradation. Ongoing and future actions/trends that affect invertebrates in the GOM include oil and gas development in State and Federal waters, dredging, trawling, land loss, coastal hypoxia, and climate change. Cumulative impacts on invertebrates in the GOM are considered to be **moderate** to **major**.	The contribution of the Program to cumulative impacts (mainly due to bottom-disturbing activities) would be **negligible** to **medium** (with **negligible** impacts to the ESA elkhorn coral), with the severity of the impacts generally decreasing with distance from bottom-disturbing activities. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on invertebrates would be **negligible** to **small**, depending on the location, timing, duration, and size of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and could range up to **moderate** if they were to occur.
Areas of Special Concern	In the GOM, Areas of Special Concern are federally managed areas such as marine protected areas, National Marine Sanctuaries, National Parks, and National Wildlife Refuges. A number of other locations have been given special designations by Federal, State, and nongovernmental organizations; these include the National Estuarine Research Reserves, National Estuary Program Sites, and the Military and NASA Use Areas. Cumulative impacts on these resources result from activities that could potentially cause damage to or degradation of fauna or habitats within these areas. Ongoing and future activities or trends that affect these areas in/near the GOM include fishing, diving, dredging operations, marine vessel traffic (and wakes), tankering, trash and debris accumulation (from various sources), onshore infrastructure (e.g., roads and vehicle traffic), and oil and gas development and infrastructure (e.g., pipeline landfalls and onshore facilities). Extreme weather events such as hurricanes and tropical storms also occur regularly in the	Routine operations under the Program could result in a **negligible** to **medium** incremental increase in effects on Areas of Special Concern. Expected oil spills (most of which are less than 1,000 bbl) that may occur during the Program could result in a **negligible** to **small** incremental contribution to cumulative impacts on Areas of Special Concern, depending on spill frequency, location, and volume; the type of product spilled; weather conditions; effectiveness of cleanup operations; and other environmental conditions at the time of the spill. Large spills (1,000 bbl and greater) or an unexpected, low-probability CDE in areas adjacent to the National Parks, NWRs, or National Forests, whether from OCS or non-OCS sources, would also depend on these factors, and could result in **moderate** impacts if they were to occur. Such spills could negatively impact the FGBNMS and coastal habitats and fauna, and could also affect

TABLE 4.6.6-1 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Areas of Special Concern (Cont.)	GOM region and potentially cause damage by increasing shoreline erosion. Climate change has the potential to profoundly affect coral communities within these areas (e.g., in the FGBNMS, the only marine sanctuary in the GOM). Cumulative impacts on Areas of Special Concern in the GOM are considered to be **negligible** to **moderate**.	subsistence uses, commercial or recreational fisheries, and tourism.
Population, Employment, and Income	Population in the GOM coastal region has been steadily increasing since 1980, with the highest growth occurring in Texas. Most of the employment (and earnings) in the region is concentrated in Florida and Texas, with services, retail/wholesale trade, and State and local government being the highest employing sectors. Cumulative economic impacts in the region generally result from direct employment and income created through offshore oil and gas development and the indirect employment/income produced through spending of wages and salaries, and from the procurement of materials and services. Population is affected by the in-migration of workers and their families into the region. The cumulative impacts of ongoing and future OCS program and non-OCS program activities would be considered **beneficial** because these activities would increase employment and earnings in the region over the next 40 to 50 yr.	The Program would add to beneficial impacts, especially in Texas and Louisiana. The incremental contribution of the Program is expected to be **negligible**, however, because the added employment demands are less than 2% of the total GOM coast regional employment. The incremental contribution of expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program would be **negligible** to **small** relative to those associated with ongoing and future OCS program and non-OCS program activities. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in **minor** to **moderate** impacts. However, short-term impacts of a CDE could be **major** as a result of lost employment and income, and possible shortages of commodities or services in both coastal and inland areas affected by the spill.
Land Use and Infrastructure	Most of the equipment and facilities supporting offshore oil and gas operations are located in the western and central GOM. Currently, there are hundreds of onshore facilities that support offshore industry. These include ports, refineries, and waste management facilities among others. Cumulative impacts on land use and infrastructure result from demands on roads, utilities, and public services and the need to develop additional onshore facilities to accommodate ongoing and future activities in the GOM. Oil spill response also places stresses on community infrastructure and increases traffic in the affected area. Cumulative impacts on land use and onshore resources could range from **minor** to **major** depending on the nature and location of demands.	The incremental contribution of routine operations under the Program to cumulative impacts would be **negligible** to **small** because the existing infrastructure is considered sufficient to handle the small increases in demands for roads, utilities, and public services related to the Program. Land use–related impacts resulting from expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program include stresses of spill response on community infrastructure, increased traffic in the response area (both onshore and offshore), and temporary restricted access to affected lands (while cleanup is conducted). Such spills would result in a

TABLE 4.6.6-1 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Land Use and Infrastructure (Cont.)		**negligible** to **small** incremental contribution to cumulative impacts on land use and existing infrastructure. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in **minor** to **moderate** impacts if they were to occur.
Commercial and Recreational Fisheries	Commercial fishers are very important to the economies of the GOM coast States. In 2009, commercial fishery landings reached almost 649,000 metric tons, worth more than $629 million. When considering related processor, wholesale, and retail businesses, the GOM seafood industry supports more than 200,000 jobs with related income impacts of $5.5 billion. In 2009, Louisiana led the States in total landings and values, followed by Mississippi, Texas, and Florida. Recreational fishing is also important to the region, with more than 4.5 million people engaged in the activity in 2010. Most of the recreational fish landings in 2010 were in Florida. Cumulative impacts on commercial and recreational fishing result from changes in commercial fishing coasts with offshore oil and gas development, and changes in accessibility of fisheries resources. Ongoing offshore oil and gas development has had both positive and negative effects in the region; the cumulative impacts are considered to be **minor**.	The incremental contribution of routine Program activities to cumulative impacts would be **small**, since these activities would be unlikely to have population- or community-level effects on fishery resources because of the limited timeframe over which most individual activities would occur and because a small proportion of habitat relative to similar available habitat would be affected during a given period. In addition, existing stipulations are in place to prevent or reduce impacts on sensitive habitats such as hard-bottom areas and topographic features. Construction of new platforms could represent a small increase in the availability of desirable recreational fishing locations for recreational anglers. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program would be **medium**, depending on the location, timing, and volumes of spills (among other environmental factors). Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be **moderate** if they were to occur.
Tourism and Recreation	The GOM coastal zone is one of the nation's major recreational regions, with marine fishing and beach-related recreation being top activities. The coast States offer diverse natural and developed landscapes and seascapes, and natural areas are visited by residents and tourists throughout the year. In 2000, Florida along had more than 22 million visitors. Cumulative impacts on tourism and recreation result from changes in accessibility of beach and offshore resources for recreational use and from increases in marine vessel and aircraft traffic in the vicinity of recreational resources. Given the existence of offshore oil and gas development and other ongoing activities in the GOM, cumulative impacts on tourism and recreation are expected to be **minor**.	The incremental contribution of routine operations under the Program to cumulative impacts would be **small**, with potential adverse aesthetic impacts on beach recreation and sightseeing and potential positive impacts on diving and recreational fishing. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on would be **negligible** to **small**, depending on the size, location, and timing of the spill (being greatest if it occurred during the peak recreational season). Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be **minor** to **moderate** if they were to occur.

TABLE 4.6.6-1 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Sociocultural Systems	The counties along the GOM coast are home to a large and heterogeneous population. Within the coastal region, the effects of the offshore oil and gas industry are felt most directly by populations living within the coastal community commuting zone where industry support facilities and the people who work in them are located. Coastal estuaries provide a wealth of wild resources for subsistence harvesting. Though much of the subsistence activities in the GOM region are practiced recreationally, some Native American groups in southern Louisiana depend on fishing, hunting, and gathering for at least part of their domestic subsistence. Commercial Vietnamese fishers also retain a quarter of their catch for family use and barter. Cumulative impacts to sociocultural systems occur when ongoing and future actions (OCS and non-OCS program) cause changes in local populations and social institutions or when jobs are lost or created. Subsistence practices have already been stressed by natural trends associated with climate change (e.g., flood control along the Mississippi River). Given all these factors, cumulative impacts on sociocultural systems are considered to be **moderate**.	The incremental contribution of routine operations under the Program to cumulative impacts would be **small**, since they are more likely to support the existing industry than to create industry growth. Any expansion of deepwater activities will result in jobs that require longer, unbroken periods of work offshore, specialized skills, and potential in-migration of part of the workforce. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program would be **small** to **medium**, especially on localized intertidal resources used by subsistence harvesters. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be **moderate** to **major** if they were to occur, especially if oil from a CDE were to reach the shore. Such spills could lead to long-term closure of fisheries, resulting in social and cultural stress.
Environmental Justice	Environmental justice impacts occur when any activity or trend results in adverse health or environmental impacts that are significantly high and disproportionately affect minority and low-income populations. A large number of minority and low-income individuals are located in the LMA counties along the GOM coast. In this region, the adverse effects of several hurricanes over the past decade are still being felt; these events have been high and disproportionate in their effects on minority and low-income populations, and will likely persist into the foreseeable future. Ongoing and future actions contributing to cumulative impacts in the region include proximity to existing oil and gas infrastructure and any associated health, environmental, and visibility impacts, and climate change (increase in hurricane frequency and intensity). Given all these factors, cumulative impacts on minority and low-income populations are considered to be **moderate** to **major**.	Because of the long-established and well-developed oil and gas industry present in the GOM and the fact that an estimated 75% of activity from the Program would occur in deep and ultra-deep waters, routine operations under the Program are not expected to cause additional environmental justice concerns; their contribution to cumulative impacts on low-income and minority populations therefore would be **negligible**. The incremental contribution of expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program would be **negligible** to **medium** because of the movement of oil and gas activities farther away from coastal areas and the demographic pattern of more affluent groups (and fewer low-income and minority populations) living in coastal areas. An unexpected, low probability CDE could result in **moderate** to **major** impacts, depending on the location, size, and timing of the event.

