3 AFFECTED ENVIRONMENT

3.1 INTRODUCTION

This programmatic environmental impact statement (PEIS) evaluates eight alternatives: the proposed action, six alternative actions, and a No Action Alternative. The proposed action would establish a 2012-2017 Outer Continental Shelf (OCS) Oil and Gas Leasing Program (the Program) that includes three planning areas in the Gulf of Mexico (GOM) (the Western and Central GOM Planning Areas, as well as a small portion of the Eastern GOM Planning Area), two planning areas in the Arctic (the Beaufort and Chukchi Sea Planning Areas), and Cook Inlet in south central Alaska. Each of the alternatives is identical to the proposed action, except that one of the six planning areas included in the proposed action is deferred from consideration for the duration of the Program; a different planning area is deferred in each alternative. Chapter 3 describes the nature and condition of natural, physical, and socioeconomic resources in these planning areas that may be affected by the Program in these planning areas.

Information regarding each resource presented in Chapter 3 and evaluated for potential impacts in Chapter 4 is presented as follows. Each resource is presented separately. For each resource, the nature and condition of the resource is provided in three groupings, based on the geographic settings of the planning areas included in the proposed action — the GOM, Cook Inlet, and Arctic Alaska. As applicable, the effects of the Deepwater Horizon spill (DWH event) on the baseline conditions of a resource are discussed, and a description is provided of potential changes in baseline conditions from climate change over the 40- to 50-yr expected period of oil and gas activities anticipated for the Program. Some information is currently unavailable, particularly with regard to affected environmental baseline changes; however, this information is not crucial in order to make a reasoned choice among alternatives at this programmatic stage (see Section 1.4.2, Incomplete and Unavailable Information).

3.2 MARINE AND COASTAL ECOREGIONS

With the exception of the Cook Inlet Planning Area, the planning areas being considered for leasing under the Program cannot be readily delineated from adjacent planning areas on the basis of clear, distinct geographical or physical boundaries. Except for topographical features associated with coastlines, the boundaries of the OCS planning areas are artificial administrative boundaries on the open oceans (Figure 3.2-1) drawn with no intended relationship to underlying ecologic, oceanographic, or other processes affecting environmental conditions on the OCS and in adjacent coastal areas. Many natural resources, as well as physical features such as currents, freely cross the boundaries of adjacent planning areas, the boundaries between the OCS and adjacent marine waters seaward of the United States Exclusive Economic Zone (EEZ), and the boundaries between coastal waters shoreward of the administrative boundary that separates State and Federal jurisdiction. As a consequence, it would be too restrictive to describe many of the natural and physical resources, or to discuss the potential effects of oil and gas development on those resources, solely on a one-by-one planning area basis. Instead, the PEIS uses marine and coastal ecoregions as a spatial framework to incorporate the areas potentially affected directly by

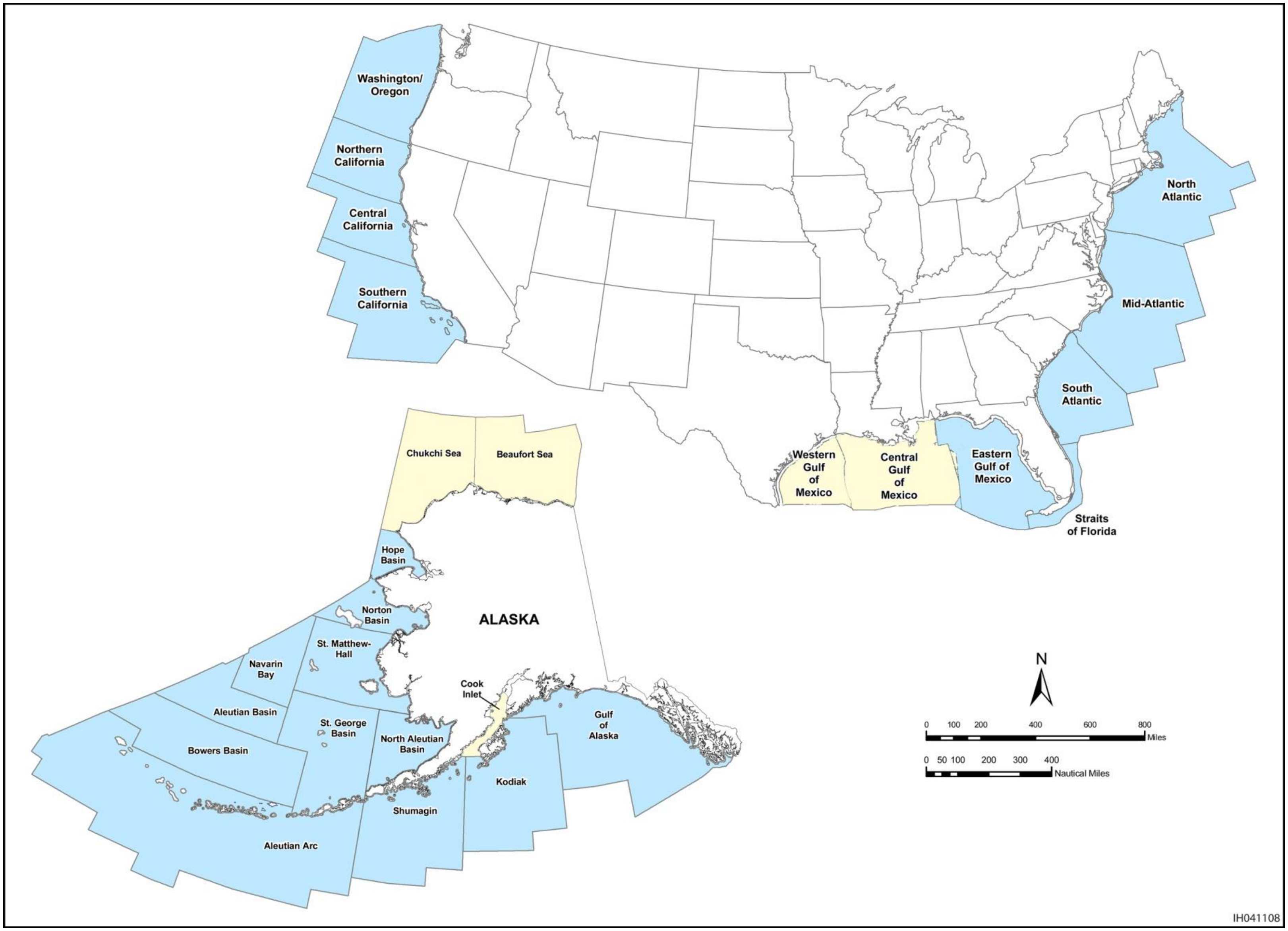

FIGURE 3.2-1 OCS Planning Areas

OCS activities within planning area boundaries as well as areas beyond the planning areas that could be affected by OCS impacts through the action of ecological and physical processes that operate at an ecoregional scale.

An ecoregion is an ecologically and geographically defined area that contains characteristic geographically distinct assemblages of natural communities and species which tend to be distinct from those in other ecoregions (McMahon et al. 2001; Omernik 2004; Bailey 2005). In terrestrial systems, individual ecoregions are associated with characteristic combinations of land forms and geologic, hydrologic, and climatic conditions (Omernik 1987, 2004). Many Federal agencies and private organizations manage terrestrial resources using land classifications based on the ecoregion concept (e.g., see http://www.fs.fed.us/rm/ecoregions).

The PEIS uses marine and coastal ecoregions to define areas being considered in this and subsequent chapters. Marine ecoregions are defined according to the boundaries of Large Marine Ecosystems (LMEs) developed by the National Oceanic and Atmospheric Administration (NOAA) (LMEW 2009). In particular, this PEIS uses the boundaries of the GOM, Chukchi Sea, Beaufort Sea, and Gulf of Alaska LMEs to define the marine areas that include the OCS Planning Areas considered in Chapters 3 and 4. NOAA developed the LME concept and established the LME program in 1984 as a tool for enabling an ecosystem-based approach to transboundary ecosystem-based science and management. The PEIS uses the LME boundaries to define the areas of analytic interest in the document based on ecologically important distinctions rather than political or administrative boundaries. The PEIS also uses the marine and coastal ecoregions developed by the Commission for Environmental Cooperation (CEC) for North America (Wilkenson et al. 2009) to subdivide the areas defined by the LME boundaries into more localized regional distinctions, where appropriate. The coastal ecoregions are also used to characterize coastal and nearshore areas.

For many environmental resources addressed in this PEIS, the descriptions of the affected environment, as well as the evaluations of possible environmental consequences associated with oil and gas activities, use locations within ecoregions rather than individual OCS planning areas as a spatial reference. The PEIS adopts this approach to facilitate a broader scale ecosystem perspective on the analysis of potential environmental effects of oil and gas activities on the OCS following lease sales under the Proposed Action Alternative. A narrowed planning area perspective is more appropriate for an EIS prepared at the lease sale or project development stages of oil and gas activities on the OCS. Adoption of a broader ecoregional perspective is intended to facilitate the National Environmental Policy Act of 1969 (NEPA) process of tiering by which programmatic analyses are intended to inform and provide context for the more geographically focused and detailed environmental analyses and reviews that will occur later under the Program.

The coastal and marine ecoregions identified in this section make up areas of interest for this PEIS. The evaluations and analyses in this and subsequent chapters will consider the potential effects of oil and gas activities on the OCS within these broad areas. The geographic scope of these analyses will vary depending on the issues being considered. Examples of specific areas of interest that could be applied to different analyses include:

1. Individual OCS Planning Areas and nearby coastal and marine areas where program-related activities could occur and directly affect local natural resource.
   - *Example Issue*: The effects of OCS-related bottom-disturbing activities (such as pipeline trenching) on benthic habitats.

2. Areas outside of OCS Planning Areas where environmental impacts may extend beyond program area boundaries through the action of ecoregion-scale physical and ecological processes.
   - *Example Issue*: Population effects on marine fauna from a very large oil spill as it is transported from a release location by ocean currents and winds.

3. Areas outside the OCS Planning Areas that contribute to and affect marine and coastal environmental baseline conditions and would need to be considered in the analysis of cumulative effects.
   - *Example Issue*: The influence of the Mississippi River drainage basin and discharge on water quality and coastal and marine habitats in the GOM.

3.2.1 Large Marine Ecosystems

LMEs are relatively large regions of coastal oceans of approximately 200,000 km^2 (77,220 mi^2) that include waters from river basins and estuaries to the seaward boundaries of continental shelves and/or seaward margins of coastal currents and water masses. They are characterized on the basis of ecological (as opposed to political) criteria, including bathymetry, hydrography, productivity, and trophic relationships. Sixty-four distinct LMEs have been delineated around the coastal margins of the Atlantic, Pacific, Arctic, and Indian Oceans (Sherman et al. 2007; LMEW 2009).

The OCS Planning Areas being considered for leasing under the Program addressed in this PEIS occur within four LMEs. The Cook Inlet Planning Area occurs in the Gulf of Alaska LME #2 (Figure 3.2.1-1); the Beaufort Sea Planning Area occurs within the Beaufort Sea LME #55; and the Chukchi Sea Planning Area occurs within the Chukchi Sea LME #54 (Figure 3.2.1-2). The Western, Central, and Eastern GOM Planning Areas occur within the GOM LME #5 (Figure 3.2.1-3). For the purposes of this PEIS, the LMEs are used solely to provide a spatial context for the planning areas considered for leasing in the Program. The following sections provide brief summary descriptions of these LMEs.

3.2.1.1 Gulf of Alaska Large Marine Ecosystem

The Gulf of Alaska LME lies along the southern coast of Alaska and the western coast of Canada (Figure 3.2.1-1), and has an area of approximately 1.5 million km^2 (569,450 mi^2), of which about 1.5% (22,500 km^2 [8,540 mi^2]) is protected (Aquarone and Adams 2009). The Cook Inlet Planning Area occupies about 1.5% of the Gulf of Alaska LME. This LME is

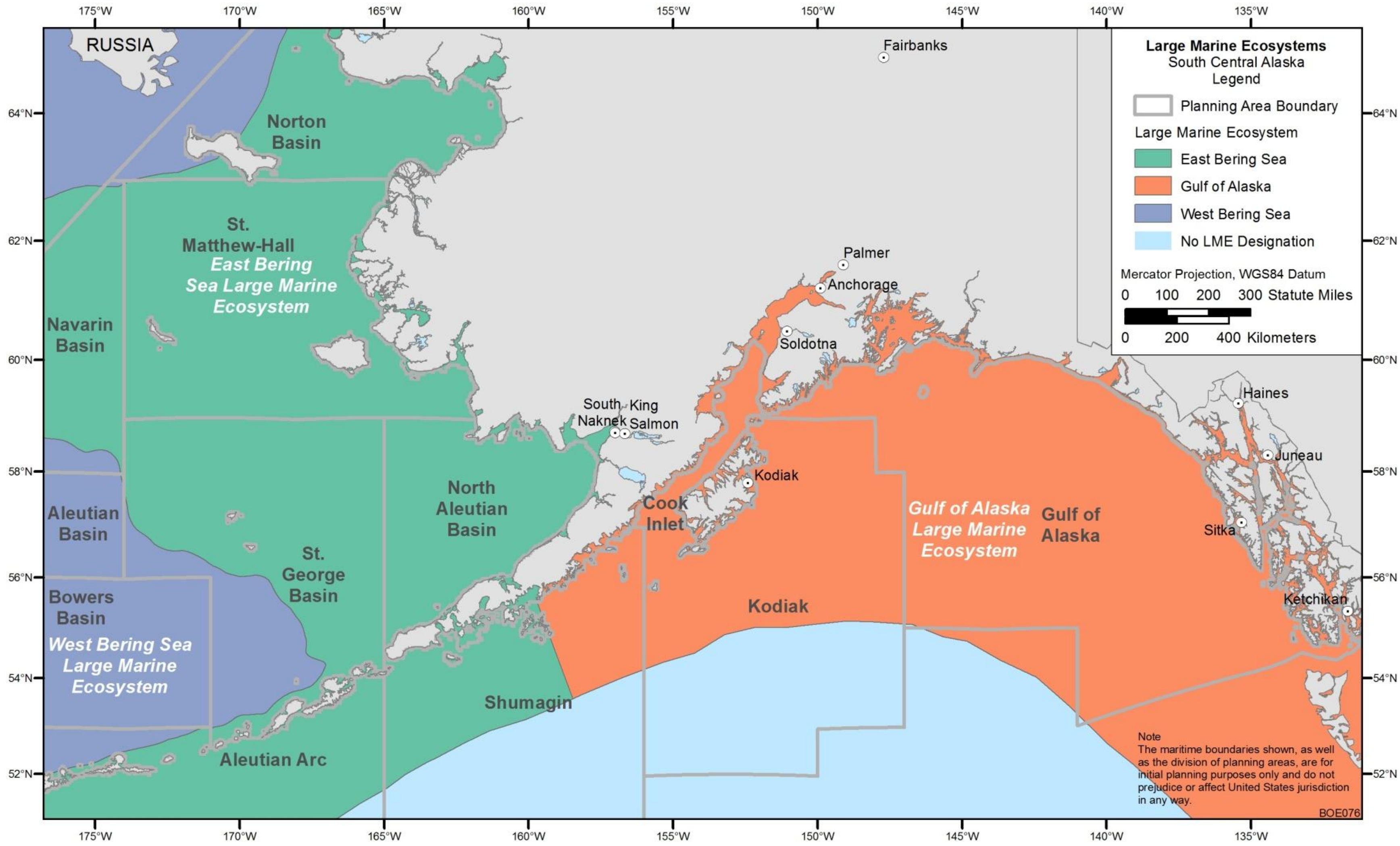

FIGURE 3.2.1-1 Large Marine Ecosystems for Southern Alaska (modified from Wilkenson et al. 2009)

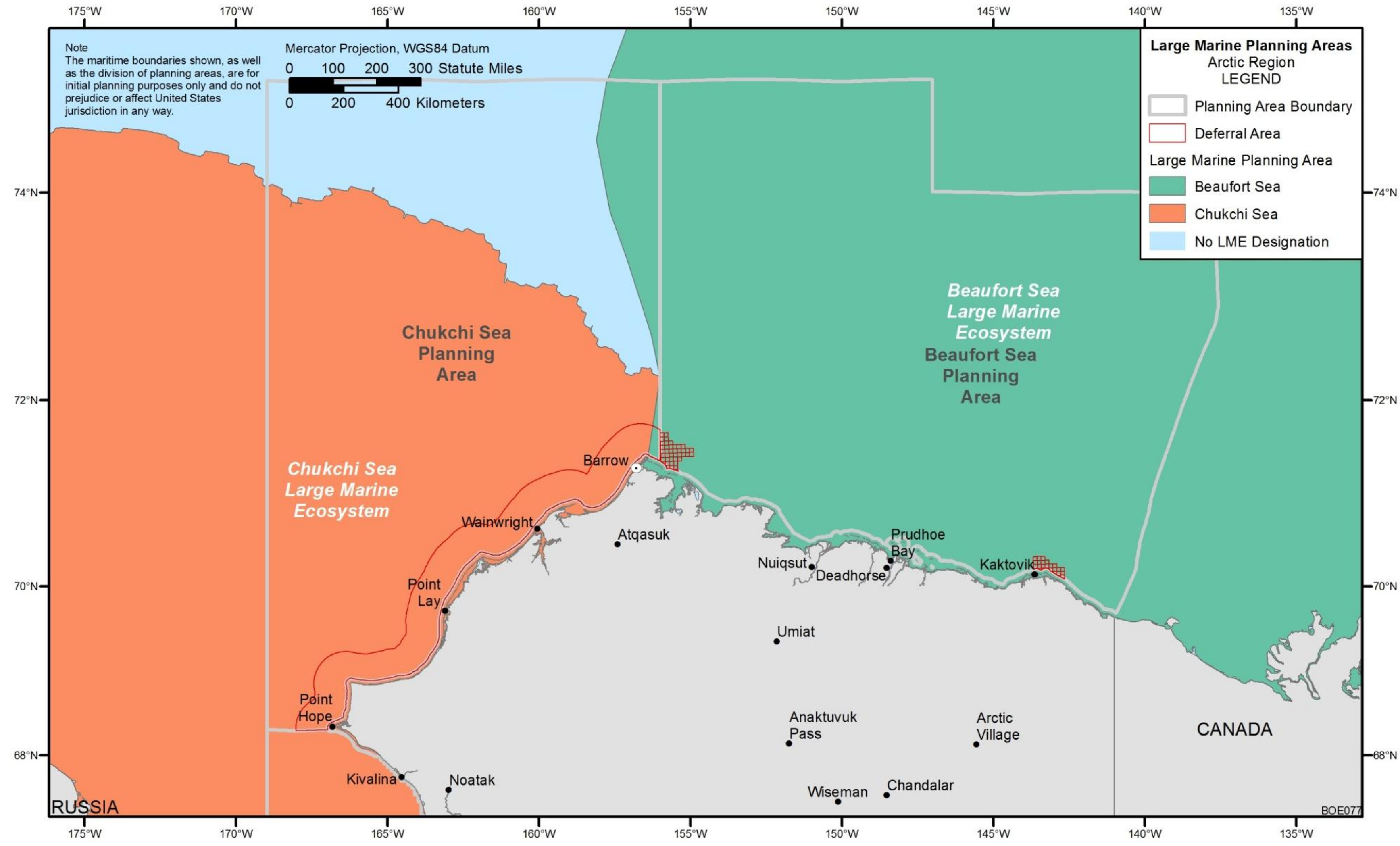

FIGURE 3.2.1-2 Large Marine Ecosystems for Arctic Alaska (modified from Wilkenson et al. 2009)

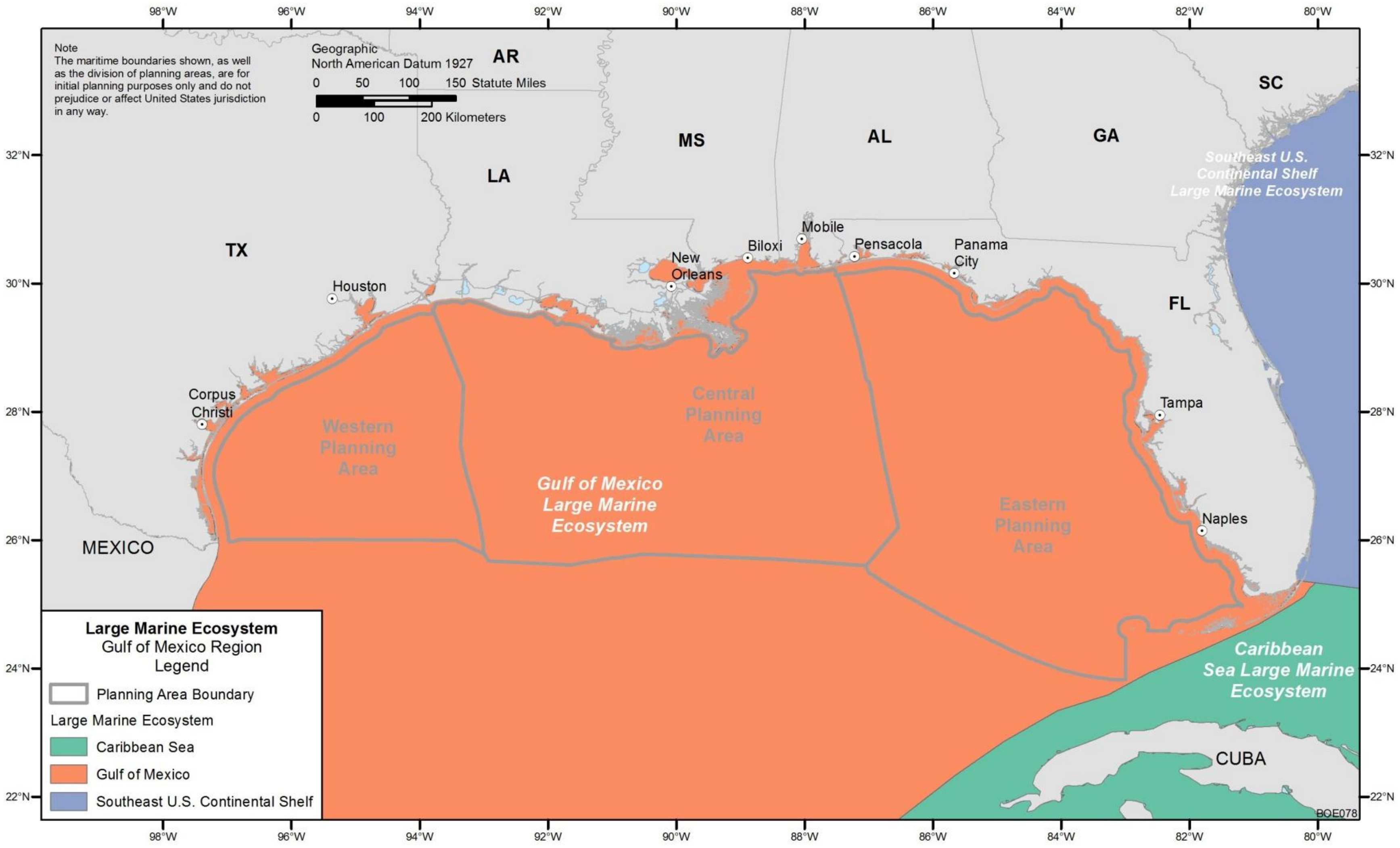

FIGURE 3.2.1-3 Large Marine Ecosystems for the GOM (modified from Wilkenson et al. 2009)

separated to the west from the East Bering Sea LME by the Alaska Peninsula and to the south borders the California Current LME. There are 14 estuaries and river systems, including the Stikine and Copper Rivers, Cook Inlet, and Prince William Sound in the Gulf of Alaska LME.