TABLE 4.6.6-1 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Archaeological and Historical Resources	Onshore cultural resources are highly varied in coastal areas of the GOM. Prehistoric cultural resources range from small, temporary use sites to substantial permanent settlements, some from the earliest known human occupation of the areas. Offshore cultural resources mainly consist of shipwrecks dating from as early as the sixteenth century; however, other structures, such as the Ship Shoal Lighthouse, can also be found offshore. Studies indicate that most shipwrecks in the northern GOM are located within a mile of shore; with the highest concentration of ships occurring in areas that experienced high volume marine traffic. Shipwrecks are also thought to be concentrated in the open sea of the eastern GOM. To date, shipwrecks have been found in water depths of up to 1,981 m (6,500 ft). Cumulative impacts to these resources occur when operations involving bottom-disturbing activities come into physical contact with artifacts or their site context, or as a result of waves, currents, and tropical storms. The cumulative impacts of ongoing and future activities (OCS and non-OCS) are not currently known, but could range from **minor** to **moderate**, mainly because activities occurring on the OCS prior to the USDOI's survey requirement, which went into effect in 1973, may already have affected significant sites.	Routine operations could affect significant archaeological and historic resources, especially offshore resources, with construction activities such as platform and pipeline construction, and dredging, potentially damaging or destroying affected resources. Onshore impacts include resource damage or loss, or visual effects and are possible from pipeline landfall, onshore pipeline, and road construction. Anchor drags could adversely affect shipwrecks. The incremental contribution of routine operations under the Program would be **negligible** to **large**, depending on the presence of significant archaeological or historic resources in the area of potential effect. Archaeological surveys that would identify significant cultural resources to be avoided could reduce these impacts. The incremental contribution of oil spills, whether expected oil spills (most of which are less than 1,000 bbl) to cumulative impacts on archaeological and historical resources in Cook Inlet would be **small** to **large**, depending on the presence of significant resources in the area of potential effect and the spill location, timing, duration, and size. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from **minor** to **major** if it were to occur.

TABLE 4.6.6-2 Summary of Cumulative Impacts and Incremental Contributions of the Program – Alaska, Cook Inlet

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Water Quality	Factors affecting the water quality in Cook Inlet include marine vessel traffic, wastewater discharge, dredging and marine disposal, oil and gas production (currently only in State waters), military operations. Water quality is also affected by numerous other factors, including river inflows, urbanization, forest practices, mining, municipal waste discharges, and agriculture. Natural seepage of oil along the west part of the inlet may also be significant. Cumulative impacts on water quality are attributed to a combination of all these factors and, overall, are considered to be **minor** to **moderate**. These impacts may lessen with time since oil and gas production in Cook Inlet is currently in decline.	The incremental contribution of routine operations under the Program would be **small** to **medium**. Compliance with NPDES permits and USCG regulations would reduce the magnitude of most impacts. The effects of expected accidental oil spills (most of which are less than 1,000 bbl) would depend upon weather and sea conditions at the spill site, the type of oil spilled, the depth of the spill event, and the volume and rate of spillage; therefore, the incremental contribution of expected oil spills to cumulative water quality impacts could range from **small** to **large**. Water quality impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from **moderate** to **major** if it were to occur. Spill response and cleanup activities could also contribute to water quality impacts.
Air Quality	Except for a few population centers such as Anchorage, the existing air quality in Alaska is relatively pristine with pollutant levels that are well within the ambient standards. Cumulative impacts on air quality in Cook Inlet are attributed to both offshore and onshore activities. Offshore activities in the region are mainly associated with the oil and gas industry, but also include various marine vessel traffic (shipping, fishing, cruise ships). Onshore emission sources include power generation, industrial plants, mining, commercial and home heating, on-road vehicles, and non-road engines (e.g., aircraft, locomotives, and construction equipment). Overall, cumulative impacts on air quality in Cook Inlet over the next 40 to 50 yr are expected to be **minor** to **moderate**.	The incremental contribution of routine operations under the Program would be **small**, because they would not cause exceedance of the NAAQS in public access areas or affect visibility. The effects of expected accidental oil spills would be localized and temporary due to dispersion; therefore, the incremental contribution of expected oil spills (most of which are less than 1,000 bbl) to cumulative air impacts could range from **small** to **medium**. Air quality impacts associated with an unexpected, low-probability CDE would also be reduced by these factors, and could be **moderate** if it were to occur. Spill response and cleanup activities could also contribute to air quality impacts.

TABLE 4.6.6-2 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Acoustic Environment	Ice, strong tidal fluctuations, and currents all play an important role in the ambient noise levels in Cook Inlet. The main sources of anthropogenic noise are aircraft overflights, marine vessel traffic, oil and gas activities (including seismic surveys and production operations), and other operations such as dredging and pile driving (for new docks). The quality of the acoustic environment in Cook Inlet would continue to be adversely affected by ongoing and future non-OCS program activities and by future OCS program activities (currently there are no existing OCS activities, although seismic studies and exploratory drilling have been conducted in the past). The magnitude of cumulative impacts in the inlet is time- and location-specific and could range from **minor** to **major**, depending on the ambient acoustic conditions and the nature and combination of noise sources from all OCS and non-OCS activities. See also Marine Mammals (this table).	The contribution of routine operations under the Program to cumulative impacts could range from **small** to **medium** and would vary with time and location and would depend on the characteristics of the noise sources present. The incremental increase in adverse acoustic environmental impacts from expected accidental oil spills in Cook Inlet waters (mainly due to noise sources associated with response and cleanup) would be localized and temporary; therefore, the incremental contribution of expected oil spills (most of which are less than 1,000 bbl) to cumulative noise-related impacts would be **small**. Noise-related impacts associated with an unexpected, low-probability CDE could range from **minor** to **moderate** if it were to occur.
Coastal and Estuarine Habitats		
Barrier Beaches and Dunes	Coastal habitats along Cook Inlet are influenced by dynamic tidal currents. Sensitive shoreline habitats in the lower Cook Inlet include marshes, sheltered tidal flats, sheltered rocky shores, and exposed tidal flats. The affects of climate change on coastal habitats in Cook Inlet are also significant. These include sea level rise, which could inundate low-lying coastal habitats, and increase in the incidence of pests and diseases, which could result in increased forest tree mortality. Cumulative impacts on coastal beaches and dunes in Cook Inlet are considered to be **moderate**.	Routine operations under the Program would result in minor localized impacts primarily due to facility construction, pipeline trenching and landfalls, channel dredging, and vessel traffic. The contribution of the Program to cumulative impacts on beaches and dunes therefore would generally be **small** to **medium**. The incremental impacts of expected accidental oil spills associated with the Program would be **negligible** to **large**, depending on the location, timing, duration, and size of the spill; the proximity of the spill to particular habitats; and the timing and nature of spill containment and cleanup activities. The majority of these spills would be small (less than 50 bbl) and most of them would not likely contact and affect coastal and estuarine habitats. Large oil spills (1,000 bbl or greater) or an unexpected, low-probability CDE have the greatest potential to affect extensive areas of shoreline and coastal and estuarine habitats. Although these are rare events, the impacts of such releases on coastal habitats could range from **moderate** to **major** if they were to occur.

TABLE 4.6.6-2 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Wetlands	Cumulative impacts on coastal and estuarine habitats result from the loss of beach and wetland habitat in Cook Inlet. While there are no past or ongoing OCS activities in the Cook Inlet Planning Area, other ongoing and future actions/trends that affect these resources include those related to State oil and gas development, commercial shipping (and other marine vessel traffic), coastal development, discharge of municipal wastes and other effluents, domestic transportation of oil and gas, logging, and climate change. These activities can be reasonably expected to continue into the future. Cumulative impacts on coastal and estuarine habitats in Cook Inlet are considered to be **moderate**.	Same as for barrier beaches and dunes.
Benthic and Pelagic Habitats	Cumulative impacts on marine benthic and pelagic habitats in Cook Inlet result of from any activities that disturb ocean bottom or marine habitats, increase sediment suspension (turbidity), degrade water quality, or affect the food supply of biota depending on these resources. Ongoing and future actions/trends that affect these resources include oil and gas activities in State waters, commercial shipping (including tankers), dredging and disposal of dredging spoils in OCS waters, and anchoring. State oil and gas activities (in upper Cook Inlet) and future OCS activities could affect seafloor and pelagic habitats; these include the generation of noise, well drilling, pipeline placement, subsea production well and platform placement, and routine discharges. Accidental oil spills are also among these actions. Cumulative impacts on benthic and pelagic habitats in Cook Inlet are considered to be **moderate** to **major**.	Routine operations under the Program in Cook Inlet could result in negligible to moderate impacts from ground disturbance during drilling and pipeline and platform placement, as well as the discharge of drilling muds and cuttings and produced water. The incremental contribution to cumulative impacts on marine benthic habitats would range from **negligible** to **medium** and would be limited by existing mitigation measures. The incremental impacts of expected accidental oil spills on benthic habitats (most of which are less than 1,000 bbl) would range from **negligible** to **small**, depending on the size, duration, timing, and location of the spill, and the nature (i.e., sensitivity) of the benthic habitat contacted by oil. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and could result in **minor** to **moderate** impacts if they were to occur.

TABLE 4.6.6-2 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Essential Fish Habitat	Cumulative impacts on EFH in Cook Inlet result of from any activities that kill of managed fish species, disturb ocean bottom habitats, increase sediment suspension (turbidity), degrade water quality, or affect the food supply for fishery resources. Ongoing and future actions/trends that affect these resources include land use practices (e.g., logging), point and non-point source pollution, dredging and disposal operations, anchoring, fishing (commercial, subsistence, personal use, and sportfishing), and commercial shipping (including imported oil). Subsistence fishing is subject to harvest limits that reduce the potential for overfishing; and much of Cook Inlet is defined as a nonsubsistence area where subsistence fishing is not authorized. For this reason, the impacts related to subsistence are considered minor. State oil and gas activities (in upper Cook Inlet) and future OCS activities could affect EFH (there are no ongoing OCS activities in the inlet); these include the generation of noise, well drilling, pipeline placement, subsea production well and platform placement, and routine discharges. Accidental oil spills are also among these actions. Cumulative impacts on EFH in the Cook Inlet are considered to be **minor** to **moderate**.	Routine operations under the Program in Cook Inlet could result in moderate short- and long-term impacts to EFH and managed species, mainly as a result of bottom disturbance during the placement of pipelines and production platforms. The incremental contribution to cumulative impacts on EFH would be **negligible** to **medium** and would be limited by specific lease stipulations. The incremental impacts of expected accidental oil spills on EFH (most of which are less than 1,000 bbl) would range from **negligible** to **medium** depending on the size of the spill, its location, environmental factors, and the uniqueness of the affected EFH. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could result in **moderate** to **major** impacts if they were to occur.
Marine and Coastal Fauna		
Marine Mammals	All marine mammals in U.S. waters are protected under the Marine Mammal Protection Act of 1972. There are 17 marine mammal species that occur in Cook Inlet or nearby waters of the Gulf of Alaska; nine of these species are threatened or endangered. Ongoing and future activities or phenomena that affect marine mammals include oil and gas development in State waters, vessel traffic; commercial, recreational, and subsistence fishing; subsistence marine mammal harvests; pollution (and marine debris), military operations, development, climate change, and invasive	Routine oil and gas-related activities (e.g., seismic surveys, facility construction, normal operations, and, eventually, decommissioning) would result in minor to moderate impacts on marine mammals. Impacts on marine mammals from these activities could include physical injury or death; behavioral disturbances; lethal or sublethal toxic effects; and loss of reproductive, nursery, feeding, and resting habitats. The contribution of Program activities to cumulative impacts on marine mammals would be **negligible** to **small**.

TABLE 4.6.6-2 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Marine Mammals (Cont.)	species. Cumulative impacts on marine mammals in the Cook Inlet are considered to be **minor** to **moderate**.	The incremental impacts of expected accidental oil spills (most of which are less than 1,000 bbl) would be **negligible** to **small**, depending on the location, timing, and volume of the spills; the environmental settings of the spills; and the species exposed to the spills. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from **minor** to **major** if it were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to these impacts.
Terrestrial Mammals	There are about 40 species of terrestrial mammals in south-central Alaska, including brown bears, moose, and river otters. Ongoing and future activities or phenomena that affect terrestrial mammals in the Cook Inlet region include State oil and gas development, aircrafts and vehicle traffic; coastal and community development, timber harvests, hunting; pollution, climate change, and natural catastrophes. Cumulative impacts on terrestrial mammals in the Cook Inlet are considered to be **minor** to **moderate**.	Routine oil and gas-related activities (e.g., facility construction including onshore pipelines, normal operations including aircraft and marine vessel traffic, and, eventually, decommissioning) would result in minor impacts on terrestrial mammals. Impacts on terrestrial mammals from these activities could include physical injury or death; behavioral disturbances; lethal or sublethal toxic effects; and loss of reproductive, nursery, feeding, and resting habitats. The contribution of Program activities to cumulative impacts would be **negligible** to **small**. The incremental impacts of expected accidental oil spills (most of which are less than 1,000 bbl) on terrestrial mammals would be **negligible** to **small**, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and other important habitats; the timing and nature of spill containment; and the status of the affected animals. An unexpected, low-probability CDE has a greater potential to affect the terrestrial habitats; therefore, impacts could range from **minor** to **major** if it were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to these impacts.

TABLE 4.6.6-2 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Marine and Coastal Birds	There are more than 492 naturally occurring bird species in Alaska. Annual use patterns of Cook Inlet are characterized by the sudden and rapid occurrence of very large numbers of birds in early may followed by a sudden and rapid departure in mid- to late-May. Cumulative impacts result from direct injury or mortality of marine and coastal birds due to collisions with onshore and offshore structures, ingestion of trash or debris, or exposure to discharges or emissions; loss or degradation of habitat due to coastal development, climate change, or construction and operations activities; and behavioral disturbance due to commercial and recreational boating and small aircraft traffic. Many bird species are currently experiencing a loss or degradation of habitat due to land development and climate change and these impacts are expected to continue into the foreseeable future. Ongoing and future actions/trends that affect marine and coastal birds include those related to oil and gas development in State waters, coastal development, vessel traffic, dredging operations, and climate change. Cumulative impacts on marine and coastal birds are considered to be **minor** to **moderate**.	Routine operations may result in localized short-term impacts due to infrastructure construction and marine vessel and aircraft traffic. The contribution of the Program to cumulative impacts on marine and coastal birds therefore would be **negligible** to **medium**. The incremental contribution of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on marine and coastal birds would be **small** to **large**, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and nesting areas; the timing and nature of spill containment; and the status of the affected birds. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from **moderate** to **major** if it were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to these impacts.
Fish	Cumulative impacts result from OCS and non-OCS activities that generate lethal or sublethal impacts to individuals as well as the loss or degradation of fish habitat. Ongoing and future actions/trends that affect fish in Cook Inlet include oil and gas development in State and Federal waters, commercial and recreational fishing, noise, dredging operations, and wastewater discharge. Climate change is also expected to affect fish habitat, productivity, and community structure. Cumulative impacts on fish in Cook Inlet are considered to be **moderate** to **major**.	The incremental contribution of routine Program activities to these impacts (primarily as a result of disturbance affecting demersal fishes) would be **negligible** to **small**, with the severity of impacts generally decreasing with distance from the disturbance (and a **negligible** contribution to impacts on threatened or endangered fish species). The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on fish would be **negligible** to **medium**, depending on the location, timing, duration, and volume of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range up to **moderate** if it were to occur. Impacts would be greatest if oil were to reach intertidal habitats.