3.2.1.2 Beaufort Sea Large Marine Ecosystem

The Beaufort Sea LME occurs along the Arctic coast of Alaska and northwestern Canada (Figure 3.2.1-2) and covers about 770,000 km^2 (297,300 mi^2), of which about 0.02% (154 km^2 [59 mi^2]) is protected (Belkin et al. 2009). The Beaufort Sea Planning Area occupies about 34% of the Beaufort Sea LME, and future oil and gas leasing activities are anticipated to be restricted to the coastal shelf areas of this LME. The Beaufort Sea LME is characterized by an Arctic climate with major annual and seasonal changes, and historically is ice-covered much of the year.

3.2.1.3 Chukchi Sea Large Marine Ecosystem

The Chukchi Sea LME is located off of Russia's East Siberian coast and the northwestern coast of Alaska (Figure 3.2.1-2). This LME is a relatively shallow marginal sea with a surface area of about 776,643 km^2 (299,820 mi^2), of which about 5.4% (42,000 km^2 [16,190 mi^2]) is protected (Heileman and Belkin 2009). The Chukchi Sea Planning Area occupies about 33% of this LME. This LME is characterized by an Arctic climate with major seasonal and annual changes, in particular, the annual formation and deformation of sea ice.

3.2.1.4 Gulf of Mexico Large Marine Ecosystem

The GOM LME is a deep marginal sea bordered by Cuba, Mexico, and the United States (Figure 3.2.1-3). The GOM is the largest semi-enclosed coastal sea in the western Atlantic, encompassing about 1,500,000 km^2 (579,150 mi^2) (Heileman and Rabalais 2009). The Central GOM Planning Area comprises about 18%, the Western GOM Planning Area about 8%, and the Eastern GOM Planning Area about 17% of the total area of this LME. About 1.6% (24,000 km^2 [9,090 mi^2]) of the GOM LME is protected, and it contains about 0.5% of the world's coral reefs. The continental shelf comprises about 30% of this LME, and the coastal areas contain more than 750 estuaries, bays, and sub-estuaries that are associated with 47 major estuaries (USEPA 2008; Heileman and Rabalais 2009). This LME is strongly influenced by freshwater input from rivers (especially the Mississippi River), which accounts for about two-thirds of the flows into the GOM (Figure 3.2.1-4), and tropical storms (i.e., hurricanes) (Figure 3.2.1-5) are a major climatological feature of the area (Heileman and Rabalais 2009). Important hydrocarbon seeps occur in the southernmost and northern portions of the LME.

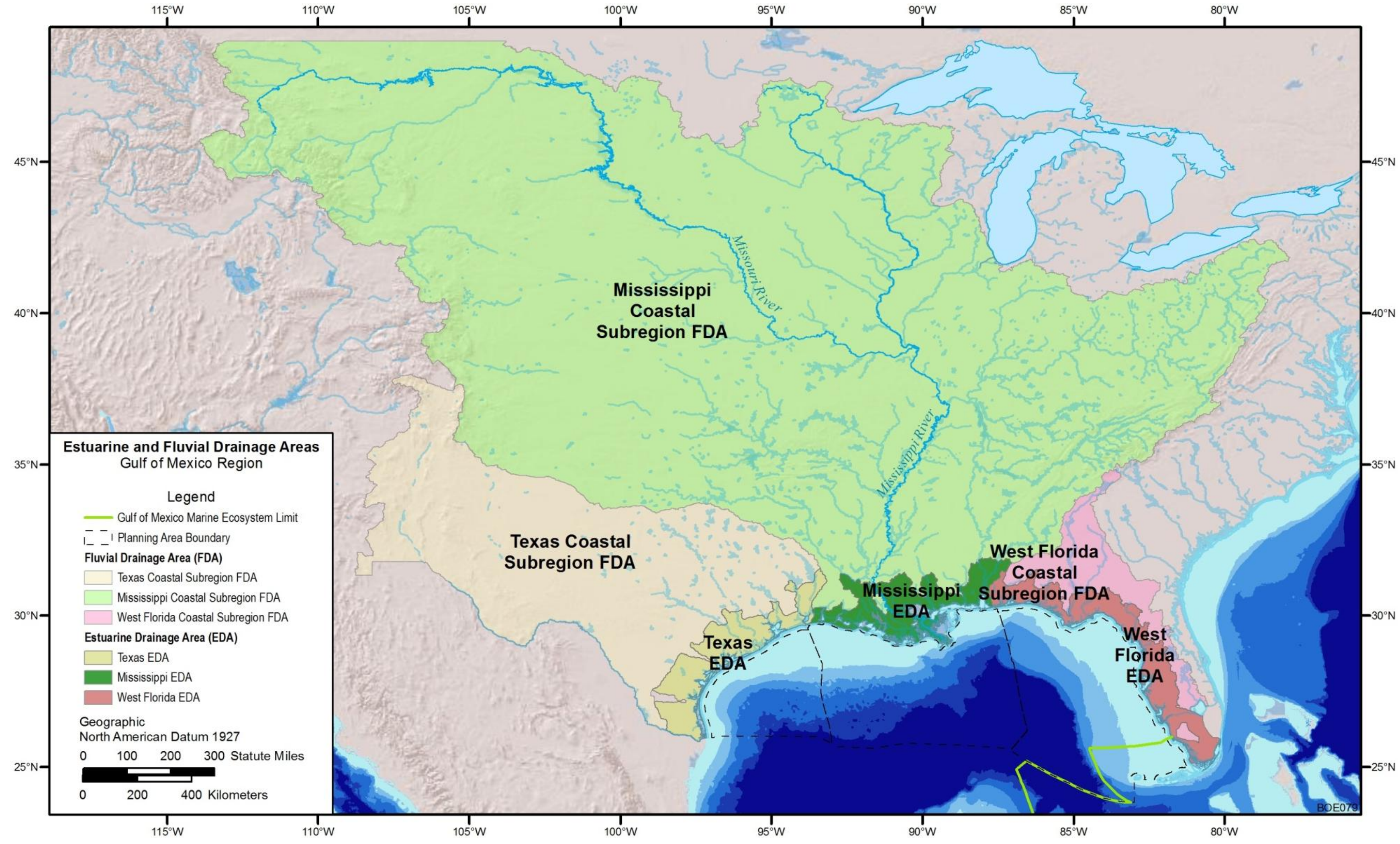

FIGURE 3.2.1-4 Estuarine and Fluvial Drainage Areas of the Northern GOM

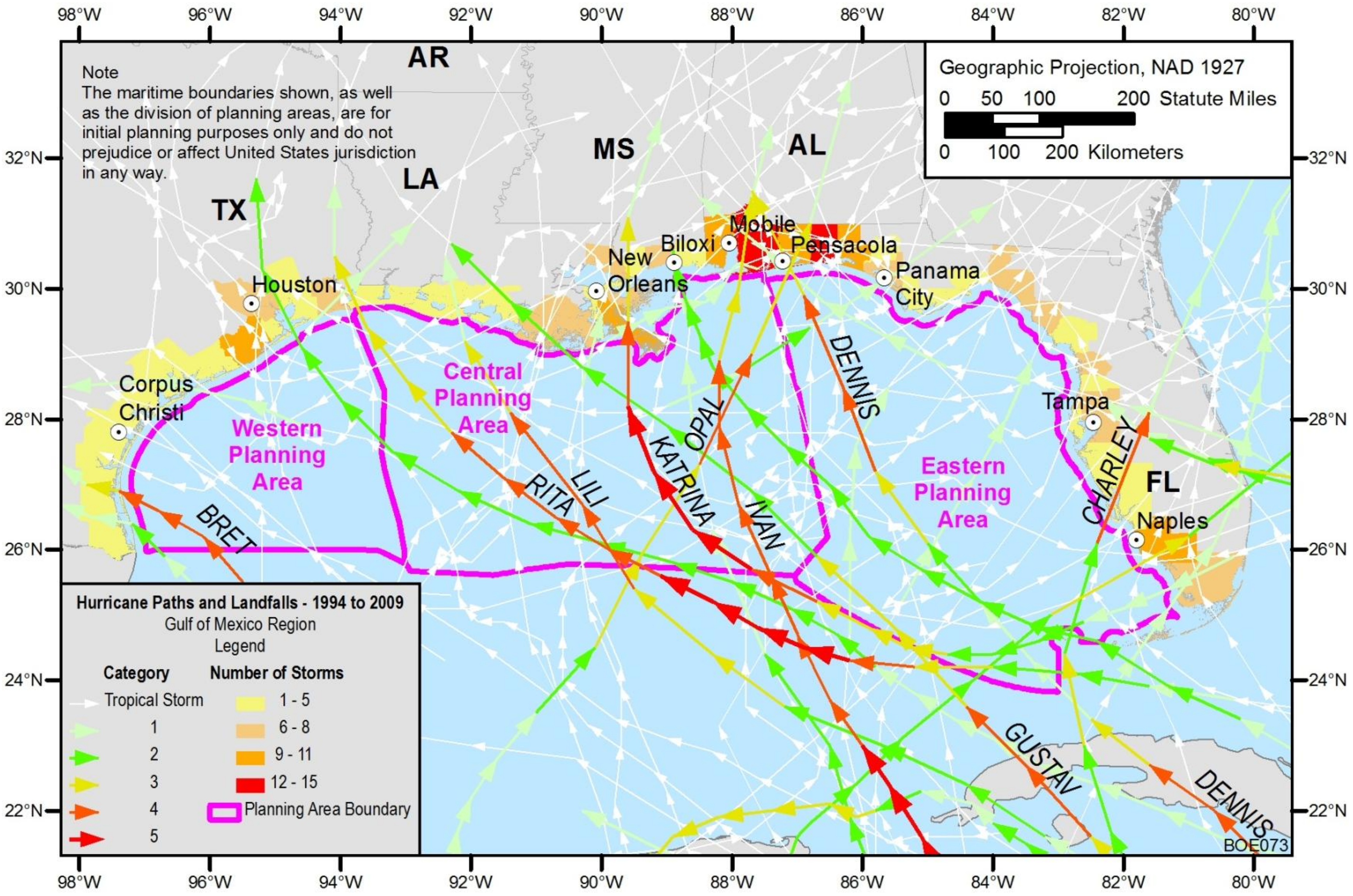

FIGURE 3.2.1-5 Tropical Storm Paths in the Northern GOM

3.2.2 Marine and Coastal Ecoregions of North America

As shown in Figures 3.2.1-1, 3.2.1-2, and 3.2.1-3, the four LMEs that encompass the OCS Planning Areas addressed in this PEIS are very large, and reflect marine ecosystem differences at their largest scale. Thus, their use in assessing the potential effects of oil and gas development activities to marine resources within individual LMEs would be similarly restricted to very large scale evaluations. The LMEs may be further examined on finer scales that distinguish ecosystems on the basis of larger physiographic features (e.g., continental slope, shelf, and abyssal plain) as well as on more locally significant conditions (such as local water characteristics, regional landforms, and biological communities). One such sub-LME classification has been developed by the CEC, a tri-national partnership comprised of government agencies, organizations, and researchers from the United States, Canada, and Mexico (see http://www.cec.org). The CEC has classified North American oceanic and coastal waters into 24 marine ecoregions according to oceanographic features and geographically distinct assemblages of species (Wilkinson et al. 2009). The Level II and Level III marine ecoregions developed by the CEC for North America are used in this PEIS to help identify and describe the marine ecosystems and resources that occur in the OCS Planning Areas that may be affected by OCS oil and gas activities under the Program.

Level II ecoregions capture the division between neritic (coastal areas out to a depth of about 200 m [600 ft]) and oceanic areas, and are determined by large-scale physiography (continental shelf, slope, and abyssal plain and also areas of islands and major trenches, ridges, and straits). The Level II classifications reflect the importance of depth as a determinant of benthic marine communities as well as the importance of major physiographic features in determining current flows and areas of upwelling. The Level III ecoregions reflect differences within the neritic areas, and are based on more locally significant variables such as local characteristics of the water mass, regional landforms, and biological community type. The Level III ecoregions are limited to the continental shelf, as only these areas have sufficient information to support finer-scale ecoregion delineations (Wilkinson et al. 2009). The CEC Level II and III marine ecoregions relevant to this PEIS are shown in Figure 3.2.2-1 for the GOM Planning Areas, Figure 3.2.2-2 for the Cook Inlet Planning Area, and Figure 3.2.2-3 for the Chukchi and Beaufort Seas Planning Areas, and are discussed below.

Other efforts have been directed toward developing ecoregions for coastal areas within LMEs (e.g., Yanez-Arancibia and Day 2004). The coastal ecoregions of Yanez-Arancibia and Day (2004) and the CEC marine ecoregions are used together in this PEIS to present an integrated ecosystem-based view of the areas that could be affected by oil and gas activities on the OCS.

The following sections identify the CEC ecoregions associated with each of the OCS Planning Areas addressed in this PEIS. Descriptions of the physical environment and ecological resources in these ecoregions are discussed in the subsequent resource-specific descriptions of the affected environment later in this chapter.

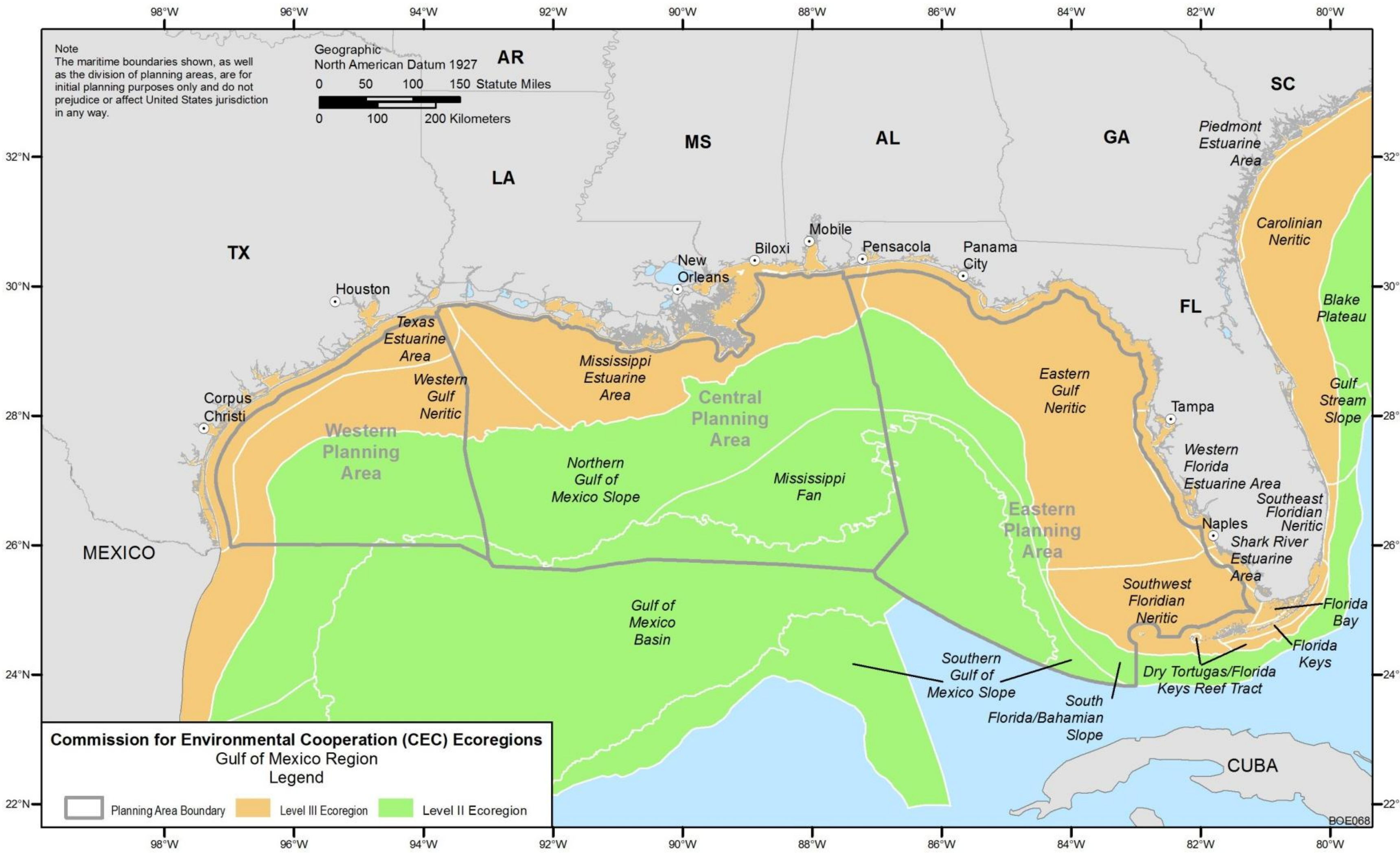

FIGURE 3.2.2-1 CEC Level II and III Marine Ecoregions of the Northern GOM

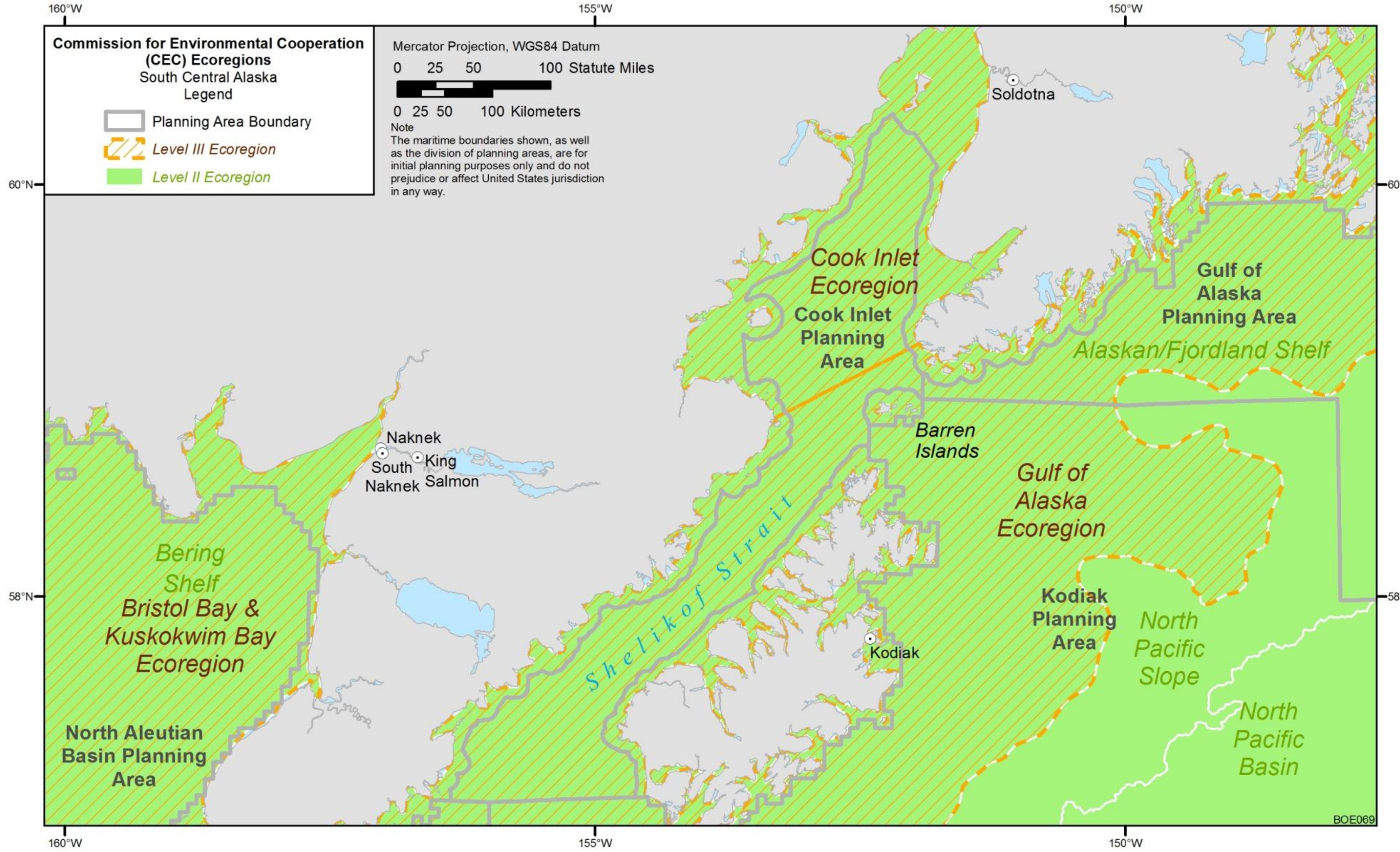

FIGURE 3.2.2-2 CEC Level II and III Marine Ecoregions of South Central Alaska

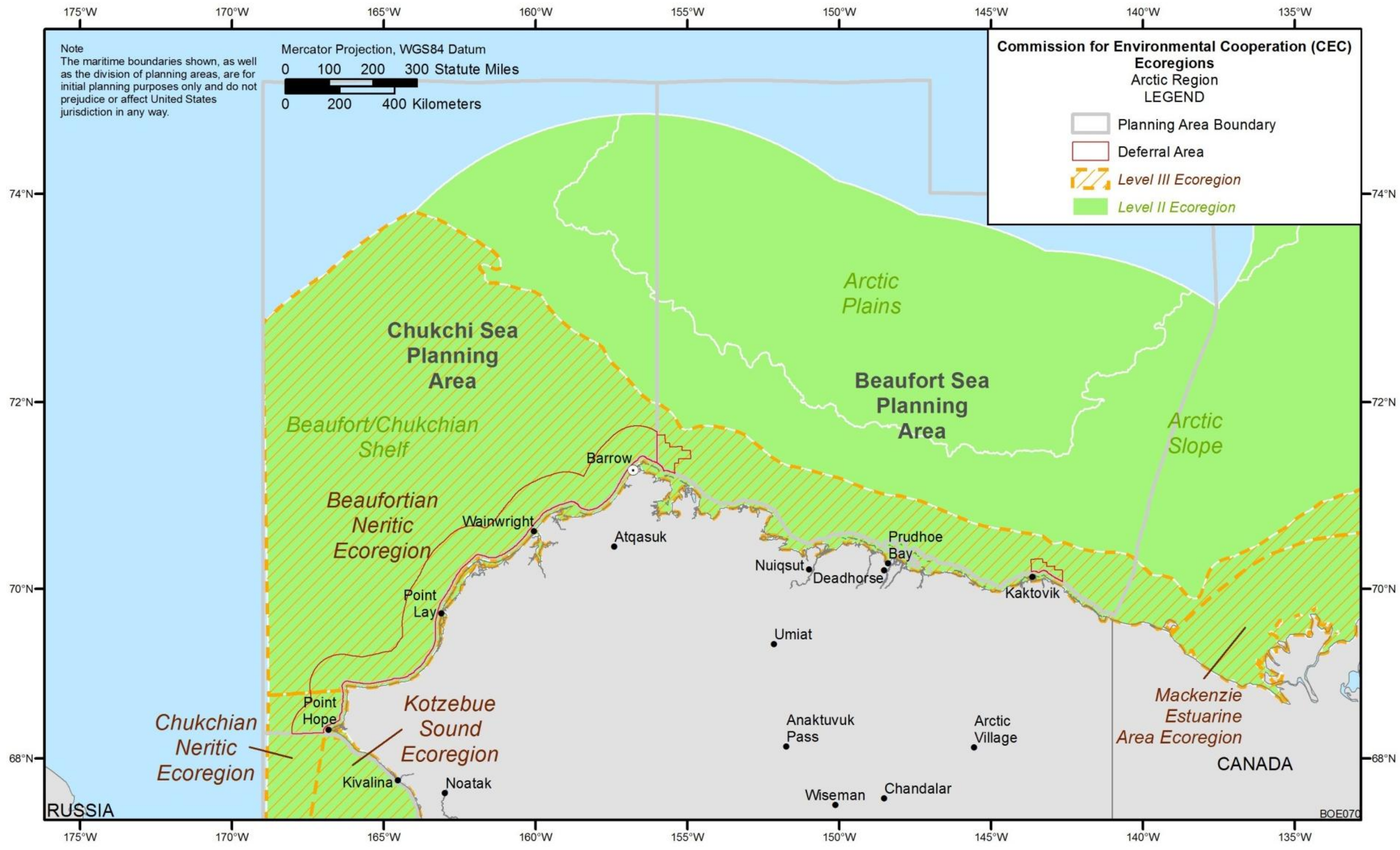

FIGURE 3.2.2-3 CEC Level II and III Marine Ecoregions of Northern Alaska

3.2.3 Ecoregions of the Northern Gulf of Mexico

As previously discussed, the GOM Planning Areas addressed in this PEIS occur within the GOM LME (see Section 3.2.2), which can be subdivided into finer-scale marine ecoregions as described by the CEC and others (Wilkenson et al. 2009). On a geomorphological basis, the GOM Planning Areas include the Northern GOM Shelf and Slope, the Mississippi Fan, and the GOM Basin Ecoregions (Figure 3.2.2-1) (Wilkinson et al. 2009). The following sections present brief overviews of these ecoregions, with more detailed discussions of physical and biological conditions and resources discussed in later sections.