TABLE 4.6.6-2 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Lower Trophic Levels and Invertebrates	Invertebrates (animals without a backbone) occupy the rocky and sandy substrates in the intertidal and subtidal zones. Water column invertebrates in Cook Inlet are composed of a mix of oceanic and coastal species. Several species of copepods (small crustaceans) dominate the macrozooplankton assemblage, peaking in late spring and summer. In lower Cook Inlet, benthic invertebrate communities vary spatially as a result of differences in ice formation, with Arctic species being more common on the western side of the inlet and temperate species being more common on the eastern side. Invertebrates and lower trophic level organisms in the rocky and sandy intertidal zone include echinoderms (sea urchins and sea stars), mollusks (bivalves, limpets, and snails), polychaetes (worms), and crustaceans (barnacles, crabs, and amphipods); clams and polychaetes are predominant in subtidal sandy and muddy sediments. Cumulative impacts result from OCS and non-OCS activities that generate lethal or sublethal impacts to individuals as well as habitat loss or degradation. Ongoing and future actions/trends that affect invertebrates in Cook Inlet include oil and gas development in State and Federal waters, dredging, trawling, and wastewater discharge. Climate change is also expected to affect fish habitat, productivity, and community structure. Cumulative impacts on invertebrates in Cook Inlet are considered to be **moderate** to **major**.	The contribution of the Program to cumulative impacts (mainly due to bottom-disturbing activities) would be **negligible** to **medium**, with the severity of the impacts generally decreasing with distance from bottom-disturbing activities. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on invertebrates would be **negligible** to **small**, depending on the location, timing, duration, and size of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and could range up to **moderate** if they were to occur.

TABLE 4.6.6-2 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Areas of Special Concern	The Alaska National Interest Lands Conservation Act of 1980 designated certain public lands in Alaska as National Parks, Wildlife Refuges, Wild and Scenic Rivers, and for the National Wilderness Preservation and National Forest Systems. Many of these occur in the Cook Inlet region. Other Areas of Special Concern include MPAs, National Estuarine Research Reserves, National Estuary Program Areas, MUAs, and NOAA-designated HCAs. In addition, there are several State parks and recreation areas bordering Cook Inlet. Cumulative impacts on these resources result from activities that could potentially cause damage to or degradation of fauna or habitats within these areas. Ongoing and future activities or trends that affect Areas of Special Concern in or near Cook Inlet include fishing, diving, dredging operations, marine vessel traffic (and wakes), tankering, trash and debris accumulation (from various sources), onshore infrastructure (e.g., roads and vehicle traffic), and oil and gas development and infrastructure (e.g., pipeline landfalls and onshore facilities). Cumulative impacts on Areas of Special Concern in the Cook Inlet are considered to be **negligible** to **moderate**.	Routine operations under the Program could result in **negligible** to **medium** incremental increases in effects on national sanctuaries, parks, refuges, and estuarine research reserves. Expected oil spills (most of which are less than 1,000 bbl) that occur during the Program could result in a **negligible** to **small** incremental contribution to cumulative impacts on Areas of Special Concern, depending on spill frequency, location, and volume; the type of product spilled; weather conditions; effectiveness of cleanup operations; and other environmental conditions at the time of the spill. Large spills (1,000 bbl and greater) or an unexpected, low-probability CDE in areas adjacent to the national parks, NWRs, or national forests, whether from OCS or non-OCS sources, would also depend on these factors, and could result in **moderate** impacts if they were to occur. Such spills could negatively impact coastal habitats and fauna, and could also affect subsistence uses, commercial or recreational fisheries, and tourism.
Population, Employment, and Income	Between 2005 and 2009, the Municipality of Anchorage had a population of 280,389, about 45% of the total population in Alaska. Employment is concentrated in Anchorage, which provides about 83% of employment in the region. The largest employing sectors in 2008 were in services, wholesale and retail trade, and State and local government. Oil and gas employment is concentrated in Anchorage, with a total of 8,636 workers employed directly in oil and gas extraction activities, pipeline and refinery activities, and support activities in 2007. Cumulative economic impacts result from direct employment and income created through the development of offshore oil and gas resources and the indirect employment and income produced through the spending of wages and salaries and from the procurement of materials and services in the region. The cumulative impacts of future OCS program and ongoing and future non-OCS program activities would be considered **beneficial** because these activities would increase employment and earnings in the region over the next 40 to 50 yr.	The Program would add to beneficial impacts, especially on the Kenai Peninsula and in Anchorage. The incremental contribution of the Program is expected to be **small**, however, because the added employment demands are less than 5% of baseline levels in Alaska. The incremental contribution of expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program would be **negligible** to **small** relative to those associated with future OCS program and ongoing and future non-OCS program activities. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in **minor** to **moderate** impacts. However, in the short-term, impacts of a CDE could be **major** as a result of lost employment, income, and property value; increased traffic congestion; increased cost of service provision; and possible shortages of commodities or services.

TABLE 4.6.6-2 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Land Use and Infrastructure	Anchorage is the State center for scheduled aircraft and the regional center for chartered aircraft. It has a cargo facility served by a railroad connecting it to Alaska's interior and the port of Seward and two military bases (Joint Base Elmendorf-Richards on). It is also the center for the State's overall road network. Much of the on-land infrastructure around Cook Inlet supports offshore oil and gas development; facilities/complexes include the Trading Bay production facility, the Tesoro Refinery, the Drift River Terminal, and the Nikiski complex (Agrium and ConocoPhillips LNG). Cumulative impacts on land use and infrastructure result from demands on roads, utilities, and public services and the need to develop additional onshore facilities to accommodate ongoing and future activities in the inlet. Oil spill response also places stresses on community infrastructure and increases traffic in the affected area. Cumulative impacts on land use and onshore resources could range from **minor** to **major**, depending on the nature and location of demands.	The incremental contribution of routine operations of the Program to cumulative impacts in the GOM would be **negligible** to **small** because the Program would not introduce new kinds of activities that would alter existing land uses. Land use–related impacts resulting from expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program include stresses of spill response on community infrastructure, increased traffic in the response area (both onshore and offshore), and temporary restricted access to affected lands (while cleanup is conducted). Such spills would result in a **small** incremental contribution to cumulative impacts on land use and existing infrastructure. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in **moderate** impacts if they were to occur.
Commercial and Recreational Fisheries	Commercial fisheries of Cook Inlet and the Gulf of Alaska target groundfish, Pacific halibut, Pacific salmon, herring, crab, shrimp, clams, scallops, sea urchins, and sea cucumbers. The groundfish fisheries accounted for the largest share ($640 million, or about 48%) of the ex-vessel value of all commercial fisheries in Alaska in 2009. Recreational fishing in the Cook Inlet region includes marine sport fishing, freshwater fishing, and shellfish gathering activities, which contribute substantially to the area's economy. On the western bank of upper Cook Inlet, there are recreational fisheries for razor clams, several species of hardshell clams, and crab. Cumulative impacts on commercial and recreational fishing result from changes in commercial fishing costs with offshore oil and gas development and changes in accessibility of fishery resources. The cumulative impacts on commercial and recreational fisheries in Cook Inlet are considered to be **minor**.	The incremental contribution of routine operations under the Program to cumulative impacts in Cook Inlet would be **small**, since these activities would be unlikely to have population-level effects on fishery resources or result in long-term loss of fishery resources. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on would be **negligible** to **medium**, depending on the location, timing, and volumes of spills (among other environmental factors). Small spills are unlikely to affect a large number of fish or have a substantial effect on recreational fishing before dilution and weathering reduced concentrations of oil in the water. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be **moderate** if they were to occur.

TABLE 4.6.6-2 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Tourism and Recreation	Opportunities for recreational activities such as hunting, hiking, boating, wildlife viewing, and sightseeing are abundant in the Cook Inlet region. Visitors reach the area via tour ships and ferries, as well as helicopters, small aircraft, and fishing charters. The Kenai Peninsula and Prince William Sound receive the heaviest recreational use by residents and nonresidents, and are in close proximity to Cook Inlet and Anchorage. The Chugach National Forest attracts hikers, campers, and other users. Cumulative impacts on tourism and recreation result from changes in accessibility of beach and offshore resources for recreational use, and from increases in marine vessel and aircraft traffic in the vicinity of recreational resources; these impacts are expected to be **minor**.	The incremental contribution of routine operations under the Program to cumulative impacts in Cook Inlet would be **small**, with potential adverse aesthetic impacts on sightseeing, boating, fishing, and hiking activities in the inlet. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program would be **negligible** to **small**, depending on the size, location, and timing of the spill (being greatest if it occurred during the peak recreational season). Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be **minor** to **moderate** if they were to occur.
Sociocultural Systems	The region surrounding Cook Inlet includes economically complex cities such as Anchorage and its suburbs, the largest urban community in the State; towns such as Kenai, Soldotna, and Nikiski that are centers of the oil and gas industry; smaller towns such as Port Lions that depend on commercial fishing; and small predominantly Alaska Native communities. Subsistence harvesting plays some role in communities of all types. Cumulative impacts to sociocultural systems occur when ongoing and future actions (OCS and non-OCS programs) cause changes in local populations and social institutions or when jobs are lost or created. Subsistence harvesting could also be affected by activities that affect marine fauna, such as increases in airborne or subsea noise (e.g., aircraft or marine vessel traffic, seismic surveys, drilling) or degradation of water quality (e.g., fuel or oil spills, chemical releases, or dredging operations that increase turbidity), or that necessitate changes in subsistence fishing practices. Cumulative impacts on sociocultural systems in Cook Inlet as a result of ongoing and future OCS and non-OCS activities and natural phenomena could be **minor** to **moderate** over the next 40 to 50 yr.	The incremental contribution of routine operations under the Program to cumulative impacts would be **small**, since they would not introduce new kinds of activities that would alter existing socioeconomic systems. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on would be **small** to **large**, especially in intertidal and estuarine zones used by subsistence harvesters. Impacts associated with an unexpected, low-probability CDE could be **major** if it were to occur, especially if resources important to subsistence harvesters, including intertidal resources, migrating fishes, and fishes with strong ties to the shore, were affected.

TABLE 4.6.6-2 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Environmental Justice	Environmental justice impacts occur when any activity or trend (OCS program or non-OCS program related) results in adverse health or environmental impacts that are significantly high and disproportionately affect minority and low-income populations. A large number of minority and low-income individuals live in the south-central Alaska region; however, the number of minority individuals in each of the local boroughs does not exceed 50% of the population or the State average by 20 percentage points or more in any of the boroughs. Thus, there is no minority population in south-central Alaska. Likewise, there are no low-income populations in any of the local boroughs. Subsistence hunting and fishing are an important part of the economies in rural communities. Although there are no environmental justice concerns here, cumulative impacts on local communities could result from changes in the proximity of onshore oil and gas infrastructure and to marine vessel and aircraft traffic. Ongoing and future oil and gas development would continue to affect populations in some regions of Cook Inlet by increasing the proximity to existing oil and gas infrastructure and associated health, environmental, and visibility impacts. Given these factors, cumulative impacts on local populations are considered to be **moderate** to **major**.	The incremental contribution of routine operations under the Program would be small, depending on the proximity of onshore pipelines and offshore infrastructure to communities and their subsistence harvest areas, but are not expected to cause additional environmental justice concerns; their contribution to cumulative impacts on low-income and minority populations therefore would be **small**. The incremental contribution of expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program would be **negligible** to **small**. Large spills (1,000 bbl or greater) or an unexpected CDE could result in **moderate** to **major** impacts on the Alaska Native population, especially if subsistence resources were diminished or tainted as a result of the spill. Mitigation measures, cooperative agreements between Native and industry groups, and government-to-government consultations are designed to limit the effects from oil spills and routine operations.
Archaeological and Historical Resources	Onshore archaeological and historic resources occur along the shoreline surrounding Cook Inlet; the predominant types of prehistoric features are house pits containing household and subsistence artifacts like stone lamps, sinkers, and arrowheads. Historic sites onshore consist of early Russian houses, churches, roadway inns, fish camps, and mining camps. Little research has been done to characterize prehistoric resources in the offshore waters of Cook Inlet; however, it is likely that high-energy tidal movement has removed at least some resources from their original resting place. The best preserved shipwrecks are likely to be found on the OCS, because wave action and ice are less likely to contribute to the breakup of ships in deeper waters. Cumulative impacts to these resources occur when operations involving	Routine operations could affect significant archaeological and historic resources, especially offshore resources, with construction activities such as platform and pipeline construction potentially damaging or destroying affected resources. Onshore impacts include resource damage or loss, or visual effects and are possible from pipeline landfall, onshore pipeline, and road construction. Anchor drags could adversely affect shipwrecks. The incremental contribution of routine operations under the Program is expected to be **negligible** to **large**, depending on the presence of significant archaeological or historic resources in the area of potential effect. Archaeological surveys that would identify significant cultural resources to be avoided could reduce these impacts.

TABLE 4.6.6-2 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Archaeological and Historical Resources (Cont.)	bottom-disturbing activities (e.g., channel dredging) come into physical contact with artifacts or their site context, or as a result of natural phenomena such as high-energy waves and currents, ice gouging, and thermokarst collapse. The cumulative impacts of future OCS and ongoing and future non-OCS activities are not currently known, but could range from **minor** to **moderate**, mainly because activities occurring on the OCS prior to the USDOI's survey requirement, which went into effect in 1973, may already have affected (i.e., damaged or destroyed) significant sites.	The incremental contribution of oil spills, whether expected oil spills (most of which are less than 1,000 bbl) to cumulative impacts on archaeological and historical resources in Cook Inlet would be **small** to **large**, depending on the presence of significant resources in the area of potential effect and the spill location, timing, duration, and size. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from **minor** to **major** if it were to occur.

TABLE 4.6.6-3 Summary of Cumulative Impacts and Incremental Contributions of the Program – Alaska, Arctic Region

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Water Quality	Factors affecting the water quality in the Beaufort and Chukchi Seas include marine vessel traffic, wastewater discharge, oil and gas production (currently only in State waters), military operations. Water quality is also affected by numerous other factors, including river inflows, mining, and municipal waste discharges. Cumulative impacts on water quality are attributed to a combination of all these factors and, overall, are considered to be **moderate**. Impacts related to marine vessel traffic in the Beaufort and Chukchi Seas (especially shipping and research vessels, icebreakers, and cruise ships) would likely increase in the coming decades as the open water season begins earlier and ends later (an effect of climate change).	The incremental contribution of routine operations under the Program would be **small** to **medium.** Compliance with NPDES permits and USCG regulations would reduce the magnitude of most impacts. The effects of expected accidental oil spills (most of which are less than 1,000 bbl) would depend upon weather and sea conditions at the spill site, the type of oil spilled, the depth of the spill event, and the volume and rate of spillage; therefore, the incremental contribution of expected oil spills to cumulative water quality impacts could range from **small** to **large**. Water quality impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from **moderate** to **major** if it were to occur. Spill response and cleanup activities could also contribute to water quality impacts.
Air Quality	The Arctic region has a low population. Barrow is the largest city in the North Slope Borough with a population (in 2010) of just 4,600. The primary industrial emissions in the region are associated with the oil and gas industry, power generation, small refineries, paper mills, and mining. Currently, the North Slope Borough is designated as an unclassified/attainment area for all criteria pollutants. The region does experience air pollution problems (e.g., Arctic haze), however, due to long-range transport of air pollutants from industrial parts of northern Eurasia and North America. Overall, cumulative impacts on air quality in the Arctic over the next 40 to 50 yr are expected to be **minor** to **moderate**.	The incremental contribution of routine operations under the Program would be **small** because they would not significantly increase onshore airborne pollutants or affect visibility. The effects of expected accidental oil spills (most of which are less than 1,000 bbl) would be localized and temporary due to dispersion; therefore, the incremental contribution of expected oil spills to cumulative air impacts could range from **small** to **medium**. Air quality impacts associated with an unexpected, low-probability CDE would also be reduced by these factors (depending on the season), and could be **moderate** if it were to occur. Spill response and cleanup activities could also contribute to air quality impacts.

TABLE 4.6.6-3 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Acoustic Environment	Arctic waters are a unique acoustic environment mainly because of the presence of ice, which can contribute significantly to ambient sound levels (e.g., ice cracking generates noise; ice deformation generates low-frequency noise). Ambient levels of natural sound can vary dramatically between and within seasons. During open water season, wind and waves are important sources of ambient sounds. The main sources of anthropogenic noise are aircraft overflights, marine vessel traffic, oil and gas activities (including seismic surveys and production operations), human settlements, and military activities. The quality of the acoustic environment in the Beaufort and Chukchi Seas would continue to be adversely affected by ongoing and future non-OCS program activities and by future OCS program activities (currently there are no existing OCS activities, although seismic studies and exploratory drilling have been conducted in the past). The magnitude of cumulative impacts in the Beaufort and Chukchi Seas is time- and location-specific and could range from **minor** to **major**, depending on the ambient acoustic conditions and the nature and combination of noise sources from all OCS and non-OCS activities.	The contribution of routine operations under the Program to cumulative impacts could range from **small** to **medium** and would vary with time and location and would depend on the characteristics of the noise sources present. The incremental increase in adverse acoustic environmental impacts from expected accidental oil spills in Arctic waters (mainly due to noise sources associated with response and cleanup) would be localized and temporary; therefore, the incremental contribution of expected oil spills (most of which are less than 1,000 bbl) to cumulative noise-related impacts would be **small**. Impacts associated with an unexpected, low-probability CDE could range from **minor** to **moderate** if it were to occur.
Coastal and Estuarine Habitats		
Barrier Beaches and Dunes	Arctic coastal habitats are greatly influenced by a short growing season and extremely cold winters; onshore sediments are underlain by permanently frozen soil (permafrost). They are also greatly affected by the dynamics of sea ice, which dominates coastal habitats during most of the year. The Arctic coastline is highly disturbed due to the movement of sea ice that frequently is pushed onshore, scouring and scraping the coastline. The affects of climate change on Arctic habitats are also significant. These include decreases in sea ice cover, warming of permafrost, a longer growing season, and changes in precipitation. Portions of the coast have experienced considerable erosive losses (up to 457 m [1,500 ft]) over the past few decades; the erosion rate in areas of the Beaufort Sea coast more than doubled between 1955 and 2005. Projections for future climate change indicate that these changes are expected to continue.	Routine operations under the Program would result in minor localized impacts primarily due to facility construction, pipeline trenching and landfalls, channel dredging, and marine vessel traffic. The contribution of the Program to cumulative impacts on beaches and dunes therefore would generally be **small** to **medium**. The incremental impacts of expected accidental oil spills associated with the Program would be **negligible** to **large**, depending on the location, timing, duration, and size of the spill; the proximity of the spill to particular habitats; and the timing and nature of spill containment and cleanup activities. The majority of these spills would be small (less than 50 bbl) and most of them would not likely contact and affect coastal and estuarine habitats. Large oil spills (1,000 bbl or greater) or an unexpected, low-probability CDE have