3.2.3.1 Northern Gulf of Mexico Shelf Ecoregion

As indicated by its name, this ecoregion encompasses the continental shelf of the northern GOM and includes about half of the Western, Central, and Eastern GOM Planning Areas (Figure 3.2.2-1). This ecoregion varies in width across the three planning areas, extending as much as 250 km (155 mi) from the coastline in some areas, being narrowest in the vicinity of the Mississippi River Delta eastward to the Florida Panhandle. Water depth extends down to about 200 m (660 ft). Coastal areas of this ecoregion may be further delineated into three estuarine areas, the Texas, Mississippi, and Western Florida Estuarine Areas, and three neritic areas, the Western GOM, Eastern GOM, and Southwest Florida Neritic Areas (Figure 3.2.2-1). These estuarine areas contain as much as 60% of the tidal marshes of the United States and receive inputs from 37 major rivers. Freshwater input (with associated sediment loads) from three major estuarine drainage areas (Figure 3.2.1-4) strongly influences the nature and distribution of habitats and associated biota along the GOM coast.

The physiological and ecological conditions of the shelf in the central portion of the northern GOM are strongly influenced by the Mississippi River and its tributary, the Atchafalaya River (Wilkenson et al. 2009). Drainage from more than 55% of the conterminous United States enters the GOM from the Mississippi River, affecting water quality and substrates of this and other ecoregions (see Section 3.4.1). Increased nutrient and sediment loads from the Mississippi River result in the annual appearance of a large “dead zone” — an area of extremely low oxygen concentration.

Habitats include coastal lagoons and estuaries, tidal freshwater grasses, salt marsh, tidal freshwater marsh flats, intertidal scrub forest, beaches, and barrier islands. The nature and extent of these habitats and the biota they support vary, depending upon location (e.g., western Texas coastline vs. the Chenier Plain, Louisiana, vs. the west coast of central Florida).

3.2.3.2 Northern Gulf of Mexico Slope Ecoregion

This ecoregion extends from the edge of the Northern GOM Shelf Ecoregion to the start of the GOM Basin, with depths ranging from 200 to 3,000 m (660 to 9,800 ft) (Figure 3.2.2-1). This ecoregion extends through all three planning areas, comprising more than half of the

Western and Central GOM Planning Areas and about a quarter of the Eastern GOM Planning Area.

3.2.3.3 Mississippi Fan Ecoregion

The Mississippi Fan Ecoregion extends from the Mississippi River Delta to the central abyssal plain (Figure 3.2.2-1), and is strongly influenced by the outflow of the Mississippi River. The upper part of the fan (to a water depth of about 2,500 m [8,200 ft]) has a complex and rugged topography attributed to salt diapirism,[1] 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.

3.2.3.4 Gulf of Mexico Basin Ecoregion

The GOM Basin Ecoregion contains the deepest waters and habitats within the GOM LME. Water depths range from 3,000 to more than 4,300 m (9,800 to more than 14,100 ft). Only a very small portion of the Western GOM Planning Area overlies this ecoregion (Figure 3.2.2-1). In contrast, about a quarter of the Central GOM Planning Area (primarily in its southeastern portion) and about a third of the Eastern GOM Planning Area (primarily its southwestern portion) overlay the GOM Basin Ecoregion.

3.2.4 Ecoregions of the Gulf of Alaska

As discussed earlier, the Cook Inlet Planning Area is located within the Gulf of Alaska LME (Figure 3.2.1-1). Cook Inlet itself is associated with the Alaskan/Fjordland Pacific Level II Ecoregion, which extends from the westernmost end of the Aleutian Islands southward to the northern end of Vancouver Island (Wilkinson et al. 2009). The Cook Inlet Planning Area includes two Level III ecoregions: the Cook Inlet Ecoregion in the upper portion of the planning area and the Gulf of Alaska Level III ecoregion in the lower portion of the planning area (Figure 3.2.2-2). These ecoregions are strongly influenced by the Alaska Current and the Alaska Coastal Current.

3.2.4.1 Alaskan/Fjordland Shelf Level II Ecoregion

The Alaskan/Fjordland Shelf Level II Ecoregion includes fjords, islands, and straits along the Pacific coast from the north end of Vancouver Island to the end of the Alaska Peninsula. The

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[1] 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 a salt diapir. Salt diapirs are common features of sedimentary basins such as the GOM (Nelson 1991).

shelf is generally narrow, ranging from about 20 km (12 mi) at its southern end to about 160 km (96 mi) along portions of the Alaska Peninsula, and is very narrow in some areas (such as around the Queen Charlotte Islands). The shelf is widest in the vicinity of the Cook Inlet Planning Area. This ecoregion has one of the most productive marine ecosystems in the northern Pacific, primarily as a result of the upwelling of nutrients by the Alaska Gyre (Wilkenson et al. 2009).

3.2.4.2 Gulf of Alaska Level III Ecoregion

The Gulf of Alaska Level III Ecoregion extends about 1,860 km (1,160 mi) along the Gulf of Alaska coast from about the vicinity of Juneau westward to the end of the Alaskan Peninsula at Unimak Pass, and has a width of about 170 km (105 mi) in the vicinity of the Cook Inlet Planning Area. This ecoregion encompasses the lower portion (the Shelikof Strait) of the Cook Inlet Planning Area, from the approximate vicinity of the Barren Islands through the Shelikof Strait to the southern end of Kodiak Island (Figure 3.2.2-2). This ecoregion is strongly influenced by the Alaska Current. The Shelikof Strait portion of this ecoregion and the planning area is about 240 km (150 mi) in length with a width of about 40–50 km (25–30 mi). Physiography of the ecoregion includes rocky coastlines and numerous fjords, islands, and embayments.

3.2.4.3 Cook Inlet Level III Ecoregion

The Cook Inlet Level III Ecoregion includes the northern portion of the Cook Inlet Planning Area, northward from the mouth of Cook Inlet proper (Figure 3.2.2-2). The inlet is about 290 km (180 mi) in length, with a watershed of about 100,000 km^2 (39,000 mi^2). Major tributaries based upon size include the Susitna, Little Susitna, Kenai, Matanuska, Eagle, Crescent, and Johnson Rivers.

3.2.5 Ecoregions of the Alaska Arctic Coast

The Beaufort Sea and Chukchi Sea Planning Areas occur within the two LMEs that encompass the Arctic coast of Alaska (Figure 3.2.1-2). While the two planning areas occur within the similarly named LMEs, the Level II and III CEC ecoregions actually cross LME and planning area boundaries (Figure 3.2.2-3). The following sections identify and describe the CEC Level II and III ecoregions where OCS oil and gas leasing may occur under the proposed action.

3.2.5.1 Arctic Slope and Arctic Plains Level II Ecoregions

These two Level II ecoregions are characterized by relatively constant covers of ice sheets and ice packs (Wilkenson et al. 2009). Water depths on the Arctic Slope may range from 200 to 3,000 m (660 to 9,800 ft) and are deeper on the Arctic Plains. Most of these two ecoregions occur in the Beaufort Sea Planning Area (Figure 3.2.2-3). While ice may cover 90–100% of these ecoregions in any given year, ice cover throughout the year is not continuous;

numerous leads of open water occur and are very important to ecological resources of these ecoregions.

3.2.5.2 Beaufort/Chukchian Shelf Level II Ecoregion

Within the Arctic Planning Areas, this Level II ecoregion extends along the Arctic coast from the eastern boundary of the Beaufort Sea Planning Area westward almost to Point Hope (Figure 3.2.2-3). In the Beaufort Sea Planning Area, this ecoregion is relatively narrow (about 80 km [50 mi]), and widens considerably in the Chukchi Sea Planning Area to as much as 390 km (240 mi). Water depths may reach 100 m (330 ft) (Wilkenson et al. 2009). Coastal areas include barrier beaches, extensive deltas, lagoons, estuaries, tidal flats, and narrow sand and gravel beaches, with low coastal relief. From October to June, this ecoregion is covered by a combination of landfast ice (extending 20 to 80 km [12 to 50 mi]) and pack ice. In summer, there is a coastal ice-free zone that may be as much as 200 km (120 mi) in width.

3.2.5.3 Beaufortian and Chukchian Neritic Level III Ecoregions

These Level III ecoregions occur within and comprise all of the Beaufort/Chukchian Shelf Level II Ecoregion (discussed above) that occurs within the two Arctic Planning Areas considered in this PEIS (Figure 3.2.2-3). The Beaufortian Neritic Level II Ecoregion accounts for the vast majority of the Beaufort/Chukchian Shelf, while the Chukchian Neritic Level II Ecoregion occurs only along a small portion of the Chukchi Sea coast in the vicinity of Point Hope. Both ecoregions (and especially the Chukchi Neritic Ecoregion) are strongly influenced by circulation flowing from the Bering Sea (Wilkenson et al. 2009).

3.3 CONSIDERATIONS OF CLIMATE CHANGE AND THE BASELINE ENVIRONMENT

Several natural and anthropogenic factors affect climate variability, but scientific evidence has led to the conclusion that current climate warming trends are linked to human activities, which are predominantly associated with greenhouse gas emissions (e.g., NRC 2010). Climate change effects have been observed to be occurring on all continents and oceans, and these observations have provided insights on relationships among atmospheric concentrations of carbon dioxide and other greenhouse gases, mean global temperature increases, and observed effects on physical and biological systems (IPCC 2007a). There are many impacts associated with climate change processes that have been observed in U.S. coastal regions that include changing air and water temperatures, rising sea levels, more intense storms, ocean acidification, coastal erosion, sea ice loss, declining coral reef conditions, and loss of critical habitats such as estuaries, wetlands, barrier islands, and mangroves (e.g., Boesch et al. 2000; ACIA 2005; Titus et al. 2009; Morel et al. 2010; Pendleton et al. 2010; Blunden et al. 2011).

The global climate system is driven largely by incoming solar energy that is reflected, absorbed, and emitted within the Earth's atmosphere, and the resulting energy balance determines atmospheric temperatures (Solomon et al. 2007). Atmospheric concentrations of greenhouse gases (carbon dioxide, methane, nitrous oxide, and halocarbons) increase absorption and emission of energy, resulting in a positive radiative forcing to the climate system and warmer global mean temperatures; this process is often described in general terms as the greenhouse effect. Global concentrations of greenhouse gases in the atmosphere have increased from pre-industrial times and by 70% from 1970 to 2004; these emission increases are linked to human activity sectors such as energy, industry, transportation, and agriculture (IPCC 2007a; Rogner et al. 2007). The climate system response to this positive radiative forcing is complicated by a number of positive and negative feedback processes among atmospheric, terrestrial, and oceanic ecosystems, but overall the climate is warming, as is evident by observed increases in air and ocean temperatures, melting of snow and ice, and sea level rise (IPCC 2007a).

Global mean atmospheric temperatures have risen by 0.74 ± 0.18°C (1.33 ± 0.32°F) between 1905 and 2005, and the rate of warming for the past 50 yr has been almost double the rate for the past 100 yr (0.13°C [0.23°F] per decade) (Trenberth et al. 2007). Atmospheric warming has not been spatially uniform, and in particular Arctic temperatures have increased about twice as much as those in lower latitudes (ACIA 2005). Preferential warming in the Arctic is partially the result of the ice-albedo effect, which occurs when highly reflective ice is replaced by less reflective water and land surfaces, resulting in more heat being absorbed by the land and water rather than being reflected back to the atmosphere (Perovich et al. 2007). About 80% of the warmth caused by greenhouse gases has been absorbed in the oceans (NRC 2010). Long-term observations of oceanic temperatures have revealed considerable inter-annual and inter-decadal variability. Between 1961 and 2003, oceanic warming was widespread in the upper 700 m (2,300 ft) of oceans, where the global mean ocean temperature has risen by 0.10°C (0.18°F) (Bindoff et al. 2007).

The effects of climate change on ecosystems are complex and nonuniform across the globe and vary among atmospheric, terrestrial, and oceanic systems (e.g., IPCC 2007a; Blunden et al. 2011). Considerations of climate change effects in OCS planning areas focus on impacts on marine and coastal systems where environmental sensitivities are typically associated with increasing atmospheric and ocean temperatures, but they can also be categorized as responses to sea level rise, coastal erosion, and ocean acidification. These general categories of climate change responses are occurring in addition to human-induced pressures related to coastal population densities (e.g., land use changes, pollution, overfishing) and trends of increasing human use of coastal areas (Nicholls et al. 2007).

Environmental Sensitivity to Atmospheric and Oceanic Temperature Increases. Environmental responses to warming atmospheric and oceanic temperatures include changes to species composition, coral reef damage, permafrost thawing, increased occurrences of storm events, coastal erosion, loss of sea ice, and changes in ocean dynamics.

Species Composition. Effects of warming temperatures have already been seen in the form of changes in species location ranges, changes in migration patterns and timing, changes in location and timing of reproduction, and increases in disease (Perry et al. 2005; Rosenzweig et al. 2007; Simmonds and Isaac 2007). As species extend their spatial ranges, there can be negative consequences related to non-native and invasive species (Twilley et al. 2001). Climate change impacts on aquatic environments have the potential to affect species composition within an ecosystem according to species-specific thresholds, as well as species characteristics such as mobility, lifespan, and availability to use available resources (e.g., Chapin et al. 2000; Levinsky et al. 2007). These variations in species-specific thresholds and characteristics result in the breakup of existing ecosystems and the formation of new ones in response to climate change, with unknown consequences (Perry et al. 2005; Simmonds and Isaac 2007; Karl et al. 2009).

Coral Reef Damage. Warmer water temperatures or increases in ultraviolet light penetration cause coral to lose their symbiotic algae, a process called bleaching. Intensities and frequencies of bleaching events have increased substantially over the past 30 yr, resulting in the death of or severe damage to about one third of the world's shallow water corals (Karl et al. 2009). In addition to coral bleaching, there has been a rise in the occurrence of excessive algal growth on reefs, as well as the presence of predatory organisms and reports of diseases related to bacterial, fungal, and viral agents (Boesch et al. 2000; Twilley et al. 2001). Additional discussion of coral reef damage is presented in Section 3.7.2.1.7.

Permafrost Thawing. Permafrost degradation affects terrestrial and hydrologic conditions in Arctic regions where the temperature at the top of the permafrost layer has increased by up to 3°C (5.4°F) since the 1980s, and in the Alaskan Arctic the permafrost base has been thawing at a rate of up to 0.04 m/yr (0.13 ft/yr) (Lemke et al. 2007). Recent data collected in 2010 suggest that trends in permafrost warming have begun to propagate southward nearly 200 km (124 mi) inland from the North Slope region (Richter-Menge and Jeffries 2011). Thawing of permafrost near coastal regions is expected to result in more rapid rates of shore erosion, increases in stored-carbon releases (Schuur et al. 2009), and damage to infrastructure such as roads and pipelines (Karl et al. 2009). These effects are expected to be compounded by reduced duration and extent of shoreline protection provided by landfast ice and more exposure to ocean storms.

Increases in Major Storm Frequency and Intensity. Regional weather conditions are influenced by modal climatic variability patterns such as the El Niño–Southern Oscillation (ENSO), Arctic Oscillation (AO), North Atlantic Oscillation (NAO), and the Pacific Decadal Oscillation (PDO) that act as connection pathways between regional atmospheric conditions and the world's oceans (NRC 1998; Liu and Alexander 2007). Major storms in low- to mid-latitude regions (e.g., cyclones, hurricanes, and typhoons) are largely controlled by the ENSO phase (Trenberth et al. 2007). In the northern hemisphere, there is a general northward shift in cyclone activity that is correlated with AO and NAO phases (ACIA 2005). Climate change affects water temperatures and wind patterns that interact to either enhance or work against storm formation, making it difficult to predict climate change effects on major storm events (Karl et al. 2009). However, a number of studies have concluded that cyclonic activity has changed over the second half of the 20th century with evidence suggesting that since the 1970s there has been a substantial upward trend toward longer-lasting and more intense storms (Trenberth et al. 2007).

Sea Ice Biome. The presence of sea ice and landfast ice in the marine environment of the Arctic creates a productive marine ice biome essential for the survival and flourishing of marine animals and supports traditional subsistence communities (e.g., Berkes and Jolly 2001;

Simmonds and Isaac 2007; Arp et al. 2010). These environments provide hunting, resting, and birthing platforms along the ice-water interface, generate local upwelling responsible for high productivity in polynyas, and release large quantities of algae growing beneath the ice surface into the food chain at ice melt (ACIA 2005). Polar bear populations are strongly correlated with regional characteristics of sea ice and vary seasonally and with respect to specific requirements for reproduction (Durner et al. 2004). The Iñupiat Eskimos, Alaska Native people of coastal villages of northwestern Alaska and the North Slope, use sea ice for hunting and fishing grounds, as well as seasonal whaling camps that are vital to support their subsistence lifestyle (Braund and Kruse 2009). The greatest threat to the sea ice biome is the loss of sea ice due to climate change. Sea ice extent, as observed mainly by remote sensing methods, has decreased at a rate of approximately 3% per decade starting in the 1970s with larger decreases occurring in summer months (Parkinson 2000). 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), but more recent studies have shown a loss of multi-year ice area of 42% from 2005 to 2008 (Kwok and Cunningham 2010).

Ocean Dynamics. While large-scale trends in ocean salinity suggest certain regions have been experiencing changes in salinity that in combination with the warming of the atmosphere and oceans can change the dynamic properties of the ocean circulation patterns, there is currently no clear evidence for suggesting significant changes to major ocean circulation patterns as a result of climate change (Bindoff et al. 2007). However, there have been more regional studies that have suggested potential mechanistic changes to ocean circulations. For example, Bakun (1990) presented evidence on the effects of altered wind patterns that could enhance coastal upwelling along the western coast of the United States, which could increase productivity in these regions as nutrient-rich bottom water ascends to the ocean surface. There has also been interest in understanding the effect of increased freshwater inputs from the Greenland Ice Sheet on overturning the North Atlantic Current (Church 2007; Rabe et al. 2011). One of the largest obstacles for understanding climate change effects on ocean currents is the lack of long-term measurements, which makes it difficult to decipher climate change responses from inter-decadal variability (Bryden et al. 2003).

Environmental Sensitivity to Sea Level Rise and Coastal Erosion. The recent global sea level rise has been caused by warming-induced thermal expansion of the oceans and accelerated melting of glaciers and ice sheets. The global mean sea level has risen at a mean rate of 1.8 ± 0.5 mm/yr from 1961 to 2003 with considerable variability spatially, as well as considerable decadal time-scale variability (Bindoff et al. 2007). Predictions in sea level rise are as much as 0.6 m (2 ft) by 2100 (Nicholls et al. 2007). The amount of relative sea level rise along different parts of the U.S. coast depends not only on thermal expansion and ice sheet melting, but also on the changes in elevation of the land that occur as a result of subsidence or geologic uplift (Karl et al. 2009). Submergence hotspots can occur as a result of local subsidence in combination with sea level rise such that the rate of rise of sea level relative to the land is expected to be higher than in other parts of the area.

Certain areas along the Atlantic and GOM coasts are undergoing relatively rapid inundation and landscape changes because of the prevalence of low-lying coastal lands (Titus et al. 2009). Barrier islands in the northern GOM have been losing land areas and changing habitat conditions because of decreased sediment supplies from rivers, sea level rise, and intense storms (Lucas and Carter 2010). Coastal erosion rates over the past couple of decades averaged 3.7 m/yr (12 ft/yr), but storm events such as Hurricane Rita have caused erosion rates of 12 to 15 m (39 to 49 ft) in a single event (Park and Edge 2011). The coasts of the Beaufort and Chukchi Seas consist of river deltas, barrier islands, exposed bluffs, and large inlets and inland are characterized by low-relief lands underlain by permafrost (Jorgenson and Brown 2005). The combination of wind-driven waves, river erosion, sea level rise, and sea ice scour with highly erodible coastal lands creates the potential for high erosion rates along the Beaufort and Chukchi Sea coasts (Proshutinsky et al. 2001; Mars and Houseknecht 2007). In addition to coastal erosion along the Arctic coast, storm surge flooding has converted freshwater lakes into estuaries, affecting habitat conditions (Arp et al. 2010).

Environmental Sensitivity to Ocean Acidification. Ocean acidification refers to the decrease in the pH of the oceans and its buffering capacity caused by the uptake of carbon dioxide from the atmosphere that reacts with seawater to form carbonic acid, leading to decreasing pH values in the oceans. Predictions of future ocean water pH levels vary somewhat, but predicted decreases range from 0.14 to 0.4 pH units over the 21st century (Caldeira and Wickett 2005; Orr et al. 2005; IPCC 2007a). Factors such as water temperatures, salinity, sea ice, and ocean mixing processes affect the amount of carbon dioxide absorbed by oceans, so climate change effects on storms, river discharge, and precipitation patterns all affect ocean acidification (IPCC 2007). The mechanisms that lead to ocean acidification also affect estuarine and coastal waters, although their impacts on estuarine ecosystems are not well known because of the multitude of processes affecting pH levels in these systems (Feely et al. 2010).

Ocean acidification affects the ability of certain organisms to create shells or skeletons by calcification, which can be especially harmful to mollusks, corals, and certain plankton species that are important to oceanic food chains (Orr et al. 2005; Karl et al. 2009). However, several laboratory experiments conducted under elevated carbon dioxide conditions have shown mixed calcification rates in many organisms (including positive responses to ocean acidification), which suggests complex mechanisms by which organisms respond to ocean acidification (Doney et al. 2009; Ries et al. 2009). Coral reefs are highly dependent on calcified structures for survival and both warm-water and cold-water corals are negatively impacted by ocean acidification (Royal Society 2005). Ocean waters in Arctic regions are highly susceptible to ocean acidification resulting from increased carbon dioxide solubility, freshwater inputs, and increased primary productivity, and these factors relating to ocean acidification are enhanced by current climate change trends and loss of sea ice (Fabry et al. 2009; Steinacher et al. 2009).

Climate Change Predictions and Uncertainties. Climate change predictions are based on a variety of models that simulate all relevant physical processes affecting interactions among the atmosphere, oceans, and biosphere, which are driven by a variety of projected greenhouse gas emission scenarios. Global climate models generate projected changes in atmospheric, ocean, and land surface climate variables at scales on the order of one degree in latitude and longitude, which are not sufficient for making regional-scale climate assessments. Downscaling global climate models and coupling them with more localized regional climate models is an active area of current research (Christensen et al. 2007; Randall et al. 2007). The complexity of modeling global and regional climate systems is great, so it is important to consider measures of uncertainty, which is typically done using a multi-model ensemble approach

(Krishnamurti et al. 2000). It is important to recognize that despite new climate model developments, uncertainty in climate projections can never be entirely eliminated (McWilliams 2007).

The Intergovernmental Panel on Climate Change (IPCC) has summarized climate change predictions over the next two decades and over the 21st century, using climate model predictions and evidence from various scientific disciplines (IPCC 2007a). The IPCC uses a 10-fold likelihood scale ranging from virtually certain (>99% probability of occurrence) to exceptionally unlikely (<1% probability) to define consistent terminology for climate change projections where uncertainty can be assessed by statistical analyses, and a 10-point scale (10 being the most confident) for projections where uncertainty was qualitatively assessed by expert judgment. The most recent climate change projections summarized by the IPCC (2007a) include some of the following:

- An increase in atmospheric temperatures of approximately 0.2°C (0.4°F) per decade is predicted over a range in projected greenhouse gas emission scenarios;

- Warming is expected to be greatest over land and at higher latitudes;

- Model estimates of sea level rise vary from 0.18 to 0.59 m (0.6 to 2 ft) by the end of the 21st century, but information on important feedback processes to sea level rise do not allow for determining a best estimate;

- Polar regions are projected to have continued reductions in sea ice, glaciers, and ice sheets;

- Projection models suggest that ocean pH values decreasing between 0.14 and 0.35 over the 21st century;

- It is likely (>66%) that tropical cyclones will become more intense;

- Increased precipitation is very likely (>90%) to occur at high-latitudes;

- There is high confidence (8 out of 10) that annual river runoff will increase by 10 to 40% at high latitudes and decrease by 10 to 30% in dry regions of mid-latitudes;

- Net carbon uptake by terrestrial ecosystems is likely (>66%) to peak during this century as natural carbon sequestration mechanisms reach their capacity; and

- There is medium confidence (5 out of 10) that predicted temperature increases will result in approximately 20 to 30% of plant and animal species that have been assessed likely (>60%) being at an increased risk of extinction.

3.3.1 Gulf of Mexico

Climate change in the GOM is expected to affect coastal ecosystems, forests, air and water quality, fisheries, and business sectors such as industry and energy (Ning et al. 2003). The GOM region has 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 (Twilley et al. 2001). In addition to temperature changes, the northern coast of the GOM is experiencing impacts associated with sea level rise that include the loss of coastal wetland and mangrove habitats, salt water intrusion into coastal aquifers and forests, and increases in shoreline erosion (Williams et al. 1999; Pendleton et al. 2010). Climate change associated sea level rise is occurring in combination with altered hydrology and land subsidence that has resulted in measures of relative sea level rise ranging between 0.002 m/yr (0.007 ft/yr) along Texas and up to 0.01 m/yr (0.03 ft/yr) along the Mississippi River Delta (Twilley et al. 2001).

Climate models generally predict a rise in temperatures in the GOM Coastal States this century; however, predictions of precipitation are more problematic due to model uncertainties (Karl et al. 2009). Predictions of precipitation among various modeling studies for the GOM region have generally predicted a slight decrease in precipitation in coastal areas, as well as more intense rainfall events and longer periods of drought, but models vary widely in upland areas, which affect river discharges (Mulholland et al. 1997; Boesch et al. 2000; Twilley et al. 2001).

Significant increases or decreases in precipitation and river runoff would affect salinity and water circulation, as well as water quality. Increased runoff would likely deliver increased amounts of nutrients (such as nitrogen and phosphorous) to estuaries, increase the stratification between warmer fresher and colder saltier water, and potentially lead to eutrophication of estuaries and increase the potential for harmful algal blooms that can deplete oxygen levels (Justic et al. 1996; Karl et al. 2009). Reductions of freshwater flows in rivers or prolonged drought periods could substantially reduce biological productivity in Mobile Bay, Apalachicola Bay, Tampa Bay, and the lagoons of Texas and could increase the salinity in coastal ecosystems, resulting in a decline in mangrove and sea grass habitats (Twilley et al. 2001). Decreased runoff could also diminish flushing of the estuaries, decrease the size of estuarine nursery zones, and allow an increase in predators and pathogens (Boesch et al. 2000).

Sea level rise along parts of the northern GOM coast are as high as 0.01 m/yr (0.03 ft/yr), which is much greater than globally averaged rates (Twilley et al. 2001; IPCC 2007a). The combination of sea level rise and land subsidence is resulting in the loss of coastal wetlands and mangroves, which is damaging to habitat functions to many important fish and shellfish populations. Future sea level rise is expected to cause additional saltwater intrusion into coastal aquifers of the GOM, potentially making some unsuitable as potable water supplies (Karl et al. 2009). Saltwater intrusion and sea level rise are damaging coastal bottomland forests (primarily along the western GOM coast) and mangroves through soil salinity poisoning, increased hydroperiods, and coastal erosion (Williams et al. 1999). Additionally, climate change model predictions suggest that there will be an increase in the intensity of hurricanes (IPCC 2007a), and coastal regions may potentially have fewer barrier islands, coastal wetlands, and mangrove forests to buffer the resulting storm surges as a result of sea level rise.

Marine biota in the GOM are influenced by changes in temperature, salinity, and ocean acidification, as well as their biological environment including predators, prey, species interactions, disease, and fishing pressure (Karl et al. 2009). Projected changes in physical oceanographic conditions 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. However, impacts on marine biota associated with climate change need to be considered against natural variation (Rosenzweig et al. 2007).

3.3.2 Alaska Region

The Arctic climate system is complex and has varied considerably over geologic time scales (ACIA 2005). Over the last 100 yr, mean Arctic temperatures have increased at a rate nearly double that of global mean temperatures (IPCC 2007a). The ice-albedo feedback mechanism has the potential to enhance the effects of warming trends as the loss of sea ice leads to more heat absorption by ocean waters, which affects both sea ice melt and regional atmospheric circulation patterns important to the global heat budget (ACIA 2005; Overland and Wang 2010). However, it is important to recognize that climate conditions in the Arctic experience strong decadal variability in relation to modal climatic variability patterns such as the AO, PDO, and NAO (ACIA 2005). A recent modeling study has suggested that Arctic regions are nearing a threshold, where amplified greenhouse effect warming is likely to overpass decadal climate variability patterns (Serreze and Francis 2006). The impacts of climate change on the Arctic include warming ocean temperatures, increasing ocean acidification, reductions in sea ice, permafrost thawing, and coastal erosion, which all affect terrestrial, coastal, and marine ecosystems (Hopcroft et al. 2008). In addition to ecosystem impacts, the loss of sea ice contributes to an ice-albedo feedback process that affects regional atmospheric circulation patterns and global heat budgets (ACIA 2005; Overland and Wang 2010).

Changes to the Arctic climate, as well as the sea ice and permafrost biomes, have been documented in several studies (Parkinson 2000; Comiso 2002; Rothrock and Zhang 2005; ACIA 2005; Anisimov et al. 2007; Hopcroft et al. 2008; Perovich et al. 2010; Richter-Menge and Jeffries 2011) and include:

- Atmospheric temperatures have increased by 1–2°C (2–4°F) since the 1960s;

- Atmospheric temperatures increasing at a rate of 1°C (2°F) per decade in winter and spring;

- Precipitation has increased by approximately 1% per decade;

- March sea ice extent has decreased at a rate of approximately 3% per decade starting in the 1970s;

- Multi-year sea ice has decreased at a rate of approximately 9 to 12% per decade since the 1980s;

- Sea ice volumes have decreased by 4% per decade since the 1950s;

- Temperatures at the top of the permafrost layer have increased by up to 3°C (5°F) since the 1980s;

- Permafrost base has been thawing at a rate of up to 0.04 m/yr (0.13 ft/yr).

Impacts of current and projected climate changes have the potential to affect sea ice (most importantly multi-year sea ice) and permafrost biomes, as well as coastal erosion rates, animal populations, and subsistence livelihoods. Retreat of sea ice would increase impacts on coastal areas from storms. Furthermore, coastlines where permafrost has thawed are more vulnerable to erosion from wave action, which can affect both erosion rates as well as change freshwater lakes into estuarine habitats (Mars and Houseknecht 2007; Arp et al. 2010). An aerial photo comparison has revealed total erosive losses up to 457 m (1,500 ft) over the past few decades along some stretches of the Alaskan coast (Alaska Regional Assessment Group 1999). At Barrow, Alaska, coastal erosion has been measured at the rate of 1–2.5 m/yr (3–8 ft/yr) since 1948 (ACIA 2005), and it has been causing severe impacts on the community. Maximum coastal erosion rates of up to 13.3 m/yr (43.6 ft/yr) have occurred near Cape Halkett and Cape Simpson during the time period of 1980–2000 (Ping et al. 2011).

Changes in permafrost have caused failure of buildings and costly increases in road damage and road maintenance in Alaska (Alaska Regional Assessment Group 1999; Hinzman et al. 2005). Present costs of thaw-related damage to structures and infrastructure in Alaska have been estimated at $35 million per year (NAST 2001). A continued warming of the permafrost is likely to increase the severity of permafrost thaw-related problems. Thawing of any permafrost increases groundwater mobility, reduces soil bearing strength, and increases the susceptibility to erosion and landslides. Thawing could disrupt petroleum exploration and production by shortening the availability of time for minimal-impact operations on ice roads and pads (ACIA 2005).

Loss of sea ice, especially multi-year ice that lasts through summer months, could cause large-scale changes in marine ecosystems and could threaten populations of marine mammals such as polar bears, walruses, and seals that depend on the ice for habitat, hunting, and transportation (Boesch et al. 2000; NAST 2001; Durner et al. 2004; Hopcroft et al. 2008; Karl et al. 2009). With studies examining the impacts of climate change on Arctic biota, there have been reported changes in abundance, range shifts, growth rates, behavior, and community dynamics for both terrestrial and marine species (Belkin 2009; Mueter et al. 2009; Wassmann et al. 2011). Seals and polar bears regularly use landfast sea ice as habitat, which is particularly susceptible to climate warming (Boesch et al. 2000). Ice edges are biologically productive systems in which ice algae form the base of the food chain, which has implications for higher trophic levels (Moline et al. 2008). The sea ice algae are crucial to Arctic cod, which is an important species to the diets of seabirds and marine animals in Arctic regions (Bradstreet and Cross 1982; Gradinger and Bluhm 2004). As ice melts, there is concern that there would be loss of prey species of marine mammals, such as Arctic cod and amphipods, which are associated with ice edges, and these impacts can propagate through food webs associated with the sea ice biome (ACIA 2005).

Ocean fisheries are highly vulnerable to changes in climatic conditions such as sea temperature and sea ice conditions (Karl et al. 2009), and fisheries in the Alaska region have experienced decadal-scale variability in climate due to modal patterns of oceanic and atmospheric interactions (Schwing et al. 2010). For example, Pacific salmon populations have shown decadal variability over the past 300 yr, which spans the timeframe of before and after commercial fishing, suggesting the strong coupling of ocean conditions and salmon populations (Finney et al. 2000). In 1977, warmer sea surface temperatures and reduced sea ice conditions generated a “regime shift” in the fisheries of the Gulf of Alaska that carried over into the 1980s, producing large salmon, pollock, and cod populations with a reduction in populations of forage fishes (Boesch et al. 2000; NAST 2001). Evidence of climate change warming effects on fisheries is difficult to detect with respect to decadal variability patterns. However, current trends of increased freshwater inputs, increased ultraviolet radiation, warmer sea surface temperatures, ocean acidification, and reduced sea ice are driving biodiversity changes across trophic levels for marine and freshwater fish of the Alaska region with both positive and negative effects depending on tolerance levels and the ability to adapt to changing habitats of the various fish populations (Reist et al. 2006; Anisimov et al. 2007; Bates and Mathis 2009). In addition to temperature and sea ice changes, permafrost thawing and alterations to terrestrial hydrology have the potential to increase sediment and nutrient availability in estuarine and nearshore habitats, which have a mixture of positive and negative impacts on marine and anadromous fish populations (ACIA 2005; Hopcroft et al. 2008).

Alaska Native subsistence communities have adapted to climate variability in the past, but current warming trends may produce uncharacteristic and extreme environmental conditions that can adversely affect these communities (Berkes and Jolly 2001; Anisimov et al. 2007). Climate change effects such as multi-year sea ice loss, permafrost loss, and sea level rise may alter traditional hunting locations and cause shifts in game patterns and quality, travel routes, and inter-community trading and social mechanisms (Alaska Regional Assessment Group 1999; ACIA 2005). In addition to climate change impacts, Alaska Native subsistence communities have been adapting to economic development and modernization occurring in Arctic regions (ACIA 2005; Braund and Kruse 2009). Alaska Native subsistence communities have experienced and are currently experiencing impacts on subsistence activities caused by a combination of environmental, social, and cultural changes. The Alaska Native subsistence communities will find it more difficult to adapt or relocate than they did in the past because most now live in established communities, which will make adaptation to climate change effects problematic in the future (ACIA 2005).

3.4 WATER QUALITY

3.4.1 Gulf of Mexico

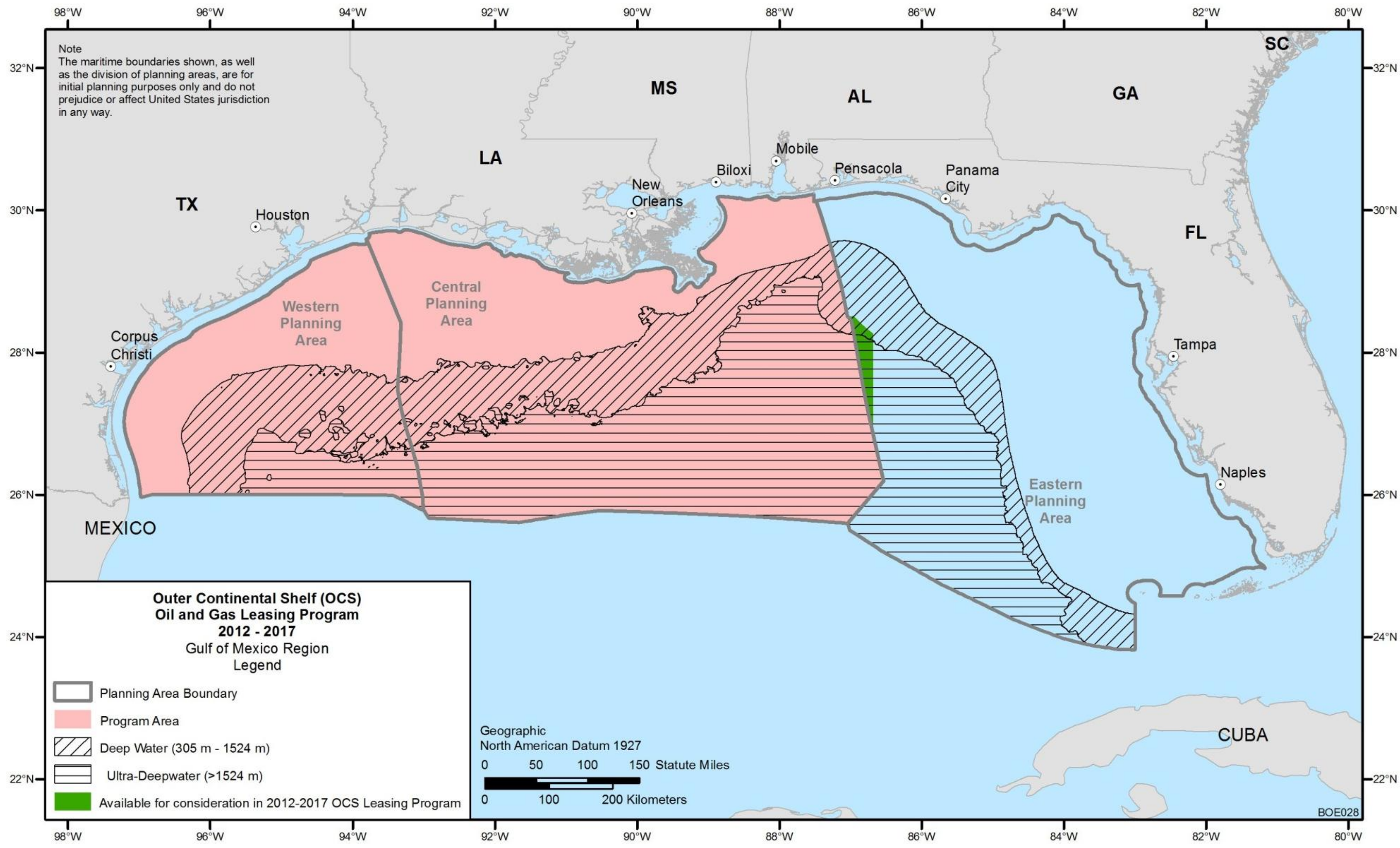
The term water quality describes the overall condition of water, reflecting its particular biological, chemical, and physical characteristics. It is an important measure for both ecological and human health. Water quality is most often discussed in reference to a particular purpose or use of the water, such as recreation, drinking, or ecosystem health. This usage divides the analysis area into coastal and marine waters and includes human uses of water for recreation and food harvest along with industrial and domestic uses. Coastal waters include all bays and estuaries from the Rio Grande River to the Florida Bay. Marine water includes both State offshore water and Federal Outer Continental Shelf (OCS) waters extending from outside the barrier islands to the Exclusive Economic Zone. The inland extent is defined by the Coastal Zone Management Act. A further distinction within the marine water areas is between continental shelf water and deep water. Figure 3.4.1-1 illustrates this distinction within marine water areas and the OCS Planning Areas for the GOM.

In general, coastal water quality is influenced by the rivers that drain into the area, the quantity and composition of wet and dry atmospheric deposition, and the influx of constituents from sediments. Human activities influence the waters closest to the land. Circulation or mixing of the water may either improve the water quality through dilution or degrade the quality by introducing factors that contribute to water quality decline.

Marine water composition in the GOM has two primary influences. These are the configuration of the GOM Basin, which controls the oceanic waters that enter and leave the GOM, and runoff from the land masses, which controls the quantity of freshwater input into the GOM. The GOM receives oceanic water from the Caribbean Sea through the Yucatan Channel and freshwater from major continental drainage systems such as the Mississippi River system. Estuarine and fluvial drainage areas in the GOM region are shown in Figure 3.2.1-4. The three major fluvial drainage areas (FDAs) drain a total of 4.1 million km^2 (1.6 million mi^2) of the inland continental United States, and have a large influence on water quality in the GOM. The large amount of freshwater runoff mixes into the GOM surface water, producing a different composition on the continental shelf from that in the open ocean.

3.4.1.1 Coastal Waters

The GOM coast contains one of the most extensive estuary systems in the world. This system extends from the Rio Grande River in Texas eastward to Florida Bay in Florida. Estuaries, semi-enclosed basins within which the freshwater of rivers and the higher salinity waters offshore mix, are influenced by both freshwater and sediment influx from rivers and the tidal actions of the oceans. The primary variables that influence coastal water quality are water temperature, total dissolved solids (salinity), suspended solids (turbidity), and nutrients. An estuary’s salinity and temperature structure are determined by hydrodynamic mechanisms governed by the interaction of marine and terrestrial influences. Hydrodynamic influences include tides, nearshore circulation, freshwater discharges from rivers, and local precipitation. Tidal mixing within GOM estuaries is limited by the small tidal ranges that occur along the GOM coast. The shallowness of most GOM estuaries, however, tends to amplify the mixing effect of the small tidal range. GOM coast estuaries exhibit a general east-to-west trend in selected attributes of water quality associated with changes in regional geology, sediment loading, and freshwater inflow. For example, the estuarine waters in Florida generally have greater clarity and lower nutrient concentrations than those in the central and western areas of the GOM coast.



Note
The maritime boundaries shown, as well as the division of planning areas, are for initial planning purposes only and do not prejudice or affect United States jurisdiction in any way.