TABLE 4.6.6-3 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Barrier Beaches and Dunes (Cont.)	Cumulative impacts on barrier beaches and dunes result from factors that increase erosion of beach and dunes, such as disturbance of dune vegetation or beach and dune substrates. Increases in wave action also contribute to the erosion of beaches. Accidental oil spills may also affect these resources. While there are no past or ongoing OCS activities in the Beaufort Sea and Chukchi Sea Planning Areas (other than exploratory drilling), other ongoing and future actions/trends that affect beaches and sand dunes include those related to State oil and gas development, commercial shipping (and other marine vessel traffic), coastal development, and climate change. These activities can be reasonably expected to continue into the future. Cumulative impacts on coastal and estuarine habitats in the Arctic region are considered to be **moderate**.	the greatest potential to affect extensive areas of shoreline and coastal and estuarine habitats. Although these are rare events, the impacts of such releases on coastal habitats could range from **moderate** to **major** if they were to occur.
Benthic and Pelagic Habitats	Cumulative impacts on marine benthic and pelagic habitats in the Arctic region result of from any activities that disturb ocean bottom or marine habitats, increase sediment suspension (turbidity), degrade water quality, or affect the food supply of biota depending on these resources. Ongoing and future actions/trends that affect these resources include oil and gas activities in State waters, commercial shipping (including tankers), dredging and disposal of dredging spoils in OCS waters, and anchoring. State oil and gas activities (especially along the Beaufort Sea coastline) and future OCS activities could affect seafloor and pelagic habitats; these include the generation of noise, well drilling, pipeline placement, subsea production well and platform placement, and routine discharges. Accidental oil spills are also among these actions. Cumulative impacts on benthic and pelagic habitats in the Arctic region are considered to be **moderate** to **major**.	Routine operations under the Program in the Arctic region could result in impacts from ground disturbance during drilling and pipeline and platform placement, as well as the discharge of drilling muds and cuttings and produced water (sensitive habitats could have long term affects depending on their proximity to these activities). The incremental contribution to cumulative impacts on marine benthic habitats would range from **negligible** to **medium** and would be limited by existing mitigation measures. The incremental impacts of expected accidental oil spills on benthic habitats (most of which are less than 1,000 bbl) would range from **negligible** to **small**, depending on the size, duration, timing, and location of the spill, and the nature (i.e., sensitivity) of the benthic habitat contacted by oil. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and could result in **minor** to **moderate** impacts if they were to occur.

TABLE 4.6.6-3 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Essential Fish Habitat	Cumulative impacts on EFH in the Arctic region result of from any activities that kill of managed fish species, disturb ocean bottom habitats, increase sediment suspension (turbidity), degrade water quality, or affect the food supply for fishery resources. Ongoing and future actions/trends that affect these resources include subsistence fishing, commercial shipping (including tankers and other marine vessels), coastal modifications, hardrock mining, dredging and disposal operations, anchoring, and climate change. Commercial fishing does not occur in the Beaufort Sea and Chukchi Sea Planning Areas. Sportfishing in the Arctic region is currently a minor activity, but could increase if regulations change and warming temperatures allow an increase in marine vessel traffic. State oil and gas activities (especially along the Beaufort Sea coastline) and future OCS activities could affect EFH; these include the generation of noise, well drilling, pipeline placement, subsea production well and platform placement, and routine discharges. Accidental oil spills are also among these actions. Cumulative impacts on EFH in the Arctic region are considered to be **moderate** to **major**.	Routine operations under the Program in the Arctic region could result in moderate short- and long-term impacts to EFH and managed species, mainly as a result of bottom disturbance during the placement of pipelines and production platforms. The incremental contribution to cumulative impacts on EFH would be **negligible** to **medium** and would be limited by specific lease stipulations. The incremental impacts of expected accidental oil spills on EFH (most of which are less than 1,000 bbl) would range from **negligible** to **medium** depending on the size of the spill, its location, environmental factors, and the uniqueness of the affected EFH. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could result in **moderate** to **major** impacts if they were to occur.
Marine and Coastal Fauna		
Marine Mammals	There are 15 species of marine mammals in the Arctic Region, four of which are listed as threatened or endangered. Ongoing and future activities or phenomena that affect marine mammals include oil and gas development in State waters; vessel traffic; commercial, recreational, and subsistence fishing; marine mammal subsistence harvests; pollution (and marine debris); development; climate change (including temporal and spatial changes in sea ice); diseases; and natural catastrophes. The contribution of the Program activities to cumulative impacts would be small; however, the incremental impacts of accidental oil spills would be small to large, depending on spill location, timing, duration, and size. Cumulative impacts on marine mammals in the Arctic region are considered to be **minor** to **moderate**.	Routine oil and gas-related activities (e.g., seismic surveys, facility construction, normal operations, and, eventually, decommissioning) would result in minor to moderate impacts on marine mammals. Impacts on marine mammals from these activities could include physical injury or death; behavioral disturbances; lethal or sublethal toxic effects; and loss of reproductive, nursery, feeding, and resting habitats. The contribution of Program activities to cumulative impacts would be **negligible** to **small**. The incremental impacts of expected accidental oil spills (most of which are less than 1,000 bbl) would be **negligible** to **large**, depending on the location, timing, and volume of the spills; the environmental settings of the spills; and the species exposed to the

TABLE 4.6.6-3 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Marine Mammals (Cont.)		spills. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from **minor** to **major** if it were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to these impacts.
Terrestrial Mammals	There are about 30 species of terrestrial mammals in the Arctic region. These include the brown bear, caribou, muskox, the Arctic fox, brown lemming, and wolverine, among others. Ongoing and future activities or phenomena that affect terrestrial mammals include State oil and gas development, aircrafts and vehicle traffic; coastal and community development, timber harvests, hunting; pollution, climate change, and natural catastrophes. Cumulative impacts on terrestrial mammals in the Arctic region are considered to be **minor** to **moderate**.	Routine oil and gas-related activities (e.g., facility construction including onshore pipelines, normal operations including vehicle and aircraft traffic, and, eventually, decommissioning) would result in minor impacts on terrestrial mammals. Impacts on terrestrial mammals from these activities could include physical injury or death; behavioral disturbances; lethal or sublethal toxic effects; and loss of reproductive, nursery, feeding, and resting habitats. The contribution of Program activities to cumulative impacts would be **negligible** to **small**. The incremental impacts of expected accidental oil spills (most of which are less than 1,000 bbl) on terrestrial mammals would be **negligible** to **large**, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and other important habitats; the timing and nature of spill containment; and the status of the affected animals. An unexpected, low-probability CDE has a greater potential to affect the terrestrial habitats; therefore, impacts could range from **minor** to **major** if it were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to these impacts.
Marine and Coastal Birds	There are more than 492 naturally occurring bird species in Alaska. Because of the limited seasonal nature of open water and snow-free conditions, the Beaufort and Chukchi Seas support a much smaller number of birds than lower parts of Alaska. Most of the birds occurring in the Arctic region are migratory, being present for all or part of the period between May and early November. Cumulative impacts result from direct injury or mortality of marine and coastal birds due to collisions with onshore and offshore structures,	Routine operations may result in localized short-term impacts due to infrastructure construction and marine vessel and aircraft traffic. The contribution of the Program to cumulative impacts on marine and coastal birds therefore would be **negligible** to **medium**. The incremental contribution of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on marine and coastal birds would be **small** to **large**, depending on the