FIGURE 3.4.1-1 Depth Zones within GOM Planning Areas and Program Areas for the OCS Oil and Gas Leasing Program 2012-2017

The primary factors that affect estuarine water quality include upstream withdrawals of water for agricultural, industrial, and domestic purposes; contamination by industrial and sewage discharges; agricultural runoff carrying fertilizer, pesticides, and herbicides; upstream land use; redirected water flows; and habitat alterations (e.g., construction and dredge-and-fill operations). Because drainage from more than 55% of the conterminous United States enters the GOM primarily from the Mississippi River, a large area of the nation contributes to coastal water quality conditions in the GOM (see Figure 3.2.1-4). There are also three major estuarine drainage areas (EDAs) that drain approximately 250,000 km^2 (95,000 mi^2) of coastal areas along the GOM, strongly influencing water quality in the estuarine environments (NOAA 1999).

Population growth results in additional clearing of the land, excavation, construction, expansion of paved surface areas, and drainage controls. These activities alter the quantity, quality, and timing of freshwater runoff. Stormwater runoff that flows across impervious surfaces is more likely to transport contaminants associated with urbanization including suspended solids, heavy metals and pesticides, oil and grease, and nutrients (U.S. Commission on Ocean Policy 2004). Additional information on factors that contribute to coastal water quality can be found in the sociocultural systems section of this chapter.

Coastal water quality is also affected by the loss of wetlands, which is discussed in detail in Section 3.7.1. Wetlands improve water quality through filtration of runoff water and provision of valuable habitat. Suspended particulate material is trapped and removed from the water, resulting in greater water clarity. Nutrients may also be incorporated into vegetation and wetland sediments and removed from the water that passes through the wetlands.

The first USEPA National Coastal Condition Report summarized coastal conditions with data collected from 1990 to 1996 (USEPA 2001). The USEPA updated this information in a third report (USEPA 2008). The first report rated the overall condition of the GOM coastal region as fair to poor. The third report ranked the water quality index fair and the overall condition fair to poor (USEPA 2008). The water quality ranking used five factors: (1) dissolved oxygen, (2) dissolved inorganic nitrogen, (3) dissolved inorganic phosphorus, (4) chlorophyll *a*, and (5) water clarity. Contaminated sediments pose an immediate threat to benthic organisms and an eventual threat to estuarine ecosystems as a whole. Contaminants in sediments may be re-suspended into the water by anthropogenic activities, storms, or other natural events, where they can expose organisms in the water column and can accumulate and move up the food chain, eventually posing health risks to humans (USEPA 2011g). The sediment quality index of the GOM coast region was ranked as poor (USEPA 2008). Sediments in the GOM coast region have been found to contain pesticides, metals, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) (USEPA 2008).

Hurricanes Katrina and Rita resulted in a number of impacts on water quality conditions in the GOM as a result of storm damage to pipelines, refineries, manufacturing and storage facilities, sewage treatment facilities, and other facilities and infrastructure. For example, Katrina damaged 100 pipelines, which resulted in approximately 211 minor pollution reports to the former Minerals Management Service (MMS) (now BOEM), while Rita damaged 83 pipelines, resulting in 207 minor pollution reports (MMS 2006a). Flood waters pumped into Lake Pontchartrain contained a mixture of contaminants, including sewage, bacteria, heavy metals, pesticides, and other toxic chemicals, and as much as 24,600 m^3 (6.5 million gal) of oil (Sheikh 2006). Sources of these contaminants include damaged sewage treatment plants, refineries, manufacturing and storage facilities, and other industrial and agricultural facilities and infrastructure (Sheikh 2006). The flood waters of New Orleans were oxygen depleted and contained elevated bacterial levels, but the pollutants occurred at about the same concentrations as typical stormwater runoff (Pardue et al. 2005). Testing following the storm identified low levels of fecal coliform in Mississippi Sound and Louisiana coastal waters. Very few toxics resulting from the hurricanes were detected in estuarine or coastal waters (USEPA 2010).

The heavy rainfall associated with Katrina increased agricultural runoff of nutrients into the GOM and decreased salinity of nearshore waters (NOAA and NMFS 2007). Storm surges as a result of the hurricanes caused temporary saltwater intrusion in some estuarine areas (NOAA and NMFS 2007). The release of contaminated Lake Pontchartrain waters into the GOM, as well as releases from damaged pipelines, caused short-term impacts on water quality in the GOM. Tidal action and normal current patterns in the GOM resulted in the dilution and dispersal of any heavily contaminated waters, potentially limiting any long-term effects on GOM water quality (Congressional Research Service 2005). Levels of contamination in oyster populations in coastal Louisiana and Mississippi after hurricane Katrina were measured and compared to the 20-yr record of contamination. Levels of organochlorine compounds and PAHs were found to be below normal, and levels of metals/trace elements were found to be elevated at most sites, compared to the historical record (NCCOS 2006).

3.4.1.2 Marine Waters

Within the GOM, marine waters occur in three regions: (1) the continental shelf west of the Mississippi River (primarily the Western GOM Planning Area and the western half of the Central GOM Planning Area), (2) the continental shelf east of the Mississippi River (the eastern half of the Central GOM Planning Area and the Eastern GOM Planning Area), and (3) deep water (>310 m). Figure 3.4.1-1 illustrates the marine water areas and the OCS Planning Areas for the GOM.

3.4.1.2.1 Continental Shelf West of the Mississippi River. The water quality in this area is highly influenced by input of sediment and nutrients from the Mississippi and Atchafalaya Rivers (Murray 1997). The Mississippi-Atchafalaya River Basin drains about 41% of the conterminous United States (see Mississippi Coastal Subregion FDA in Figure 3.2.1-4). A turbid surface layer of suspended particles is associated with the freshwater plume from these rivers. The river system supplies nitrate, phosphate, and silicate to the shelf. During summer months, the low-salinity water from the Mississippi River spreads out over the shelf, resulting in a stratified water column. While surface oxygen concentrations are at or near saturation, hypoxia, defined as oxygen concentrations less than 2 milligrams per liter (mg/L), is observed in bottom waters during the summer months in waters of the continental shelf west of the Mississippi River.

The Hypoxic Zone. Hypoxic, or low-oxygen, conditions occur on the continental shelf in the northern part of the GOM in areas where the dissolved oxygen level is below 2 mg/L. Hypoxia in the GOM is attributed to large nutrient influxes from the rivers draining the continental United States and stratification of GOM waters from differences in temperature and density (Mississippi River/GOM Watershed Nutrient Task Force 2009). The average size of the hypoxic zone over the period of measurement (1985–2011) is 13,600 km^2 (5,300 mi^2) (LUMCON 2011). Over the 5-yr period between 2006 and 2010, the hypoxic zone had an average size of 17,300 km^2 (6,700 mi^2), and in 2010, the hypoxic zone was measured to be 17,520 km^2 (6,765 mi^2) (USEPA 2011h). The hypoxic zone increased from an average size of 8,300 km^2 (3,200 mi^2) in the 1985−1992 period to more than 16,000 km^2 (6,200 mi^2) in the 1993−1997 period (Rabalais et al. 2002), and it reached a record 22,000 km^2 (8,500 mi^2) in 2002. The size of the hypoxic zone is directly correlated with the flux of nitrogen from the Mississippi River and river discharge (Scavia et al. 2003). Veil et al. (2005) evaluated the loading of nutrients and other oxygen-demanding materials in produced water discharged from offshore oil and gas platforms located in the hypoxic zone. Veil et al. (2005) found that the nitrogen and phosphorus loading in produced water discharges were about 0.16% and 0.013%, respectively, of the nutrient loading entering the GOM from the Mississippi and Atchafalaya Rivers.

Pollutant Sources. Analysis of shelf sediments off the coast of Louisiana has found trace organic pollutants including PAHs, herbicides such as Atrazine, chlorinated pesticides, PCBs, and trace inorganic (metal) pollutants (Turner et al. 2003). The detection of organochlorine pesticides and PAHs in sediment cores collected in water depths of 10 to 100 m (33 to 330 ft) off the southwest pass of the Mississippi River increased in sediments deposited after the 1940s (Turner et al. 2003). The river was identified as the primary source of both organochlorine and the pyrogenic PAHs, which are associated with the burning of fossil fuels; however, higher concentrations of petrogenic PAHs, associated with natural seeps and/or oil and gas exploration, were found farther from the mouth of the river (Turner et al. 2003).

The offshore oil and gas industry operates hundreds of platforms throughout this portion of the GOM. Many platforms have discharges of drilling wastes, produced water, and other industrial wastewater streams that have adverse impacts on water quality. The USEPA regulates the discharge of these wastes through an NPDES permit. Except in shallow waters, the effects of these discharges are generally localized near individual points of discharge (Neff 2005).

3.4.1.2.2 Continental Shelf East of the Mississippi River. Water quality on the continental shelf from the Mississippi River Delta to Tampa Bay is influenced by river discharge, runoff from the coast, and eddies from the Loop Current. The Mississippi River accounts for 72% of the total discharge onto the shelf (SUSIO 1975). The outflow of the Mississippi River generally extends 75 km (45 mi) to the east of the river mouth (Barry A. Vittor & Associates, Inc. 1985), except under extreme flow conditions. Mobile Bay and several smaller rivers east of the Mississippi River including the Apalachicola and Suwannee Rivers also contribute runoff to the area (Jochens et al. 2002). The Loop Current intrudes in irregular intervals onto the shelf, and the water column can change from well mixed to highly stratified very rapidly. Discharges from the Mississippi River can be easily entrained in the Loop Current.

Hypoxia is rarely observed on the Mississippi-Alabama shelf, although near-hypoxic conditions have been observed in the spring and summer during research cruises in 1987 through 1989 (Brooks and Giammona 1991) and 1998 through 2000 (Jochens et al. 2002).

The Mississippi-Alabama shelf sediments are strongly influenced by fine sediments discharged from the Mississippi River. The shelf area is characterized by a bottom nepheloid layer and surface lenses of suspended particulates that originate from river outflow. The West Florida Shelf receives very little sediment input. The water clarity is higher toward Florida, where the influence of the Mississippi River outflow is rarely observed.

Pollutant Sources. Analysis of water, sediments, and biota for hydrocarbons between 1974 and 1977 indicated that the Mississippi, Alabama, and Florida (MAFLA) area is pristine, with some influence of anthropogenic and petrogenic hydrocarbons from river sources (SUSIO 1977; Dames and Moore, Inc. 1979). Analysis of trace metal contamination for the nine trace metals analyzed (barium, cadmium, chromium, copper, iron, lead, nickel, vanadium, and zinc) also indicated no contamination sources (SUSIO 1977; Dames and Moore, Inc. 1979). A study done between 1987 and 1989 indicated that high molecular-weight hydrocarbons can come from natural petroleum seeps at the seafloor or recent biological production as well as input from anthropogenic sources (Brooks and Giammona 1991). The primary source of petroleum hydrocarbons and terrestrial plant material on the Mississippi-Alabama shelf is the Mississippi River. Higher levels of hydrocarbons were observed in late spring, coinciding with increased river influx. The sediments, however, are washed away later in the year, as evidenced by low hydrocarbon values in winter months. Contamination from trace metals was not observed (Brooks and Giammona 1991).

Several small rivers and the Loop Current are the primary influences on water quality on the shelf from DeSoto Canyon to Tarpon Springs and from the coast to a 200-m (656-ft) water depth (SAIC 1997). Because there is very little onshore development in this area, the waters and surface sediments are uncontaminated. The Loop Current flushes the area with clear, low-nutrient water (SAIC 1997).

3.4.1.2.3 Deep Water. Limited information is available on the deepwater environment of the GOM. Water at depths greater than 1,400 m (4,600 ft) is generally relatively homogeneous with respect to temperature, salinity, and oxygen (Nowlin 1972; Pequegnat 1983; Gallaway and Kennicutt 1988). A dissolved-oxygen low appears to occur at water depths of between 250 and 750 m (820 and 2,460 ft), depending upon the location within the GOM (Nowlin 1972). Pequegnat (1983) has pointed out the importance of the flushing time of the GOM. Jochens et al. (2005) provided a summary of estimated flushing rates presented in the literature, which range from 3 to 270 yr for different areas of the GOM. The waters of the western and southwestern GOM are estimated to have longer flushing times than the rest of the GOM; however, flushing rates are uncertain and are not well understood in the deepwater zone (Jochens et al. 2005). Investigations of historical oxygen data for the GOM and modeling of the distribution indicate that oxygen levels in the deep GOM would suffer only localized impacts from activities, but basin-wide decreases in oxygen would not occur (Jochens et al. 2005).

Limited analyses of trace metals and hydrocarbons for sediments exist, and water column measurements are primarily limited to salinity, temperature, and nutrients (Trefry 1981; Gallaway and Kennicutt 1988; CSA 2006; Rowe and Kennicutt 2009). Between 2000 and 2002, MMS completed two studies to measure concentrations of organics, metals, and nutrients in sediments in the deepwater zone (CSA 2006; Rowe and Kennicutt 2009). These studies helped to create a baseline of information related to the ecological function of these sediments, the extent of naturally occurring organics, and the impacts seen from OCS oil and gas activities. The study by Rowe and Kennicutt (2009) reported total PAH concentrations in deepwater sediments of between 0.02 and 1.0 mg/kg. Measurements of PAHs obtained by CSA (2006) in the vicinity of exploration and production wells mostly fell into the same range, with the exception of two samples within a 300-m (984-ft) radius of one of the well sites that had PAH concentrations of 3.5 and 23.8 mg/kg. The authors hypothesized that the source of the PAH was from some contaminant from the drilling or production activity (CSA 2006).

Hydrocarbon (oil) seeps are extensive throughout the continental slope and naturally contribute hydrocarbons to the sediments and water column (Sassen et al. 1993a). Remote sensing techniques have identified approximately 350 natural seeps in the northern half of the GOM (Kvenvolden and Cooper 2003). Estimates of the total volume of seeping oil in the northern half of the GOM vary widely from 29,000 barrels per year (bbl/yr) (MacDonald 1998) to 520,000 bbl/yr (Kvenvolden and Cooper 2003). When combined with estimates of oil seeping into the southern portion of the GOM, the estimated volume of oil seeping into the GOM is approximately 1.0 million bbl/yr (Kvenvolden and Cooper 2003). These estimates used satellite data and an assumed slick thickness. At hydrocarbon seeps, pore water of three different origins has been identified to leak out in addition to hydrocarbons: (1) seawater trapped during the settling of sediments, (2) briny fluid that is associated with the dissolution of underlying salt deposits, and (3) highly saline deep-seated formation waters (Fu and Aharon 1998; Aharon et al. 2001). The first two fluids leak out in the vicinity of carbonate deposits, while the third is rich in barium and is associated with barite deposits such as chimneys (Fu and Aharon 1998).

3.4.1.3 Climate Change Effects

Water quality in the GOM is expected to be affected by climate change (Ning et al. 2003). A thorough discussion of the impacts of climate change to the baseline environment can be found in Section 3.3. Anticipated sea-level rise would cause salinity increases in estuaries and lead to increases in coastal erosion (Nicholls et al. 2007). Changes in precipitation in the large fluvial drainage areas that contribute to the GOM (see Figure 3.2.1-4) are anticipated to change the quantity and timing of runoff that enters into the GOM. Significant changes in runoff would impact salinity in the coastal waters of the GOM, change coastal water circulation, and also impact the quantities of contaminants carried to the GOM, including suspended solids, heavy metals, pesticides, oil and grease, and nutrients. Increased runoff would likely deliver increased amounts of nutrients, increase the stratification between warmer fresher and colder saltier water, and potentially lead to eutrophication of estuaries and increase the potential for harmful algal blooms that can deplete oxygen levels (Justic et al. 1996; Karl et al. 2009). Reductions of freshwater flows in rivers or prolonged drought periods could increase the salinity in coastal ecosystems (Twilley et al. 2001). Ocean temperatures in the upper 700 m (2,300 ft) increased by 0.10°C (0.18°F) between 1961 and 2003 (Bindoff et al. 2007). Future sea surface temperature increases are anticipated and would affect chemical and microbial processes in coastal and marine environments. Rising temperatures are anticipated to lead to increased thermal stratification, increased coral bleaching and mortality, and increased algal blooms, but other impacts are difficult to predict, due to the complexity of ecological processes (Nicholls et al. 2007). In addition, ocean pH values are anticipated to decrease by up to 0.35 pH units over the 21st century, leading to ocean acidification (IPCC 2007a).

3.4.1.4 Deepwater Horizon Event

On April 20, 2010, the Deepwater Horizon drilling platform collapsed leading to the largest offshore oil spill in U.S. history, the Deepwater Horizon event (DWH event) (OSAT 2010). It is estimated that between April 22 and July 15, 2010, approximately 4.9 million barrels (with an uncertainty of plus or minus 10%) of oil were released from the well and 4.1 million barrels were released into the GOM from the DWH event (Lubchenco et al. 2010; TFISG 2010; McNutt et al. 2011). Hydrocarbon flow rates from the spill were independently verified using direct acoustic measurement methods (Camilli et al. 2011). A potential lower limit of fluids released into the GOM during the DWH event is presented by Ryerson et al. (2011). Analysis of event video footage led scientists to conclude that the majority of the volume of the release of the DWH event was hydrocarbon gases, and oil comprised 44% of the volume of the release (TFISG 2010). Reddy et al. (2011) estimated that the total quantity of gas released into the water column during the DWH event was 170 million kg (190,000 tons) of hydrocarbon gases and Joye et al. (2011) estimated that the DWH event released 450 million kg (500,000 tons) of hydrocarbon gases at depth. In addition, approximately 7,000 m^3 (1.84 million gal) of the chemical dispersants COREXIT 9500A and COREXIT 9527 were used on the DWH event (National Commission 2011a). Of the total volume, approximately 2,900 m^3 (771,000 gal) of chemical dispersants were applied directly to the DWH wellhead at a depth of about 1,500 m (4,900 ft) below the water surface, which was the first application of dispersants at the source of a subsea spill (Kujawinski et al. 2011).

An estimate of the fate of the oil (as of August 2010, when the well was capped) was released by the National Incident Command (NIC) in August 2010; findings were as follows: 25% of the oil was estimated to be removed by burning, skimming, and direct recovery from the wellhead; 25% was estimated to have evaporated or dissolved into the water column; 24% was estimated to be dispersed into the water column; and 26% was estimated to remain as oil on or near the water surface, onshore oil that remains or has been collected, and oil that is buried in sand and sediments (Lubchenco et al. 2010). As of August 2010, oil that was reported to be dissolved or was dispersed into the water column, and thus remaining in the environment, was estimated to be between 2.9 and 3.2 million bbl by a group of academics organized by the Georgia Sea Grant (Hopkinson 2010). It should be noted that the studies by Lubchenco et al. (2010) and Hopkinson (2010) had different methodologies; Hopkinson (2010) considered dissolved and dispersed oil to be residual oil remaining in the environment.

The principal impacting factors to GOM water quality from the DWH event were (1) the release of oil, (2) the release of gas, and (3) the use of chemical dispersants. Impacts of the DWH event on water quality have been monitored by various Federal and State agencies and by the academic community. The December 17, 2010, report released by the Operational Science Advisory Team of the Unified Area Command (OSAT) summarized water and sediment quality data measuring concentrations of oil- and dispersant-related chemicals collected from the start of the DWH event through October 23, 2010 (OSAT 2010). The OSAT is a group of Federal scientists and stakeholders that was put together by the Unified Area Command to collect data to inform cleanup operations, restoration activities, research, and the Natural Resources Damage Assessment (NRDA) process (OSAT 2010). As of January 20, 2011, a total of 13,677 water samples and 4,506 sediment samples had been taken to support the NRDA process (NOAA 2011g). Shoreline Cleanup Assessment Team (SCAT) observations indicated that oiling along barrier islands and coastal areas in Louisiana, Mississippi, Alabama, and Florida during and after the DWH event persisted on some shorelines as of January 2011 (Geoplatform 2011a,b). As of January 20, 2011, 134 km (83 mi) of shoreline were classified as heavily or moderately oiled (NOAA 2011c). 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).

The oil that leaked during the DWH event is known as light sweet crude oil and has many chemical constituents. To evaluate the impacts of the DWH event on the environment, the USEPA selected “benchmark” concentrations of 41 hydrocarbon compounds and two metals found in the oil from the DWH event for human health, aquatic health, and sediment (OSAT 2010). The compounds include 7 volatile organic compounds (VOCs), 16 parent PAHs, and 18 derivative compounds of the PAHs (OSAT 2010). The composition of the oil from the DWH event varies with the state of weathering of the oil; lighter-end components are removed more quickly than the heavier-end components (Core and Technical Working Groups 2010). Some of the constituents released during the DWH event evaporated at the surface, some compounds underwent photo-oxidation at the surface, and some constituents rapidly dissolved into the GOM waters before the oil reached the surface. 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). Other constituents remained in the water column and bottom sediments for longer periods (OSAT 2010). In addition, the chemical dispersant used during the spill has been tracked in the GOM by measuring concentrations of 2-butoxyethanol, dipropylene glycol n-butyl ether (DPnB), propylene glycol, and dioctyl sulfosuccinate (DOSS) — four of its traceable constituents — and comparing those concentrations to water quality aquatic life benchmarks set by the USEPA (OSAT 2010). Areas contacted by the event were identified by tracking certain constituents. Other chemicals associated with the event include other surface washing agents, which are used to lift oil off of shoreline surfaces and further prevent those surfaces from becoming sources of pollution (NOAA 2011a).

Both short-term and long-term impacts from the DWH event on water quality in the GOM are currently being assessed. The current understanding of the status of water quality in coastal and marine areas as a result of the event will be discussed below.

3.4.1.4.1 Effects of Deepwater Horizon Event on Coastal Water Quality. As a result of the DWH event, oil was present on the surface as well as dispersed and in suspension below the surface in coastal areas (OSAT 2010). The NRDA process has collected a large amount of data, and as of December 1, 2010, approximately 6,400 linear km (4,000 linear mi) of shoreline had been assessed by NRDA teams for oil contamination (NOAA 2010a). Data from regional SCAT teams indicates that oil contamination persisted on some GOM shorelines as of March 2012. As of December 20, 2010, the Louisiana SCAT team observations indicated tar balls and varying degrees of oiling were still present on the shoreline, marshes, and barrier islands of Louisiana. As of January 5, 2011, Mississippi, Alabama, and Florida SCAT team observations indicated varying degrees of oiling were present on portions of the barrier islands and shoreline in Mississippi, Alabama, and western Florida (Geoplatform 2011a,b). Much of the oil residue from the DWH event has been removed by natural attenuation and, to some degree, cleanup efforts along the shoreline (OSAT-2 2011). As of January 20, 2011, 134 km (83 mi) of shoreline were classified as heavily or moderately oiled; 1,694 km [1,053 mi] of shoreline had been found to be oiled out of a total of 6,783 km [4,215 mi] of shoreline surveyed (NOAA 2011c). NOAA has not published an updated summary of surveyed versus oiled shoreline since the January 2011 summary. SCAT observations in March 2012 indicated that oiling still persisted in some areas along barrier islands and coastal areas in Louisiana, Mississippi, Alabama, and Florida (ERMA 2012a,b).