TABLE 4.6.6-3 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Marine and Coastal Birds (Cont.)	ingestion of trash or debris, or exposure to discharges or emissions; loss or degradation of habitat due to coastal development, climate change, or construction and operations activities; and behavioral disturbance due to commercial and recreational boating and small aircraft traffic. Many bird species are currently experiencing a loss or degradation of habitat due to land development and climate change and these impacts are expected to continue into the foreseeable future. Ongoing and future actions/trends that affect marine and coastal birds include those related to oil and gas development in State waters, coastal development, vessel traffic, and climate change. Cumulative impacts on marine and coastal birds are considered to be **minor** to **moderate**.	location, timing, duration, and size of the spill; the proximity of the spill to feeding and nesting areas; the timing and nature of spill containment; and the status of the affected birds. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from **moderate** to **major** if it were to occur. Spill response activities (e.g., vessel traffic, *in situ* burning, and the use of dispersants) could add to these impacts.
Fish	The Beaufort and Chukchi Seas support at least 98 fish species, with the greatest number found in Chukchi Sea. Fish in the Arctic region must survive extended seasonal periods of frigid and harsh conditions such as reduced light, seasonal darkness, prolonged low temperatures, and ice cover. Food resources tend to be scare during winter months, so most of a fish's yearly food supply must be acquired during the brief Arctic summer. Many species found in the Beaufort and Chukchi Seas are at the northern limits of their range. Subsistence fishing has a long history in the region (commercial fishing occurred infrequently in the past). Cumulative impacts result from activities that generate lethal or sublethal impacts to individuals as well as the loss or degradation of fish habitat. Cumulative impacts result from OCS and non-OCS activities that generate lethal or sublethal impacts to individuals as well as the loss or degradation of fish habitat. Ongoing and future actions/trends that affect fish include oil and gas development in State and Federal waters, noise, dredging operations, and the potential effects of climate change such as the loss of sea ice, habitat alteration, and changes in fish productivity and community structure. Cumulative impacts on fish in Arctic waters are considered to be **moderate** to **major**.	The incremental contribution of routine Program activities to these impacts (primarily as a result of disturbance affecting demersal fishes) would be **negligible** to **small**, with the severity of impacts generally decreasing with distance from the disturbance (and a **negligible** contribution to impacts on threatened or endangered fish species). The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on fish would be **negligible** to **medium**, depending on the location, timing, duration, and volume of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range up to **moderate** if it were to occur. Impacts would be greatest if oil were to reach intertidal habitats.

TABLE 4.6.6-3 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Lower Trophic Levels and Invertebrates	Invertebrates (animals without a backbone) occur in various intertidal and deepwater habitats in the Beaufort and Chukchi Seas. Benthic invertebrates are predominantly echinoderms, polychaetes, sponges, anemones, bivalves, gastropods, and bryozoans. The most common water column macroinvertebrates in the Arctic region are the copepods. Larger invertebrates tend to be sparse in much of the Beaufort Sea relative to the Chukchi Sea, where echinoderms, crabs, and shrimp are more abundant. Zooplankton productivity is highly seasonal. At the lowest trophic levels, microbes such as bacteria and protists are important in Arctic waters for breaking down and recycling nutrients and organic matter. Cumulative impacts on invertebrates and lower trophic organisms result from activities that generate lethal or sublethal impacts to individuals as well as habitat loss or degradation. Cumulative impacts result from OCS and non-OCS activities that generate lethal or sublethal impacts to individuals as well as habitat loss or degradation. Ongoing and future actions/trends that affect invertebrates include oil and gas development in State and Federal waters, dredging, trawling, and the potential effects of climate change such as the loss of sea ice, changes in invertebrate habitat and changes in invertebrate productivity and community structure. Cumulative impacts on invertebrates in Arctic waters are considered to be **moderate** to **major**.	The contribution of the Program to cumulative impacts (mainly due to bottom-disturbing activities) would be **negligible** to **medium**, with the severity of the impacts generally decreasing with distance from bottom-disturbing activities. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on invertebrates would be **negligible** to **small**, depending on the location of the spill and the season in which the spill occurred. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE would also depend on these factors, and could range up to **moderate** if they were to occur.

TABLE 4.6.6-3 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Areas of Special Concern	The Alaska National Interest Lands Conservation Act of 1980 designated certain public lands in Alaska as National Parks, Wildlife Refuges, Wild and Scenic Rivers, and as designated for the National Wilderness Preservation and National Forest Systems. Some of these occur in the Arctic region. Other Areas of Special Concern include MPAs; there are no MUAs, National Estuarine Research Reserves, National Estuary Program Areas, or NOAA-designated HCAs in or adjacent to the Beaufort Sea or Chukchi Sea Planning Area. Cumulative impacts on these resources result from activities that could potentially cause damage to or degradation of fauna or habitats within these areas. Ongoing and future activities or trends that affect Areas of Special Concern in or near Arctic waters include fishing, diving, dredging operations, marine vessel traffic (and wakes), tankering, trash and debris accumulation (from various sources), onshore infrastructure (e.g., roads and vehicle traffic), and oil and gas development and infrastructure (e.g., pipeline landfalls and onshore facilities). Cumulative impacts on Areas of Special Concern in Arctic waters are considered to be **negligible** to **moderate**. The impacts of activities taking place within the Areas of Special Concern located onshore, such as National Parks and National Forests, are regulated through permitting processes.	Routine operations Routine operations under the Program could result in **negligible** to **medium** incremental increases in effects on national parks and wildlife refuges. Expected oil spills (most of which are less than 1,000 bbl) that occur during the Program could result in a **negligible** to **small** incremental contribution to cumulative impacts on Areas of Special Concern, depending on spill frequency, location, and volume; the type of product spilled; weather conditions; effectiveness of cleanup operations; and other environmental conditions at the time of the spill. Large spills (1,000 bbl and greater) or an unexpected, low-probability CDE in areas adjacent to the National Parks and NWRs, whether from OCS or non-OCS sources, would also depend on these factors, and could result in **moderate** impacts if they were to occur. Such spills could negatively impact coastal habitats and fauna, and could also affect subsistence uses.
Population, Employment, and Income	The population in the Beaufort Sea and Chukchi Sea Planning Areas is concentrated in Barrow. It increased at an average annual rate of 3.6% between 1980 and 1990, and 2.1% between 1990 and 2000; it decreased by 1.0% between 2000 and 2009. The components of population increase include the natural increase due to births and net positive domestic migration; the population trend is uncertain over the next 50 yr and will likely depend on the availability of jobs. Most communities in the borough have a high percentage of American Indian or Alaska Natives. Cumulative impacts of future OCS program and ongoing and future non-OCS program activities	The Program would add to beneficial impacts. The incremental contribution of routine operations under the Program is expected to be **small**, however, because the added employment demands are less than 10% of total Alaska employment. The incremental contribution of expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program would be **negligible** to **small** relative to those associated with future OCS program and ongoing and future non-OCS program activities. Large spills (1,000 bbl or greater) or an unexpected CDE could result in

TABLE 4.6.6-3 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Population, Employment, and Income (Cont.)	would be considered **beneficial** because these activities would increase employment and earnings in the region over the next 40 to 50 yr (although rural Alaskan employment in the petroleum industry, especially among Alaska Natives, would likely remain relatively low).	**minor** to **moderate** impacts. In the short-term, impacts of a CDE could be major as a result of lost employment, income, and property value; increased traffic congestion; increased cost of service provision; and possible shortages of commodities or services.
Land Use and Infrastructure	Land use in much of the Arctic region is not intense, with oil and gas-related development (onshore and offshore in State waters) and subsistence being the predominant uses. There are only a few small communities in the area, the largest of which is Barrow. Barrow is the economic, transportation, and administrative center for the North Slope Borough. Transportation-related infrastructure is minimal, but concentrated in the Prudhoe Bay oil field area. Marine shipping to North Slope communities is by barge and by lightering of cargo to shore because of the shallow coastal waters and the lack of dredging and heavy-lift equipment. Paved and unpaved roads are generally limited to the area within communities. During the winter, many residents travel by snowmobile. Airports and related service facilities are also limited. Most of the oil and gas-related infrastructure in the Arctic region is along the Beaufort Sea coastline. The Prudhoe Bay/Kuparuk oil field infrastructure is served by about 480 km (300 mi) of interconnected gravel roads, 640 km (400 mi) of pipeline routes, and related processing and distribution facilities. Cumulative impacts on land use and infrastructure result from demands on roads, utilities, and public services and the need to develop additional onshore facilities to accommodate ongoing and future activities in the region. Oil spill response also places stresses on community infrastructure and increases traffic in the affected area. Cumulative impacts on land use and onshore resources could range from **minor** to **major**, depending on the nature and location of demands.	The incremental contribution of routine operations under the Program to cumulative impacts in the Arctic region would be **small** to **medium** because of land use changes needed for new onshore pipeline construction and transportation network. Land use–related impacts resulting from expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program include stresses of spill response on community infrastructure, increased traffic in the response area (both onshore and offshore), and temporary restricted access to affected lands (while cleanup is conducted). Such spills would result in a **small** incremental contribution to cumulative impacts on land use and existing infrastructure. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in **moderate** to **major** impacts if they were to occur.