OSAT reported that all water samples collected after August 3, 2010 (in waters deeper than 10 ft), indicated that oil- and dispersant-related chemicals were below levels set by the USEPA to be chronically toxic to humans and aquatic life. The OSAT report also identified some residual contamination remaining in shallow waters in the form of tar mats, defined as "submerged sedimented oil," located in the subtidal zone. The OSAT (2010) report indicated the need to further define the tar mats and evaluate them as a potential source of shoreline contamination through "re-oiling." In February 2011, the OSAT published a second report focused on remnant oil along shorelines in the GOM (OSAT-2 2011). 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 when compared with the potential negative impact to those resources that could be sustained through prolonged cleanup activities. Hayworth et al. (2011) and Hayworth and Clement (2011) provide an evaluation of the effectiveness of beach cleanup activities in Alabama as of mid-2011. In these articles, the authors document the presence of residual oil in the beach system and note important steps to take to minimize the impacts and increase effective documentation of potential impacts in the future. Suggestions include creating a master sampling plan, examining more effective beach cleanup techniques, and creating baseline assessments of inhabitants of these beach ecosystems.

OSAT (2010) defined nearshore waters as those within 5.6 km (3 nautical mi; 3.5 linear mi) of the coastline, which are also defined as "State" waters in most cases. Visible oil was first found in nearshore waters on approximately May 15, 2010, in Louisiana and June 1, 2010, for Alabama, Mississippi, and Florida. Nearshore water and sediment quality were sampled before oil reached the nearshore zone, starting in late April, to create a baseline/

reference dataset (OSAT 2010). Concentrations of oil-indicator and dispersant chemicals were measured in samples to determine the presence or absence of impacts from the event. The concentrations of those chemicals were then compared with the human health and ecological health benchmarks set by the USEPA as indicators of health risks. Findings of indicator concentrations of oil- and dispersant-related chemicals were also compared to the composition of the oil from the DWH event to rule out samples that may have been contaminated by other sources (e.g., oil leaks from boats). Samples that were found to be of indeterminate origin were considered to be the oil from the DWH event. Results of the water and sediment quality sampling are detailed in Table 3.4.1-1 and indicate that there were very few exceedances of the benchmarks set by the USEPA. No exceedances of the human health benchmark for oil-related chemicals or the aquatic life benchmark for dispersant-related chemicals were measured in samples. Sampling after August 3, 2010, found traces of oil and dispersant remaining in the nearshore zone, but all samples that exceeded water and/or sediment quality benchmarks were not consistent with the oil from the DWH event (OSAT 2010).

Wong et al. (2011) found that sediments collected in October 2010 along GOM shorelines that were found to contain oil contamination likely from the DWH event were directly correlated with the location of the full extent of the surface oil slick. Ninety percent of the shoreline sediment samples collected contained at least a trace of oil (Nowell et al. 2011). The chemical signature of 39% of the sediment samples and tar balls collected along the shorelines of Louisiana, Alabama, Mississippi, and Florida matched that of the oil released during the DWH event (Nowell et al. 2011).

3.4.1.4.2 Effects of Deepwater Horizon Event on the Continental Shelf. The December 17, 2010, OSAT report summarized data collected measuring concentrations of oil- and dispersant-related chemicals in water and sediment from the start of the event through October 23, 2010. The OSAT (2010) report defined the offshore zone as those waters between 5.6 km (3 nautical mi) of the coastline (boundary of “State” waters) to the 200-m (656-ft) bathymetric contour. Concentrations of oil- and dispersant-indicator chemicals were measured in samples to determine the presence or absence of impacts from the event. The concentrations of those chemicals were then compared with the human health and ecological health benchmarks set by the USEPA as indicators of health risks. Findings of indicator concentrations of oil- and dispersant-related chemicals were also compared to the composition of the oil from the DWH event to rule out samples that may have been contaminated by other sources (e.g., oil leaks from boats, oil from natural seeps). Results of the water and sediment quality sampling are detailed in Table 3.4.1-1 and indicate that there were very few exceedances of the benchmarks set by the USEPA. No exceedances of the human health benchmark for oil-related chemicals or the aquatic life benchmark for dispersant-related chemicals were measured in water samples, and no exceedances of the aquatic life benchmark for oil-related chemicals were measured in sediment samples. Sampling after August 3, 2010, found traces of oil and dispersant remaining in the offshore zone, but no samples taken after this time had concentrations that exceeded water quality benchmarks (OSAT 2010). A summary of offshore water quality sampling data available by January 5, 2011 is presented by Boehm et al. (2011) and focuses on concentrations of total PAH through time and space after the DWH event. Edwards et al. (2011) reports high observed

TABLE 3.4.1-1 Summary of Results of Water and Sediment Quality Sampling from the Deepwater Horizon Event as of October 23, 2010[a]

Sample Type	Total Samples	Number of Detects	Samples Exceeding Benchmark[b]	Exceedances Consistent with Oil from DWH Event
Nearshore Zone[c]				
Oil-Related Chemicals				
Water quality sample compared to human health benchmark[b]	6,090	2,685	0	0
Water quality sample compared to aquatic life benchmark	5,773	395	41	22
Sediment quality sample compared to aquatic life benchmark	1,136	441	24	13
Dispersant-Related Chemicals				
Water quality sample compared to aquatic life benchmark	5,262	60	0	0
Sediment quality sample	412	6	NA[d]	NA
Offshore Zone[e]				
Oil-Related Chemicals				
Water quality sample compared to human health benchmark[b]	750	242	0	0
Water quality sample compared to aquatic life benchmark	481	283	6	6
Sediment quality sample compared to aquatic life benchmark	268	207	0	0
Dispersant-Related Chemicals				
Water quality sample compared to aquatic life benchmark	440	199	0	0
Sediment quality sample	242	1	NA	NA
Deepwater Zone[f]				
Oil-Related Chemicals				
Water quality sample compared to human health benchmark[b]	4,794	673	0	0
Water quality sample compared to aquatic life benchmark	3,612	821	70	63
Sediment quality sample compared to aquatic life benchmark	120	114	7	7
Dispersant-Related Chemicals				
Water quality sample compared to aquatic life benchmark	4,114	353	0	0
Sediment quality sample	120	1	NA	NA

[a] Data as presented in OSAT (2010).

[b] Values of the USEPA benchmarks are presented in the report by OSAT (2010).

[c] Nearshore zone is defined as coastal waters out to 5.6 km (3 nautical mi) from the shoreline (State waters).

[d] NA = No sediment quality benchmarks were established for dispersant-related chemicals.

[e] Offshore zone is defined as waters from 5.6 km (3 nautical mi) of the shoreline to a depth of 200 m (656 ft).

[f] Deepwater zone is defined as waters deeper than 200 m (656 ft).

rates of bacterial degradation within the surface oil slick, despite nutrient limitations thought to inhibit oil respiration.

3.4.1.4.3 Effects of Deepwater Horizon Event on Deep Water. The December 17, 2010, OSAT report summarized oil- and dispersant-related chemical concentrations in water and sediment from the start of the DWH event through October 23, 2010. The OSAT (2010) defined the deepwater zone as those waters beyond the 200-m (656-ft) bathymetric contour. Concentrations of oil- and dispersant-indicator chemicals were measured in samples to determine the presence or absence of impacts from the DWH event. The concentrations of those chemicals were then compared with the human health and ecological health benchmarks set by the USEPA as indicators of health risks. Findings of indicator concentrations of oil- and dispersant-related chemicals were also compared to the composition of the oil from the DWH event to rule out samples that may have been contaminated by other sources (e.g., oil leaks from boats, oil from natural seeps). Results of the water and sediment quality sampling (Table 3.4.1-1) indicate that there were very few exceedances of the benchmarks set by the USEPA. No exceedances of the human health benchmark for oil-related chemicals or the aquatic life benchmark for dispersant-related chemicals were measured in samples. Sampling after August 3, 2010, found traces of oil and dispersant remaining in the deepwater zone, and 7 out of 18 sediment samples taken within 3 km (2 mi) of the wellhead exceeded the aquatic life sediment quality benchmark and were consistent with the oil from the DWH event (OSAT 2010).

Camilli et al. (2010) conducted a subsurface hydrocarbon study two months after the start of the DWH event (depth 1,500 m [4,921 ft]) in the GOM while oil was still being released from the wellhead. They 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. 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 micrograms per liter. The plume persisted for months at this depth with no substantial biodegradation. They also measured concentrations throughout the water column and found similarly high concentrations of aromatic hydrocarbons in the upper 100 m (328 ft). Polycyclic aromatic hydrocarbons were found at very high concentrations (reaching 189 micrograms per liter) by Diercks et al. (2010) after the DWH event at depths between 1,000 and 1,400 m (3,281 and 4,593 ft) extending as far as 13 km (8 mi) from the subsurface DWH event site.

Joye et al. (2011) estimated that the DWH event released 450 million kg (500,000 tons) of hydrocarbon gases at depth. During a research cruise in May/June 2010, Joye et al. (2011) found high concentrations of dissolved hydrocarbon gases (methane, ethane, propane, butane, and pentane) in a water layer between 1,000 and 1,300 m (3,281 and 4,265 ft) (Joye et al. 2011). These concentrations exceeded the background concentration of hydrocarbon gases by up to 75,000 times. Results from a study by Yvon-Lewis et al. (2011) showed that, beginning 53 days after the DWH event and for 7 days of continuous chemical analysis at sea, there was a low flux of methane from the DWH event to the atmosphere. Based on these methane measurements at the surface water and concurrent measurements at depth, they concluded that the majority of methane from the DWH event remained dissolved in the deep ocean waters (Yvon-Lewis et al. 2011). Valentine et al. (2010) reported that two months after the DWH event, propane and ethane gases at depth were the major gases driving rapid respiration by bacteria. They also found these gases at shallower depths but at concentrations that were orders of magnitude lower (Valentine et al. 2010).

Methane release in the DWH event and biodegradation by deepwater methanotrophs were studied by Kessler et al. (2011). They found that a deepwater bacterial bloom respired the majority of the methane in approximately 120 days. Similarly, Hazen et al. (2010) found indigenous bacteria at 17 deepwater stations biodegrading oil 2–3 months after the DWH event. Atlas and Hazen (2011) provide an overview of the biodegradation processes found in the dispersed plume of oil, surface water, and sediments in response to hydrocarbons released during the DWH event.

The fate of the estimated 771,000 gallons of chemical dispersants injected at the DWH wellhead near the seafloor (1,500 m [4,921 ft]) was studied by Kujawinski et al. (2011). Their results show that the anionic surfactant DOSS (dioctyl sodium sulfosuccinate) ingredient in the dispersants injected at the wellhead was concentrated in hydrocarbon plumes at 1,000–1,200 m (3,281–3,937 ft) depth 64 days after dispersant application was stopped and as far away as 300 km (186 mi). They concluded that the chemical dispersants at this depth underwent slow rates of biodegradation (Kujawinski et al. 2011). Kujawinski et al. (2011) did not draw conclusions as to the toxicity of the dispersant or dispersant-oil mixtures found at depth; the dispersant concentrations and dispersant-to-oil ratios measured were lower than those published in toxicology studies, and the authors identified a need for further studies assessing the impact of dispersant-oil mixtures on pelagic biota.

3.4.2 Alaska – Cook Inlet

The term water quality describes the overall condition of water, reflecting its particular biological, chemical, and physical characteristics. It is an important measure for both ecological and human health. Water quality is most often discussed in reference to a particular purpose or use of the water, such as recreation, drinking, or ecosystem health. Alaska State and Federal laws define the type of water quality that must be maintained for these purposes.

Alaska marine waters are a mixture of several sources — atmospheric (precipitation), rivers, streams, groundwater, snowmelt, glacier-melt, ice-melt, and oceanic sources such as vents on the deep seafloor. Constituents in marine waters come into the system naturally (biogenic) and are introduced by humans (anthropogenic). Climate change is affecting the sources and constituents of marine water as increasing carbon dioxide and increasing air temperatures force changes in seawater acidification, seawater temperature, and related water quality variables.

Precipitation, snowmelt, glaciers, and groundwater springs feed the many lakes, streams, ponds, and wetlands throughout Alaska. High tundra, muskeg, willow-alder habitats, and alpine bedrock feed constituents into these freshwater systems. Rivers originating in headwaters introduce and transport sediment into the drainage basins on a seasonal basis. Volcanic eruptions have also played an important role in contributing chemical constituents to the freshwater systems of Alaska.

In Alaska, there are several seasonal or occasional natural events that contribute to water quality and to which natural systems are adapted. Examples of these events include hydrocarbons from natural oil seeps, sediment from natural coastal erosion, sediment derived from glacial-fed rivers, natural levels of nutrients from river flooding, and metals from river sediments, volcanic eruptions, and rock erosion (AMAP 1997, 2002). Several metals, such as zinc and iron, in very low natural concentrations are essential for life processes in the marine environment (Ezoe et al. 2004).

The Alaska OCS water quality to date has received relatively little contribution from the more common land-based and marine anthropogenic pollution found in the Lower 48 States. The rivers that originate in Alaska and flow into coastal marine waters remain relatively unpolluted by human activities. Industrial and shipping impacts on water quality have been and are relatively low at this time, with some notable exceptions of events such as the *Exxon Valdez* oil spill and the *Selendang Ayu* and other ship groundings or accidents.

There are, however, several sources of anthropogenic contaminants in the Alaska marine environment. They travel through pathways to the arctic marine ecosystem including deposition from the atmosphere, discharges to the sea, drifting sea ice, or directly from accidental or intentional dumping of pollutants. Water quality pollutants arrive in Alaska from sources both within and outside the circumpolar environment. The types of pollutants that come from these near and distant sources include oil-based hydrocarbons, manufactured chemicals, metals (e.g., mercury, lead, cadmium), nutrients loads, high sediment loads (nonpoint runoff of disturbed lands), organic waste (e.g., seafood processing), and radionuclides (from radioactive materials).

Persistent organic pollutants (POPs) are a category of anthropogenic pollutants that are particularly resistant to degradation in the environment. POPs have a potential for long-range transport, and they accumulate in concentrations in aquatic species. Polyaromatic hydrocarbons (PAHs), a byproduct of burning hydrocarbon fuel, and polychlorinated biphenyls (PCBs), used in manufacturing products, are two persistent organic pollutants found in the Alaska (AMAP 2004).

Many of these pollutants concentrate in animals and bioaccumulate as they move through the food web. Contaminated animals can then transport the pollutant into or away from the Arctic (AMAP 2004). Migratory whales, migratory seabirds, and salmon species are examples of pollutant transporters through the marine aquatic system.

Human society sometimes discharges into the environment constituents that also occur naturally in the ecosystem. These anthropogenic discharges, however, are different than the biogenic sources because they occur in greater concentrations and often suddenly; the chemical bondings are different than what is found in the natural system; the discharges occur outside the area that they would naturally occur; or they occur out of phase of the natural cycle of the same biogenic contributions to the system. Examples of anthropogenic constituents include sediment, metals, and hydrocarbons.

The Cook Inlet Planning Area is located in south central Alaska and has a watershed of approximately 100,000 km^2 (38,600 m^2) (Saupe et al. 2005). The continental shelf off of south central Alaska supports a productive ecosystem that includes numerous species of fishes, marine mammals, sea birds, and invertebrates. The Cook Inlet watershed is home to two thirds of the population of the State of Alaska; therefore, runoff in the watershed is influenced by human activity more than in any other region in Alaska (Saupe et al. 2005). The principal point sources of anthropogenic contaminants in Cook Inlet are discharges from municipalities, seafood processors, and the petroleum industry (MMS 1996b). Point source pollution is rapidly diluted by the energetic tidal currents in the Cook Inlet, and it is estimated that 90% of the water in the Cook Inlet is flushed every 10 months (MMS 2003a). The State of Alaska has identified several coastal impaired water bodies throughout the south central coastal area that have total maximum daily load (TMDL) restrictions implemented or remain on the Clean Water Act 303(d) list of impaired water bodies with TMDLs planned to be implemented by 2013 (ADEC 2010a). The impaired areas are all relatively small and are mainly affected by urban runoff, timber harvest, or seafood processing (ADEC 2010a). These small impaired areas would not have an appreciable effect on marine water quality. The coastal waters of south central Alaska have recently been assessed to be in good condition by the USEPA National Coastal Condition Report, and were deemed to be in better condition than any other U.S. coastal waters assessed for the report (USEPA 2008).

Cook Inlet waters are influenced by riverine and marine inputs. During summer and fall, surface salinity varies from 32% at the entrance to lower Cook Inlet to approximately 26% at the West Forelands (Rosenberg et al. 1967; Kinney et al. 1970; Wright et al. 1973; Gatto 1976; Muench et al. 1978). Oxygen levels measured in May 1968 in the surface waters of Cook Inlet ranged from about 7.2 to 11.0 mL/L (Kinney et al. 1970). None of the waters in the inlet were found to be oxygen depleted, because of the strong tidal currents in the inlet that mix the entire water column (Kinney et al. 1970).

The distribution of suspended particulate matter in Cook Inlet shows horizontal gradients in both the longitudinal and cross-inlet directions (Feely and Massoth 1982). The suspended particulate matter concentrations are higher (up to 2,000 parts per million [ppm]) in the northeastern end of upper Cook Inlet and decrease through the lower inlet (up to 100 ppm) depending on inputs from rivers at the time of measurement (Kinney et al. 1970; Wright et al. 1973; Sharma 1979; Feely and Massoth 1982; Saupe et al. 2005).

The activities associated with petroleum exploitation in State waters that are most likely to affect water quality in the Cook Inlet are (1) the permitted discharges from exploration drilling units and production platforms and (2) petrochemical plant operations. The USEPA compared pollutant concentrations resulting from an estimated Cook Inlet discharge of cuttings generated while drilling with synthetic-based fluid to both Federal criteria and State water quality standards (because the projected discharges occur in State waters). There was no predicted exceedance of the Federal criteria or State water quality standards in the Cook Inlet (USEPA 2000). The National Research Council (NRC 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 water column and sediment contamination.

Sediment sampling for sediment quality was conducted in depositional areas in the outer portion of Cook Inlet in 1997 and 1998 (Boehm et al. 2001a). Analysis of dated sediment cores demonstrated that the concentration of hydrocarbons has not increased appreciably over the past few decades (since before State offshore oil exploration and production in Cook Inlet). The concentrations of total PAHs found by Boehm et al. (2001a) in the outer portion of Cook Inlet range from less than 120 to 490 parts per billion (ppb). The highest concentrations tend to occur in the southeast corner of Cook Inlet. These concentrations are the result of a combination of eroded coal and oil sources, plus seep oil being deposited in sediments by the coastal current entering Cook Inlet from the eastern Gulf of Alaska (Boehm et al. 2001a). The concentrations down current of Cook Inlet are actually diluted up to several-fold by Cook Inlet discharges. This results in the highest concentrations of hydrocarbons existing in coastal sediments where the influence of estuarine Cook Inlet discharges is smallest, particularly in eastern lower Cook Inlet (Boehm 2001). Water and sediment quality were also sampled in 2002 by the USEPA and the Alaska Department of Environmental Conservation (ADEC) for the National Coastal Assessment Program (Saupe et al. 2005). Total PAH concentrations in sediments of Cook Inlet ranged from less than 10 ppb to 840 ppb, with the majority of samples having concentrations less than 150 ppb (Saupe et al. 2005). No persistent organic contaminants, such as PCBs or dichlorodiphenyltrichloroethanes (DDTs) were detected in sediments during sampling in 2002 (Saupe et al. 2005). Sampling for metals concentrations in sediment indicate that levels of most metals are below a range to produce effects (as defined by the ADEC); however, concentrations of nickel and chromium in sediments were found to exceed the threshold for effects at three stations and one station, respectively, within the Cook Inlet (Saupe et al. 2005). Measurements of sediment total organic carbon taken in 1971 were found to be low and suggestive of an unpolluted environment (MMS 2003a).

Hydrocarbons are found throughout the waters of Cook Inlet in generally low concentrations. Natural oil seeps occur on the west side of the Cook Inlet, which release hydrocarbons from biogenic sources (Saupe et al. 2005). Concentrations generally are similar to those found in other unpolluted coastal areas.

3.4.2.1 Climate Change Effects

Climate change is anticipated to impact water quality of the Cook Inlet. A thorough discussion of the impacts of climate change to the baseline environment can be found in Section 3.3. Anticipated sea-level rise would cause salinity increases in estuaries and lead to increases in coastal erosion (Nicholls et al. 2007). Increases in precipitation are anticipated to increase the quantity of runoff that enters into Cook Inlet (IPCC 2007a). Significant changes in runoff would impact salinity in Cook Inlet, change water circulation and stratification in Cook Inlet, and also impact the quantities of suspended solids and nutrients delivered to Cook Inlet (ACIA 2005). In addition, anticipated thaw of permafrost would increase susceptibility to erosion and landslides, which could lead to increased input of suspended solids to Cook Inlet (ACIA 2005). Ocean temperatures in the upper 700 m (2,300 ft) increased by 0.10°C (0.18°F) between 1961 and 2003 (Bindoff et al. 2007). Future sea surface temperature increases are anticipated and would affect chemical and microbial processes in coastal and marine environments (Nicholls et al. 2007). Coastal erosion is anticipated to increase due to climate change (Alaska Regional Assessment Group 1999). In addition, ocean pH values are anticipated to decrease by up to 0.35 pH units over the 21st century, leading to ocean acidification (IPCC 2007a).

3.4.3 Alaska – Arctic

The term water quality describes the overall condition of water, reflecting its particular biological, chemical, and physical characteristics. It is an important measure for both ecological and human health. Water quality is most often discussed in reference to a particular purpose or use of the water, such as recreation, drinking, or ecosystem health. Alaska State and Federal laws define the type of water quality that must be maintained for these purposes. General characteristics of water quality in Alaskan waters are presented above in Section 3.4.2.

Because of limited municipal and industrial activity around the Arctic Ocean coast, most pollutants occur at low levels in the Arctic. The rivers that flow into the Alaskan arctic marine environment remain relatively unpolluted by human activities, but they carry into the marine environment natural loads of suspended sediment particles with trace metals and hydrocarbons. Winds and drifting sea ice may play a role in the long-range redistribution of pollutants in the Arctic Ocean. The broad arctic distribution of pollutants is described in a report by the Arctic Monitoring and Assessment Program (AMAP 1997) entitled *Arctic Pollution Issues: A State of the Arctic Environmental Report*.

The areas of the Arctic region in the proposed action are in the Beaufort Sea and Chukchi Sea Planning Areas (Figure 3.4.3-1). Under Alternatives 5 and 6, leasing activity would be deferred in the Beaufort Sea and Chukchi Sea, respectively. In both seas, the water quality is relatively pristine. Degradation of water quality, where it occurs in the Arctic, is largely related to aerosol deposition and localized anthropogenic pollution from, for example, mining facilities and former military facilities (ADEC 2010a).

Water quality in the nearshore Arctic Ocean (landward of the 40-m [131-ft] water depth line) may be slightly affected locally by both anthropogenic and natural sources. Most detectable pollutants occur at very low levels in the arctic waters and/or sediments and do not pose an ecological risk to marine organisms (MMS 2003a). The State of Alaska does not identify any Clean Water Act Section 303(d) impaired water bodies within the Arctic region (ADEC 2010a). However, some annual water quality monitoring (temperature and total dissolved solids) is required for the Nearshore Beaufort Lagoons as a condition for oil and gas operations. The Nearshore Beaufort Lagoons were on the Clean Water Act 303(d) list for impaired water bodies between 1996 and 1998 for temperature and salinity, but mitigation measures have brought water quality into compliance with Alaska standards since 2002 (ADEC 2010a).

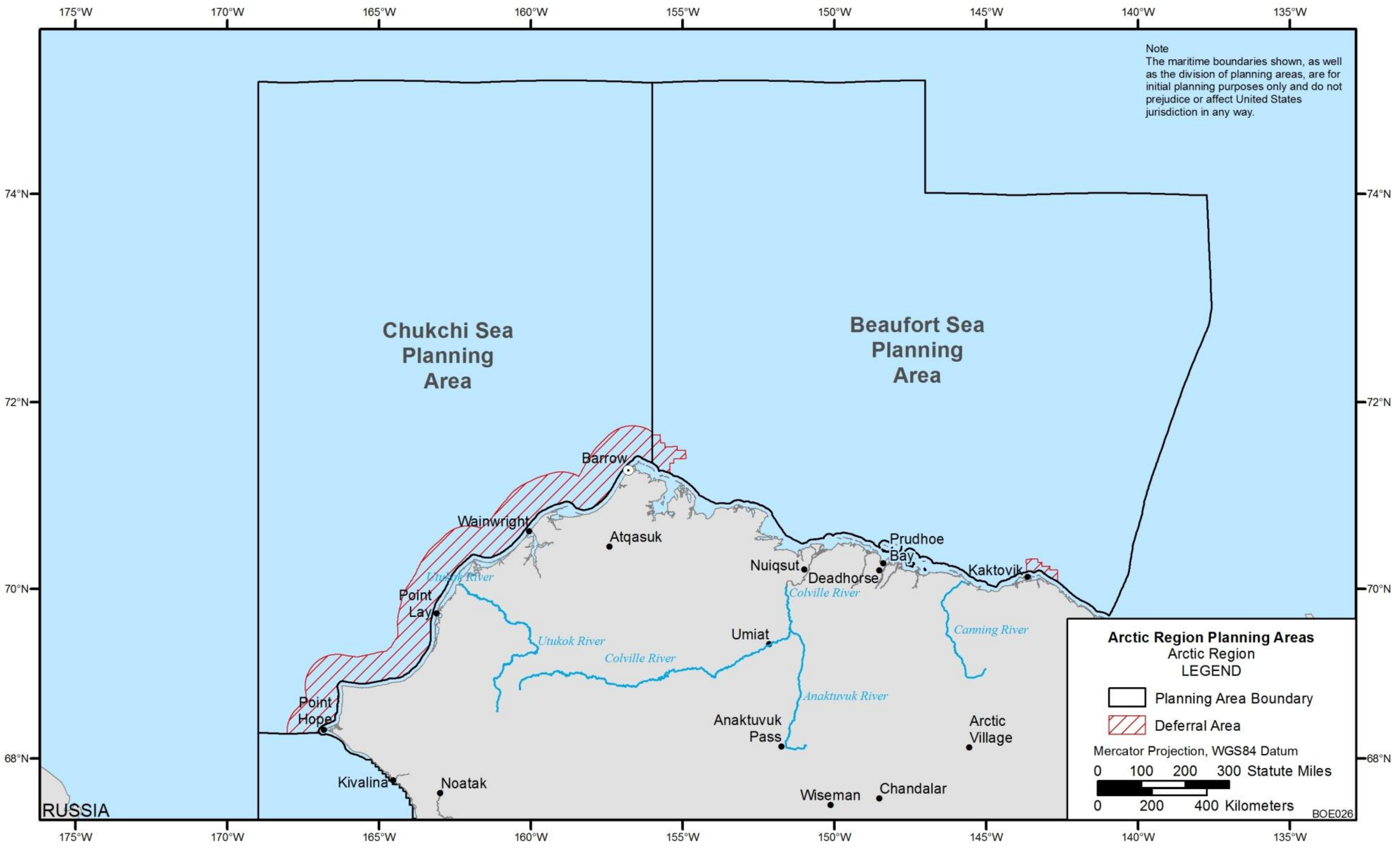


FIGURE 3.4.3-1 Beaufort Sea and Chukchi Sea Planning Areas

The primary rivers that flow into the arctic marine environment remain relatively unpolluted by human activities. They do, however, carry into the marine environment suspended sediment particles with some trace metals, hydrocarbons, and other pollutants. Suspended sediment concentrations are highest during the spring runoff, when rivers flow into the Arctic under landfast ice (Alkire and Trefry 2006). Plumes of river water can extend to 20 km (12.4 mi) under the ice, as mixing and wave action are low under the seasonal ice (Alkire and Trefry 2006).

Suspended sediment concentrations in the Beaufort Sea under summer conditions are usually low, but can be elevated by wind-wave activity in shallow waters closer to shore (less than 10 m [33 ft] deep) (Boehm et al. 2001b). Suspended sediment concentrations in the Beaufort Sea are estimated to be at background levels (Trefry et al. 2009). Water quality also is affected by natural erosion of organic material along the shorelines. The Chukchi is a high-energy shore once the ice is gone (MMS 2008b). Erosion and flooding occur with autumn and spring storms and ice movement (MMS 2008b). The increased oxygen demand of these inputs may marginally lower oxygen levels and locally increase turbidity. These effects usually occur in waters less than 5 m (16.4 ft) deep and do not generally extend seaward of the barrier islands. Another cause of altered water quality is sea ice cover (MMS 2008b). As sea ice forms during the fall, particulates are removed from the water column by ice crystals and are locked into the ice cover. The result is very low turbidity levels during the winter.

Dissolved and particulate trace metal concentrations in sediments of the Beaufort nearshore do not show evidence of significant impact from the nearby oil and gas activities in Prudhoe Bay (Naidu et al. 2001, 2005; Trefry et al. 2009). However, elevated concentrations of copper, lead, cadmium, silver, arsenic, antimony, nickel, mercury, and cobalt have been measured at a monitoring station near the West Dock in Prudhoe Bay and are assumed to be related to construction activity in the area (Boehm et al. 2001b). Results of monitoring activities around the Northstar site and the original proposed Liberty site also indicate that hydrocarbon and metals concentrations in sediments are not significantly influenced by anthropogenic input (Brown 2003). Trace-metal concentrations in the Chukchi are elevated compared to those in the eastern portions of the Arctic Ocean. The higher concentrations are thought to come from Bering Sea water that passes first through the Chukchi Sea and then through the Beaufort Sea (MMS 2008b). These waters, however, are considerably lower in trace-metal concentrations than the USEPA criteria for the protection of marine life (MMS 2008b). One potential source of anthropogenic input of trace metals is the Red Dog Mine. A study for the National Park Service (Hasselbach et al. 2005) showed extensive airborne transport of cadmium and lead; although the study was focused only on the Cape Krusenstern National Monument, these contaminants are probably carried out into the Chukchi Sea (Hasselbach et al. 2005).

Background hydrocarbon concentrations in Beaufort Sea waters appear to be biogenic and on the order of less than 1 ppb (Trefry et al. 2004). No seafloor oil seeps have been identified in the Beaufort or Chukchi Sea (Becker and Manen 1988). However, naturally occurring oil seeps have been identified onshore above the low-tide line along the coast of the Beaufort Sea (Becker and Manen 1988). Recent studies of sediments in Beaufort Lagoon, located in the eastern portion of the Alaskan arctic coast, have indicated that no anthropogenic hydrocarbon or metals contamination exists (Naidu et al. 2005). These sediment data will serve as a baseline against which to evaluate impacts to nearshore sediments from anthropogenic activities (Naidu et al. 2005). Hydrocarbon concentrations in sediments of the Beaufort Sea are relatively high compared with other nonpolluted marine areas (Steinhauer and Boehm 1992). Total saturated hydrocarbon concentrations in sampled sediments ranged from 2.5 to 36 mg/kg (Steinhauer and Boehm 1992; Brown 2003). PAH concentrations in the sediments ranged from 0.04 to 2.2 mg/kg, which are well below levels that have detrimental effects on the environment (Brown 2003; Naidu et al. 2001). Examination of sediment cores gives little indication that oil and gas activities in the area have measurably contaminated the sediments (Brown 2003), and molecular markers do not indicate input from oil and gas industrial activities (Naidu et al. 2001). However, concentrations of PAHs at a sampling site near West Dock in Prudhoe Bay show signs of elevated hydrocarbons when compared to the other sampling stations (Boehm et al. 2001b). Considering the limited sources of anthropogenic input to the area, concentrations of hydrocarbons in the Chukchi Sea are expected to be at background levels.

3.4.3.1 Climate Change Effects

Climate change is anticipated to impact water quality of the Beaufort and Chukchi Seas. A thorough discussion of the impacts of climate change to the baseline environment can be found in Section 3.3. Anticipated sea-level rise would cause salinity increases in estuaries and lead to increases in coastal erosion (Nicholls et al. 2007). Increases in precipitation are anticipated to increase the quantity of runoff that enters arctic waters (IPCC 2007a). Significant changes in runoff would impact salinity and also impact the quantities of suspended solids and nutrients delivered to the Beaufort and Chukchi Seas (ACIA 2005). In addition, anticipated thaw of permafrost would increase the susceptibility to erosion and landslides, which could lead to increased input of suspended solids to arctic waters (ACIA 2005). Ocean temperatures in the upper 700 m (2,300 ft) increased by 0.10°C (0.18°F) between 1961 and 2003 (Bindoff et al. 2007). Future sea surface temperature increases are anticipated and would affect chemical and microbial processes in coastal and marine environments (Nichols et al. 2007). Coastal erosion is anticipated to increase due to climate change, due to permafrost thaw (Alaska Regional Assessment Group 1999). Retreat of sea ice would increase impacts to coastal areas from storms, change the sea surface temperature and salinity, and alter ocean stratification (ACIA 2005). In addition, ocean pH values are anticipated to decrease by up to 0.35 pH units over the 21st century, leading to ocean acidification (IPCC 2007a).

3.5 METEOROLOGY AND AIR QUALITY

3.5.1 Climate

3.5.1.1 Gulf of Mexico

Most of the southern States, including the coastal areas along the GOM, have humid subtropical climates characterized by hot summers and mild winters, with high humidity in all seasons. These climates are classified as Cfa under the Köppen-Geiger climate classification system (Peel et al. 2007). The GOM is influenced by a maritime subtropical climate controlled mainly by the clockwise wind circulation around a semipermanent, high barometric pressure area alternating between the Azores and Bermuda Islands. The circulation around the western edge of the high pressure cell results in the predominance of moist southeasterly wind flow in the region. However, winter weather is quite variable. During the winter months, December through March, cold fronts associated with outbreaks of cold, dry continental air masses influence mainly the northern coastal areas of the GOM. Tropical cyclones may develop or migrate into the GOM during the warmer season, especially in the months of August through October. In coastal areas, the land-sea breeze is frequently the primary circulation feature in the months of May through October. Note that the following discussion is limited to the Western and Central Planning Areas and westernmost part of the Eastern Planning Area. Meteorological data summaries are based on two primary references: (1) local climatological data (NCDC 1995, 2011a) for coastal cities along the GOM and (2) meteorological data collected from the shoreline stations and buoy stations over open waters of the GOM (NDBC 2011).

For the coastal areas along the GOM, prevailing wind directions are generally from the southeast and the south, except for the coastal areas stretching from Alabama to the Florida Panhandle, where the prevailing wind is from the north (NCDC 1995, 2011a). Along the southern tip of Texas, southerly and southeasterly winds prevail throughout the year. Along the eastern coastal area (e.g., Pensacola, Florida), these wind components are limited to spring and early summer, and more northerly winds prevail during the rest of the year. Based on the National Data Buoy Center (NDBC) data in the Western and Central Planning Areas, southeasterly winds prevail (NDBC 2011). However, easterly winds are more frequent in the Eastern Planning Area. Near the coastal area in Alabama and the Florida Panhandle, the prevailing wind direction is from the north, the same as that for coastal cities (NCDC 2011a). Average wind speeds from the shoreline and buoy stations are relatively uniform, ranging from 5.2 to 6.4 m/s (11.6 to 14.3 mph), although anemometer heights vary from 5.0 to 30.5 m (16.4 to 100.1 ft). In general, wind speeds are highest in the winter months and lowest in the summer months, except for the shoreline stations in Texas where they are highest in May.

Ambient temperatures in the coastal areas and open waters of the GOM depend primarily on latitude and secondarily on proximity to the coastline. In the warmest month in the summer, average temperatures in the GOM coastal cities are relatively uniform, ranging from about 28 to 29 degrees Celsius (°C) (82 to 85 degrees Fahrenheit [°F]) (NCDC 1995, 2011a). During the warm months, there is little diurnal or spatial variation in temperature. Average temperatures for the coldest month in winter range from about 11°C (51°F) in the northern coastal cities to about 16°C (61°F) in the southernmost city in Texas. Ambient temperatures over the open GOM exhibit much smaller daily and seasonal variations due to the moderating effects of large bodies of water. Annual average temperatures range from 20°C (69°F) at the shoreline stations to 25°C (77°F) at open water buoy stations (NDBC 2011). Irrespective of the locations of NDBC stations, highest monthly temperatures, which occur mostly in August, are relatively uniform, ranging from about 28 to 29°C (82 to 84°F), which are similar to those in the coastal cities (NCDC 1995, 2011a). The lowest monthly temperatures occur mostly in January and vary depending on the location, ranging from 11°C (52°F) at the shoreline stations to 21°C (71°F) at open water buoy stations.

Humid subtropical climates exhibit abundant and fairly well-distributed precipitation throughout the year. Precipitation in the coastal cities along the GOM tends to peak in the summer months; lowest precipitation can occur in any of non-summer seasons. Annual mean precipitation tends to be heavier to the east than to the west of the GOM (NCDC 1995, 2011a). Annual precipitation ranges from 70.0 cm (27.55 in.) in Brownsville, Texas, to 168.4 cm (66.29 in.) in Mobile, Alabama. Rainfall in the warmer months is usually associated with convective cloud systems that produce showers and thunderstorms. Winter rains are associated with the passage of frontal systems through the area. Snowfall along the GOM is uncommon: highest annual snowfall along the coastal cities is about 1.0 cm (0.4 in.) (NCDC 1995, 2011a).

Due to the proximity of the GOM, the relative humidity over the coastal areas is high, especially for the northern coastal areas during the warmer months. Lower humidities in the winter season are associated with outbreaks of cool, dry continental air from the interior. Annual average relative humidities range from 75 to 79% for the coastal cities along the GOM (NCDC 1995, 2011a). Typically, the highest relative humidity occurs during the coolest part of the day (around sunrise), while the lowest relative humidity occurs during the warmest part of the afternoon.

Fog occurs occasionally in the cooler season as a result of warm, moist GOM air blowing over cool land or water surfaces. The days with heavy fog (visibility of 0.4 km [0.25 mi] or less) occur from 21 to 47 days per year along the GOM coastal cities (NCDC 1995, 2011a). The poorest visibility conditions occur from November through April. During air stagnation, industrial pollution and agricultural burning can also impact visibility.

Atmospheric stability plays an important role in dispersing gases or particulates emitted into the atmosphere. Vertical motion and pollution dispersion are enhanced in an unstable atmosphere and are suppressed in a stable atmosphere. Over land, the atmospheric stability is more variable, depending on the time of day, cloud cover, and wind speed. Under calm to low winds, the atmosphere tends to be unstable during the daytime due to surface heating by solar insolation and stable at night due to radiative cooling. Under higher wind speeds and/or greater cloud cover, the atmosphere tends to be neutral irrespective of time of day. For coastal areas along the GOM, unstable conditions occur about 20% of the time, while neutral and stable conditions each occur about 40% of the time (Doty et al. 1976). Different from overland behavior, there is no large sensible heat flux driven by solar radiation over water. In addition, heating and cooling of the water surface takes place slowly due to its high heat capacity. In general, the atmosphere over water tends to be neutral to slightly unstable, since there are usually positive heat and moisture fluxes.

The mixing height is the height above the surface through which relatively vigorous vertical mixing occurs, primarily through the action of atmospheric turbulence. When the mixing height is low (i.e., very little vertical motion), ground-level concentrations of pollutants will be relatively high because the pollutants are prevented from dispersing upward. Mixing heights commonly go through large diurnal variations due to solar heating and surface cooling. Mixing heights are generally lowest around sunrise and highest during mid- to late afternoon. By season, mixing heights are typically the highest in summer and the lowest in winter. Near large water bodies (e.g., the GOM), diurnal and seasonal variations in mixing heights are relatively small compared with those at inland stations due to the moderating effects of the water. For coastal areas along the GOM, the mean annual morning mixing heights range from 500 to 900 m (1,640 to 2,950 ft), while the mean afternoon mixing heights range from 1,000 to 1,400 m (3,280 to 4,590 ft) (Holzworth 1972). Over water, the absence of a strong sensible heat flux to drive the marine mixed layer and the small surface roughness of sea results in relatively low mixing heights. LeMone (1978) indicated that typical marine mixing height is about 500 m (1640 ft) over low-latitude oceans.

In the GOM region, severe weather events such as thunderstorms, lightning, floods, tornadoes, and tropical cyclones are common. Thunderstorms occur from 26 days per year in Brownsville, Texas, to 80 days per year in Mobile, Alabama (NCDC 1995, 2011a). Thunderstorms occur most frequently in summer months and are least frequent in winter months. The number of lightning strikes per km^2-yr is as low as one at the southern tip of Texas and as high as 14 (NOAA 2011b). During the 1980–1999 period, tornadoes occurred from about 0.2 days per year[2] at the southern tip of Texas up to 1.2 days per year in the southeastern Texas, Louisiana, and Mississippi along the GOM (NSSL 2003). While tornadoes and floods are the primary weather hazards in the southern States, the GOM coastal zone is most vulnerable to hurricanes and their accompanying impacts such as storm surges.

Tropical cyclones affecting the GOM originate over the tropical portions of the Atlantic basin, including the Atlantic Ocean, the Caribbean Sea, and the GOM. Tropical cyclones occur as early as May and as late as December, but most frequently from mid-August to late October (NHC 2011a). On average, about 11 tropical cyclones occur in the Atlantic Basin, many of which remain over the ocean and never impact the U.S. coastlines. About six of these storms become hurricanes each year (NHC 2011b). Coastal counties adjacent to the Western and Central Planning Areas could expect return periods, ranging from 3.6 to 7.0 yr, for hurricanes passing within 139 km (86 mi) of a given location (NHC 2011a). Figure 3.5.1-1 shows landfalling hurricanes in the continental U.S. for the period 1994–2009. Tropical cyclones cause damage to physical, economic, biological, and social systems in the GOM, but the severest effects tend to be highly localized. The GOM is also periodically affected by wintertime extratropical cyclones generated when continental, cold air outbreaks interact with the warm GOM waters. These storms can produce gale force winds and high seas, and are hazardous to shipping due to their sudden onset and rapid formation. For a discussion of the effects of tropical cyclones and severe storms on OCS oil operations in the GOM, see previous EISs prepared for OCS oil and gas activities in the GOM (MMS 2007a, 2008a).

3.5.1.2 Alaska – Cook Inlet

Climate in Alaska depends primarily on three factors: latitude, continentality, and elevation (ACRC 2011). The climate of the southern coastal Alaska including the Cook Inlet Planning Area is marine, characterized by short and cool summers and mild winters. The climate is moderated due to marine influences; however, the upper reaches of the Cook Inlet see

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[2] The mean number of days with one or more events occurring within 40 km (25 mi) of a point.