TABLE 4.6.6-3 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Commercial and Recreational Fisheries	There currently is no commercial fishing and little data on recreational fishing in the Beaufort or Chukchi Seas (although the North Pacific Fishery Management Council has concluded that there are few recreational fisheries in these waters). Sport fishing likely occurs in coastal areas of larger population centers such as Barrow. Subsistence fishing is widespread in coastal areas of the Arctic; fisherman target Pacific herring, Dolly Varden char, whitefish, Arctic cod, and sculpin. Given the importance of fishing to local communities in the Arctic region, the most important cumulative impacts would result from any activities that cause a decline in fish availability for subsistence harvest. The cumulative impacts on recreational (and subsistence) fisheries in Arctic waters are considered to be **moderate** to **major**.	The incremental contribution of routine Program activities to cumulative impacts would be **small**, since routine operations under the Program would not occur in the immediate area where fisheries are located. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on would be **medium**, depending on the location, timing, and volumes of spills (among other environmental factors). Small spills are unlikely to affect a large number of fish or have a substantial effect on fishing before dilution and weathering reduced concentrations of oil in the water. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be **moderate** if they were to occur.
Tourism and Recreation	Tour groups to the North Slope Borough make up most of the nonresidential recreational activity. Most visitors stay in Barrow or Deadhorse. Travel to these areas is primarily by air, although bus tours occasionally arrive via the Dalton Highway. Hikers and river rafters also visit the Arctic National Wildlife Refuge and other areas using scheduled or chartered airplanes for access. An increasing number of cruise ships are entering the Chukchi and Beaufort Seas. Cumulative impacts on tourism and recreation result from disruptions to land-based activities, increases in the trash and debris accumulation, and competition between workers and tourists for local services, such as air transport and hotel accommodations; these impacts are expected to be **moderate** to **major**.	The incremental contribution of routine operations under the Program to cumulative impacts would be **small**, with potential adverse aesthetic impacts on sightseeing, hiking, and rafting activities. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on would be **negligible** to **small**, depending on the size, location, and timing of the spill (being greatest if it occurred during the peak recreational season). Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could range from **minor** to **moderate** if they were to occur.

TABLE 4.6.6-3 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Sociocultural Systems	Most of the sparsely populated rural lands in the Arctic region are inhabited by indigenous Alaskans. Barrow is the largest permanent community on the North Slope and serves as the administrative and commercial hub of the region. The Alaska Natives living in communities along the coast of the Beaufort and Chukchi Seas are primarily Iñupiaq Eskimo. Alaska Native communities along the Arctic coast are heavily dependent on subsistence harvesting of sea mammals, fish, and terrestrial fauna. Enclaves of workers at Prudhoe Bay and nearby oil fields are employed by the oil and gas industry. They commute from mostly south central Alaska, Fairbanks, and States outside of Alaska. For the most part, these two communities (Alaska Native communities and worker enclaves) have had little interaction because of the physical distance that separates them. Cumulative impacts to sociocultural systems occur when ongoing and future actions (OCS and non-OCS program) cause changes in local populations and social institutions or when jobs are lost or created. Subsistence harvesting could also be affected by activities that affect marine fauna, such as increases in airborne or subsea noise (e.g., aircraft or marine vessel traffic, seismic surveys, drilling) or degradation of water quality (e.g., fuel or oil spills, chemical releases, or dredging operations that increase turbidity), or that necessitate changes in subsistence fishing practices. Cumulative impacts on sociocultural systems in the Arctic Planning Areas as a result of ongoing and future OCS and non-OCS activities and natural phenomena could be **moderate** over the next 40 to 50 yr.	The incremental contribution of routine operations under the Program to cumulative impacts would range from small to medium, especially if subsistence-related activities, central to the well-being of Alaska Natives who inhabit the area, are affected. Many of these potential effects are mitigatable. Onshore linear features (e.g., pipelines and roads) affect the migration patterns of terrestrial mammals. Because of the high level of dependence on subsistence harvesting, the incremental contribution of the Program to cumulative impacts on subsistence activities near the Beaufort and Chukchi Seas would be expected to be **small** to **medium**. Design stipulations and operational procedures could reduce the impact of onshore development. The incremental impacts of expected accidental spills (most of which are less than 1,000 bbl) associated with the Program on would be **small** to **medium**, depending on the location, volume, and timing (i.e., season) of the spill. Impacts associated with large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could be **major** if they were to occur, especially if they disrupt sea mammal harvest or resulted in the IWC reducing or eliminating whale quotas in the Alaska Arctic.
Environmental Justice	Environmental justice impacts occur when any activity or trend (OCS program or non-OCS program related) results in adverse health or environmental impacts that are significantly high and disproportionately affect minority and low-income populations. A large number of minority and low-income individuals are located in the Arctic region, although the number of low-income individuals does not exceed 50% of the total population (thus there is no low-income population in the region). Subsistence hunting and fishing	The incremental contribution of routine operations under the Program would be small, depending on the proximity of onshore pipelines and offshore infrastructure to communities and their subsistence harvest areas, but are not expected to cause additional environmental justice concerns; their contribution to cumulative impacts on low-income and minority populations therefore would be **small**.

TABLE 4.6.6-3 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Environmental Justice (Cont.)	are an important part of the economies in Arctic communities. Cumulative impacts on local communities could result from changes in the proximity of onshore oil and gas infrastructure and to marine vessel and aircraft traffic. Ongoing and future oil and gas development would continue to affect populations in some regions along the Beaufort and Chukchi Seas by increasing the proximity to existing oil and gas infrastructure and associated health, environmental, and visibility impacts. Given these factors, cumulative impacts on local populations are considered to be **moderate** to **major**.	The incremental contribution of expected accidental oil spills (most of which are less than 1,000 bbl) associated with the Program would be **negligible** to **small**. Large spills (1,000 bbl or greater) or an unexpected, low-probability CDE could result in **moderate** to **major** impacts on the Alaska Native population, especially if subsistence resources were diminished or tainted as a result of the spill. Mitigation measures, cooperative agreements between Native and industry groups, and government-to-government consultations are designed to limit the effects from oil spills and routine operations.
Archaeological and Historical Resources	At the height of the late Wisconsinan glacial advance, about 19,000 years ago, the global sea level was much lower than at present and created land bridges between the North American and Asian continents. During this time, large expanses of the OCS were exposed as dry land and shorelines shifted depending on the location of ice. These relict shorelines (and other relevant landforms) are currently inundated. Some studies indicate that ice gouging may have altered the seafloor in the Arctic region, removing all archaeological evidence of the first peoples; however, the extent of the disturbance is not known. To date, more studies have been done in the Beaufort Sea, but more will be needed to fully understand the potential for significant artifacts to be present. Numerous shipwrecks have been documented in the Beaufort and Chukchi Seas. Most of these were associated with commercial whaling which occurred in the region between 1849 to 1921 and are likely to be in State waters. There are significant onshore historic sites in the Arctic region; these include Cold War era outposts, radar stations, and missile sites, and the Ipiutak Site National Historic Landmark at Point Hope among others. Cumulative impacts to these resources	Routine operations could affect significant archaeological and historic resources, especially offshore resources, with construction activities such as platform and pipeline construction potentially damaging or destroying affected resources. Onshore impacts include resource damage or loss, or visual effects and are possible from pipeline landfall, onshore pipeline, and road construction. Anchor drags could adversely affect shipwrecks. The incremental contribution of routine operations under the Program could be **negligible** to **large**, depending on the presence of significant archaeological or historic resources in the area of potential effect. Archaeological surveys that would identify significant cultural resources to be avoided could reduce these impacts. The incremental contribution of oil spills, whether expected oil spills (most of which are less than 1,000 bbl) to cumulative impacts on archaeological and historical resources in the Arctic region would be **small** to **large**, depending on the presence of significant resources in the area of potential effect and the spill location, timing, duration, and size. Impacts associated with an unexpected, low-probability CDE would also depend on these factors, and could range from **minor** to **major** if it were to occur.

TABLE 4.6.6-3 (Cont.)

	Anticipated Trends and Cumulative Impacts	Contributions of Program to Cumulative Impacts
Archaeological and Historical Resources (Cont.)	occur when operations involving bottom-disturbing activities (e.g., channel dredging) come into physical contact with artifacts or their site context, or as a result of natural phenomena such as high-energy waves and currents, ice gouging, and thermokarst collapse. The cumulative impacts of future OCS and ongoing and future non-OCS activities are not currently known, but could range from **minor** to **moderate**, mainly because activities occurring on the OCS prior to USDOI's survey requirement, which went into effect in 1973, may already have affected (i.e., damaged or destroyed) significant sites.	

4.7 REFERENCES

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