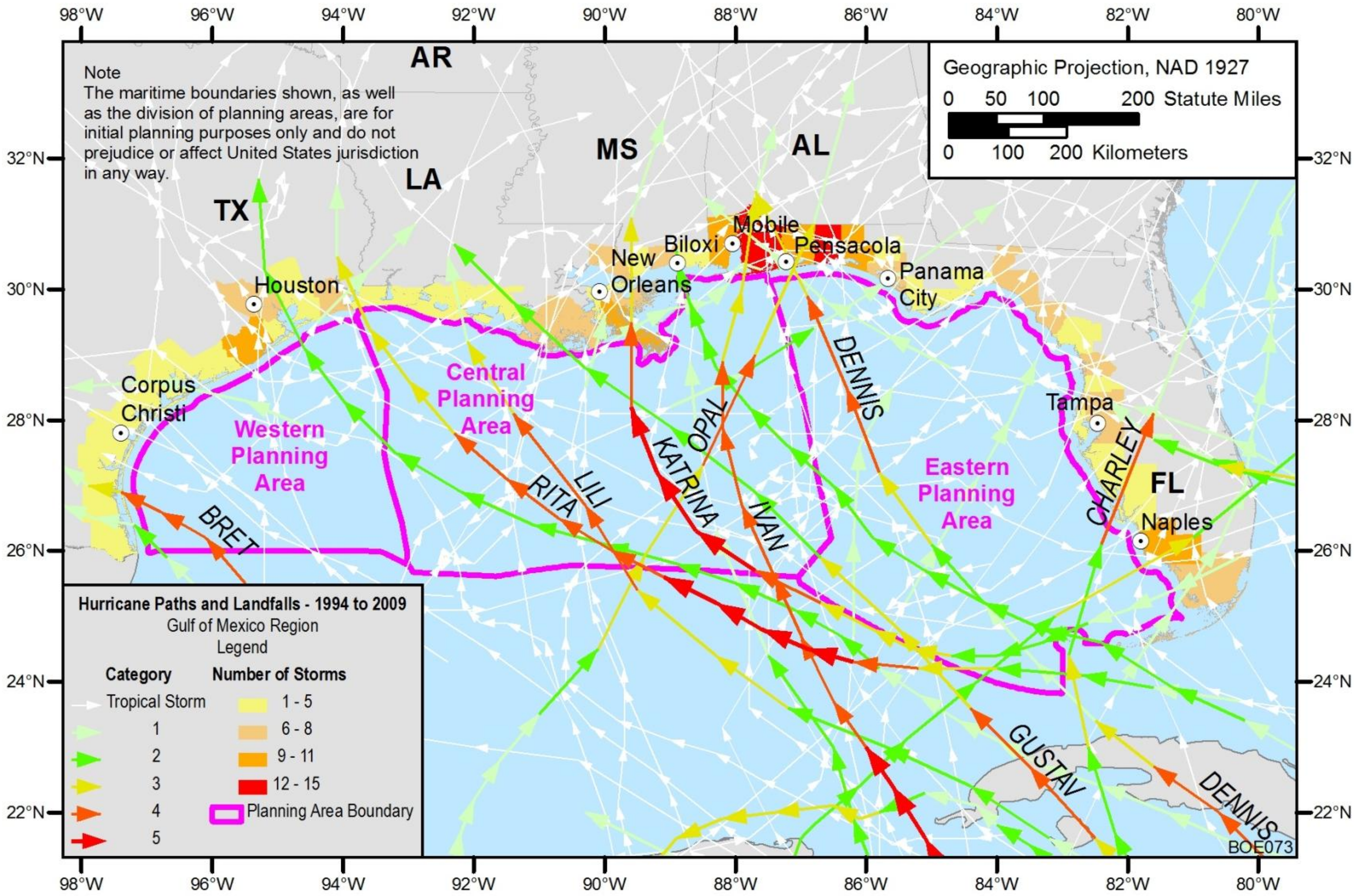

FIGURE 3.5.1-1 U.S. Landfalling Hurricanes, 1994–2009 (NHC 2011a)

more continental effects. Although the Cook Inlet Planning Area is relatively small compared to the other two planning areas, weather patterns significantly vary over a relatively short distance due to nearby complex terrains. The following discussion for wind, ambient temperature, and precipitation is based on data from primarily two National Weather Service (NWS) first-order stations: Homer, which is located on the southwest side of the Kenai Peninsula, and Kodiak, which is located on the east side of Kodiak Island. Homer and Kodiak are located in the upper and lower portions of the Cook Inlet Planning Area, which represent a wide spectrum of variations in climate around the area.

Winds are strongly influenced by local topography and mostly blow parallel to nearby mountain ranges. In Cook Inlet, the general prevailing wind direction is from the northeast. However, wind direction and speed at any location in Cook Inlet vary greatly depending on the orientation and elevation of and proximity to nearby mountain ranges/valleys and the openness to the Gulf of Alaska. At Homer, the prevailing wind direction is from the northeast during September through March, while winds blow more frequently from the west during April through August (NCDC 2011b). The average wind speed at Homer is about 3.3 m/s (7.3 mph), with a slightly higher value in spring and a slightly lower value in summer. At Kodiak, the prevailing wind direction is from the northwest throughout the year, except in June and July when east-northeast winds blow more frequently (NCDC 2011b). The average wind speed at Kodiak is about 5.0 m/s (11.1 mph), with the highest reading in winter and the lowest in summer. At the NDBC buoy and coastal stations scattered within the Cook Inlet Planning Area, prevailing wind directions vary clockwise from the west to the northeast (NDBC 2011). Average wind speeds from NDBC stations range from 4.4 to 7.4 m/s (9.9 to 19.6 mph), with the highest reading in winter and the lowest in summer.

During the normal period (1970–2000), the average temperature at Homer was about 3.4°C (38.1°F) (NCDC 2011b). January was the coldest month, with a mean daily minimum of –8.1°C (17.5°F); August was the warmest month, with a mean daily maximum of 16.1°C (61.0°F). In summer, maximum temperatures go over 21.1°C (70°F) about 2 days per year, while about 178 and 10 days have minimum temperatures at or below freezing and at –17.8°C (0°F) or below, respectively (NCDC 2011b). The highest temperature, 27.2°C (81°F), was reached in July 1993, and the lowest, –31.1°C (–24°F), in January 1989. For the same period, the average temperature at Kodiak was about 4.7°C (40.5°F), with the lowest mean daily minimum of –4.3°C (24.3°F) in February and the highest mean daily maximum of 16.3°C (61.4°F) in August (NCDC 2011b). About 8 days annually exceed 21.1°C (70°F), while about 131 days and 1 day have minimum temperatures at or below freezing and at –17.8°C (0°F) or below, respectively. Extreme temperatures at Kodiak range from –26.7°C (–16°F) to 30.0°C (86°F). Temperature patterns from NDBC stations are similar to those at Homer and Kodiak, except for a little higher annual average temperature range of about 0.5°C (0.9°F) at NDBC stations (NDBC 2011).

The amount of precipitation depends strongly on the surrounding topographic features. During the normal period (1970–2000), annual precipitation at Homer averaged about 64.6 cm (25.45 in.) (NCDC 2011b). An annual average of 148 days have measurable precipitation (0.025 cm [0.01 in.] or higher). Precipitation is recorded throughout the year but is the highest in fall, followed by winter, and lowest in spring. Snow starts as early as October and continues as late as May. Most of the snow falls from November through March. The annual average snowfall at Homer is about 158.2 cm (62.3 in.). For the same period, annual precipitation at Kodiak averages about 191.4 cm (75.35 in.), and an annual average of 201 days have measurable precipitation (NCDC 2011b). By season, precipitation is the highest in fall, followed by winter, and lowest total in summer. Snow starts as early as October and continues as late as May. Most of the snow falls from November through April. The annual average snowfall at Kodiak is about 181.6 cm (71.5 in.).

Severe weather events, such as floods, hail, high winds, and winter events (such as heavy snow, ice storms, winter storms, blizzards), have been reported in the area surrounding Cook Inlet (NCDC 2011c). A normal storm track along the Aleutian chain, the Alaska Peninsula, and all of the coastal area of the Gulf of Alaska exposes these parts of the State to a large majority of the storms crossing the North Pacific, resulting in a variety of wind-related issues (NCDC 2011d). Wind velocities exceeding 45 m/s (100 mph) are not common but do occur, usually associated with mountainous terrain and narrow passes. In 2006, Kodiak experienced a wind gust estimated at 59 m/s (131 mph) that caused minor property damage. Intense coastal winds occur as a result of atmospheric pressure differentials between interior Alaska and the Gulf of Alaska. Higher interior atmospheric pressure also promotes periodic, local offshore winds that are orographically funneled, attaining velocities up to 42 m/s (93 mph) and extending up to 30 km (19 mi) offshore (Lackmann 1988).

Atmospheric stability provides a measure of the amount of vertical mixing and dispersion of air pollutants. Along the Gulf of Alaska, atmospheric stability is predominantly neutral. This is due to the frequent occurrence of relatively high wind speeds and cloud cover. Stable conditions are found about 15–25% of the time, while unstable conditions occur less than 10% of the time. Neutral conditions prevail for the rest of the time. The stable conditions are associated with clear, calm conditions at night. Over open water in the wintertime, unstable conditions are expected to be more frequent. More stable conditions are expected over water in the summer season because of the relatively colder temperature of the sea surface in relation to the ambient air.

3.5.1.3 Alaska – Arctic

As discussed above, climate in Alaska depends primarily on three factors: latitude, continentality, and elevation (ACRC 2011). The climate of the land mass bordering the Beaufort and Chukchi Seas is classified as tundra, characterized by a lack of warm summers (average temperature for the warmest month is less than 10°C (50°F) but above freezing (>0°C [32°F]), and scant (or trace) precipitation.

3.5.1.3.1 Winds. In general, wind patterns at the coastal stations along the Beaufort and Chukchi Sea Planning Areas are characterized by (1) relatively high average wind speeds, about 5.4 m/s (12.0 mph) at stations in the Beaufort Sea, ranging from 4.7 m/s (10.5 mph) at Point Lay to 6.5 m/s (14.6 mph) at Point Hope in the Chukchi Sea; (2) frequent extreme winds; and (3) higher easterly wind components (NCDC 2011e).

The eastern Beaufort Sea coastal winds are strongly influenced by channeling due to the Brooks Range to the south. In the eastern Beaufort Sea around Barter Island, westerly and west-northwesterly winds become more frequent in the winter months, with prevailing easterly and east-southeasterly winds in other months (NCDC 2011e). These bimodal wind direction patterns are also observed in central Beaufort Sea around Prudhoe Bay, but prevailing and secondary wind directions are shifted to east-northeast and west-southwest, respectively.

Along the coast of the Chukchi Sea from Barrow to Cape Lisburne, surface winds commonly blow from the east-northeast and the east (NCDC 2011e). At these stations, northeasterly to east-southeasterly wind components prevail almost every month without any comparable westerly components. However, the prevailing wind direction at Point Hope (the westernmost coastal station of the Chukchi Sea) is from the north, but winds there blow from the southeast and south-southeast a considerable amount of the time. At this station, south-southeasterly winds prevail in June and July, while north-northwesterly to northeasterly winds prevail in all other months.

During the winter, northerly winds prevail in the Chukchi Sea, with directions ranging from northwest in the western part of the sea to northeast in the eastern part (Proshutinsky et al. 1999). During the summer, the Chukchi Sea exhibits a more complicated wind regime, with alternating northerly and southerly winds.

3.5.1.3.2 Ambient Temperature. Along the Beaufort Sea, the average temperature ranges from –12.3°C (9.8°F) at Barter Island to –11.2°C (11.8°F) at Kuparuk (WRCC 2011). February is the coldest month, with a mean monthly minimum temperature ranging from –31.2°C (–24.2°F) to –32.4°C (–26.3°F); July is the warmest month, with a mean monthly maximum ranging from 7.4°C (45.4°F) to 13.3°C (55.9°F). In summer, maximum temperatures seldom go over 21.1°C (70°F). Daily maxima above freezing have been recorded only one-third of the days. Freezing temperatures have been observed every month of the year (about 287–310 days per year); more than half of the days (about 163–167 days per year) have minimum temperatures of –17.8°C (0°F) or below (WRCC 2011). The highest temperature, 28.3°F (83°F), was reached at Kuparuk and Prudhoe Bay, and the lowest, –52.2°C (–62°F), at Prudhoe Bay.

Along the Chukchi Sea, the average temperature ranges from –12.0°C (10.4°F) at Barrow to –8.1°C (17.5°F) at Cape Lisburne (WRCC 2011). February is the coldest month, with a mean monthly minimum temperature ranging from –25.7°C (–14.3°F) to –34.7°C (–30.5°F), and July is the warmest month, with a mean monthly maximum ranging from 7.6°C (45.7°F) to 10.9°C (51.6°F). Freezing temperatures have been observed every month of the year (about 264–316 days per year); about half of the days (about 125–165 days per year) have minimum temperatures of –17.8°C (0°F) or below (WRCC 2011). Both the highest temperature of 26.7°F (80°F) and the lowest of –48.9°C (–56°F) were recorded at Wainwright.

3.5.1.3.3 Precipitation. Precipitation on the tundra is generally meager; thus the tundra is desert-like in terms of precipitation. Along the Beaufort Sea, the average annual precipitation ranges from 10.1 cm (3.97 in.) at Kuparuk to 15.7 cm (6.19 in.) at Barter Island (WRCC 2011). Annual average measurable precipitation (0.025 cm [0.01 in.] or higher) ranges from 62 days at Kuparuk to 87 days at Barter Island. Precipitation is recorded throughout the year, mostly as rainfall, with the lowest amounts in spring and the highest in late summer. Snow falls every month of the year but approximately half falls in fall months. The annual average snowfall ranges from 82.0 cm (32.3 in.) at Kuparuk to 106.2 cm (41.8 in.) at Barter Island (WRCC 2011).

Along the Chukchi Sea, the average annual precipitation ranges from 11.7 cm (4.62 in.) at Barrow to 28.8 cm (11.34 in.) at Cape Lisburne (WRCC 2011). The annual average measurable precipitation ranges from 66 days at Point Lay to 112 days at Cape Lisburne. The annual average snowfall ranges from 43.2 cm (17.0 in.) at Point Lay to 105.2 cm (41.4 in.) at Cape Lisburne (WRCC 2011).

3.5.1.3.4 Severe Weather. Storms (wind velocities of greater than 15 m/s [34 mph]) are observed more often in winter than in summer. In the Chukchi Sea, 6–10 storm days occur per month. The duration of storms ranges from 6 to 24 hours in 70–90% of cases, but stormy weather can last 8–14 days (Proshutinsky et al. 1999).

On October 3, 1963, an intense storm that hit Barrow with little warning and caused more damage than any other storm in Barrow's historical records is described in detail by Brunner et al. (2004). Wind gusts as high as 34–36 m/s (75–80 mph) may have been reached, and the highest official observation of sustained winds was 25 m/s (55 mph). The resulting storm surge (or rise in sea level) reached 3.0 m (10 ft), and may have been as high as 3.7 m (12 ft). The storm surge and wave action caused extensive flooding in coastal areas, and more than 150,000 m^3 (200,000 yd^3) of sediment transport caused bluffs in the Barrow area to retreat as much as 3.0 m (10 ft) (Brunner et al. 2004). Since this episode, at least 30 storms have produced severe winds at Barrow and along the Chukchi Sea coast. Lynch et al. (2001) document high-wind events at Barrow for the period 1960–2000 and concluded that high-wind events are common in fall and winter, but rare in summer. It remains uncertain whether the more frequent storms and the summer storms seen in the past few years are part of a new pattern.

Since 2001, severe weather events, such as floods, storm surges, hail, high winds, winter events (such as heavy snow, winter storms, extreme windchills, blizzards), have been reported in the coastal areas surrounding the Beaufort and Chukchi Seas (NCDC 2011c). In 2005, Cape Lisburne, (nearly the westernmost point of the Chukchi Sea Planning Area) experienced a wind gust estimated at 40 m/s (89 mph) that caused no property damage.

3.5.1.3.5 Atmospheric Stability. Atmospheric stability provides a measure of the amount of vertical mixing and dispersion of air pollutants. Along the Arctic Ocean, the atmosphere is predominantly neutral, due to the frequent occurrence of high wind speeds and cloud cover. Stable conditions are found about 15–25% of the time, while unstable conditions occur less than 10% of the time. Neutral conditions prevail for the rest of the time. Stable conditions are usually associated with clear, calm conditions at night. The presence of sea ice tends to result in more stable conditions, but also greater winds speeds, which could lead to a neutral atmosphere. Stable conditions also tend to be favored in the summertime due to the relatively colder temperatures of the sea surface in relation to the ambient air.

3.5.2 Air Quality

3.5.2.1 Gulf of Mexico

Under the Clean Air Act (CAA), which was last amended in 1990, the USEPA has set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment (USEPA 2011a). NAAQS have been established for six criteria pollutants — carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_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), ozone (O_3), and sulfur dioxide (SO_2), as shown in Table 3.5.2-1. The CAA established two types of NAAQS: primary standards to protect public health including sensitive populations (e.g., asthmatics, children, and the elderly) and secondary standards to protect public welfare, including protection against degraded visibility and damage to animals, crops, vegetation, and buildings. Any individual State can have its own State Ambient Air Quality Standards (SAAQS) but SAAQS must be at least as stringent as the NAAQS. If a State has no standard corresponding to one of the NAAQS or the SAAQS is not as stringent as the NAAQS, then the NAAQS apply. Currently, all GOM States have adopted NAAQS.

Areas considered to have air quality as good as or better than NAAQS are designated by the USEPA as attainment areas. Areas where air quality does not meet the NAAQS are designated by the USEPA as nonattainment areas. Nonattainment areas where air quality has improved to meet the NAAQS are redesignated as maintenance area and are subject to an air quality maintenance plan. The CAA requires each State to develop and regularly update a State Implementation Plan (SIP) to demonstrate how it will attain and maintain the NAAQS. SIPs include the regulations, programs, and schedules that a State will impose on sources and must demonstrate to the USEPA that the NAAQS will be attained and maintained.

In general, ambient air quality on coastal counties along the GOM is relatively good. Currently, all of the coastal counties along the GOM are in attainment for all criteria pollutants except lead and 8-hour ozone (USEPA 2011b). A portion of Hillsborough County, Florida, around the EnviroFocus Technologies Facility is in nonattainment for lead. For 8-hour ozone, all coastal counties in Mississippi, Alabama, and Florida are classified as in attainment, but a number of counties in Texas and Louisiana are designated as nonattainment or maintenance areas. Eight counties in the Houston-Galveston-Brazoria designated area in southeast Texas are classified as severe (maximum attainment date no later than June 2019) nonattainment areas, while three counties in the Beaumont/Port Arthur designated area are classified as moderate maintenance areas. In Louisiana, five parishes in the Baton Rouge designated area are classified as moderate (maximum attainment date no later than June 2010) nonattainment areas. For the Houston-Galveston-Brazoria and Baton Rouge nonattainment areas, 8-hour ozone concentrations have had a general downward trend since 1998 but ozone concentrations frequently exceed the NAAQS (USEPA 2011c). During the 2004–2008 period, the highest of the annual

TABLE 3.5.2-1 National Ambient Air Quality Standards (NAAQS) and Maximum Allowable Prevention of Significant Deterioration (PSD) Increments

		NAAQS[b]		PSD Increment ($\mu g/m^3$)[d]		
Pollutant[a]	Averaging Time	Value	Type[c]	Class I	Class II	Class III
CO	8-hour	9 ppm	P	–[e]	–	–
	1-hour	35 ppm	P	–	–	–
Pb	Rolling 3-month average	0.15 $\mu g/m^3$	P, S	–	–	–
NO_2	Annual	53 ppb	P, S	2.5	25	50
	1-hour	100 ppb	P	–	–	–
PM_{10}	Annual	–	–	4	17	34
	24-hour	150 $\mu g/m^3$	P, S	8	30	60
$PM_{2.5}$	Annual	15 $\mu g/m^3$	P, S	1	4	8
	24-hour	35 $\mu g/m^3$	P, S	2	9	18
O_3	8-hour	0.075 ppm	P, S	–	–	–
SO_2	Annual	–	–	2	20	40
	24-hour	–	–	5	91	182
	3-hour	0.5 ppm	S	25	512	700
	1-hour	75 ppb	P	–	–	–

[a] CO = carbon monoxide; NO_2 = nitrogen dioxide; O_3 = ozone; Pb = lead; $PM_{2.5}$ = particulate matter ≤2.5 μm; PM_{10} = particulate matter ≤10 μm; and SO_2 = sulfur dioxide.

[b] Refer to 40 CFR Part 50 for detailed information on the attainment determination and reference method for monitoring.

[c] P = primary standards, which set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly; S = secondary standards, which set limits to protect public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

[d] The final rule for PSD increments for $PM_{2.5}$ is effective on December 20, 2010 (75 FR 64864).

[e] A dash denotes that no standard exists.

Sources: 40 CFR 52.21; 75 FR 64864; USEPA 2011a.

fourth-highest daily maximum 8-hour ozone concentrations were 0.106 ppm and 0.097 ppm, recorded in the Houston-Galveston-Brazoria and Baton Rouge nonattainment areas, respectively.

This region has several favorable conditions for the photochemical production of ozone. Precursor emissions of ozone, such as nitrogen oxides (NO_x) and VOCs, are abundant in the region due to a huge population, the oil and gas industry, and the petrochemical industry, including electricity generating facilities, chemical plants, petroleum refining facilities, oil and gas storage and transportation industries, and associated onroad vehicles and nonroad equipment. In addition, considerable emissions of biogenic VOCs are widespread and ubiquitous in the region. The subtropical climate of the region (characterized by relatively high temperature and intense solar radiation, despite frequent occurrences of precipitation) plays a role in establishing conditions conducive to high ozone episodes.

In recent years, four revisions to NAAQS have been promulgated. Effective May 27, 2008, the USEPA revised the 8-hour ozone standards from 0.08 ppm to 0.075 ppm (73 FR 16436). Effective January 12, 2009, the USEPA revised the Pb standard from a calendar-quarter average of 1.5 $\mu g/m^3$ to a rolling 3-month average of 0.15 $\mu g/m^3$ (73 FR 66964). Effective April 12, 2010, the USEPA established a new 1-hour primary NAAQS for NO_2 at 100 ppb (75 FR 6474), while, effective August 23, 2010, the USEPA established a new 1-hour primary NAAQS for SO_2 at 75 ppb (75 FR 35520). It takes several years to establish monitoring plans and collect data to determine whether an area is in compliance with a new standard.

The Prevention of Significant Deterioration (PSD) regulations (see 40 CFR 52.21), which are designed to limit the growth of air pollution in clean areas, apply to major new sources or modifications of existing major sources within an attainment or unclassified area. While the NAAQS (and SAAQS) place upper limits on the levels of air pollution, PSD regulations place limits on the total increase in ambient pollution levels above established baseline levels for NO_2, PM_{10}, $PM_{2.5}$, and SO_2, thus preventing “polluting up to the standard” (see Table 3.5.2-1). All State air quality jurisdictions are divided into three classes of air quality protection. These allowable increases are smallest in Class I areas, special areas of natural wonder and scenic beauty, such as National Parks (NPs), National Monuments, and Wilderness Areas (WAs), where air quality and air quality-related values (such as visibility and acid deposition) should be given special protection. The rest of the country is subject to larger Class II increments. States can choose a less stringent set of Class III increments, but none have done so. Major (large) new and modified stationary sources must meet the requirements for the area in which they are locating and any areas they impact. Thus, a source locating in a Class II area near a Class I area would need to meet the more stringent Class I increment in the Class I area and the Class II increment elsewhere, as well as any other applicable requirements.

As a matter of policy, the USEPA recommends that the permitting authority notify the Federal land managers (FLMs) when a proposed PSD source would locate within 100 km (62 mi) of a Federal Class I area. If the source’s emissions are considered large, the USEPA recommends that sources beyond 100 km (62 mi) of a Federal Class I area be brought to attention of the FLM. There are several Class I areas in the GOM coastal zones, in Louisiana and Florida, as shown in Figure 3.5.2-1. In Louisiana, there is one Federal Class I area, while Florida has four. The Federal Class I area offshore of Louisiana consists of the Breton Wildlife Refuges, located on Breton Island and on many of the Chandeleur Islands (40 CFR 81.412). Federal Class I areas in Florida, such as Bradwell Bay WA,[3] Everglades NP, Chassahowitzka WA, and St. Marks WA (40 CFR 81.407), are located more than 250 km (155 mi) from the eastern boundary of the Central Planning Area. In addition, these Class I areas are not located downwind of prevailing winds in the Western and Central Planning Areas, and thus are not much affected by any current activities occurring in the Western or Central Planning Areas.

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[3] In 1980, Bradwell Bay WA along with Rainbow Lake in Wisconsin were excluded for purposes of visibility protection as Federal Class I areas.

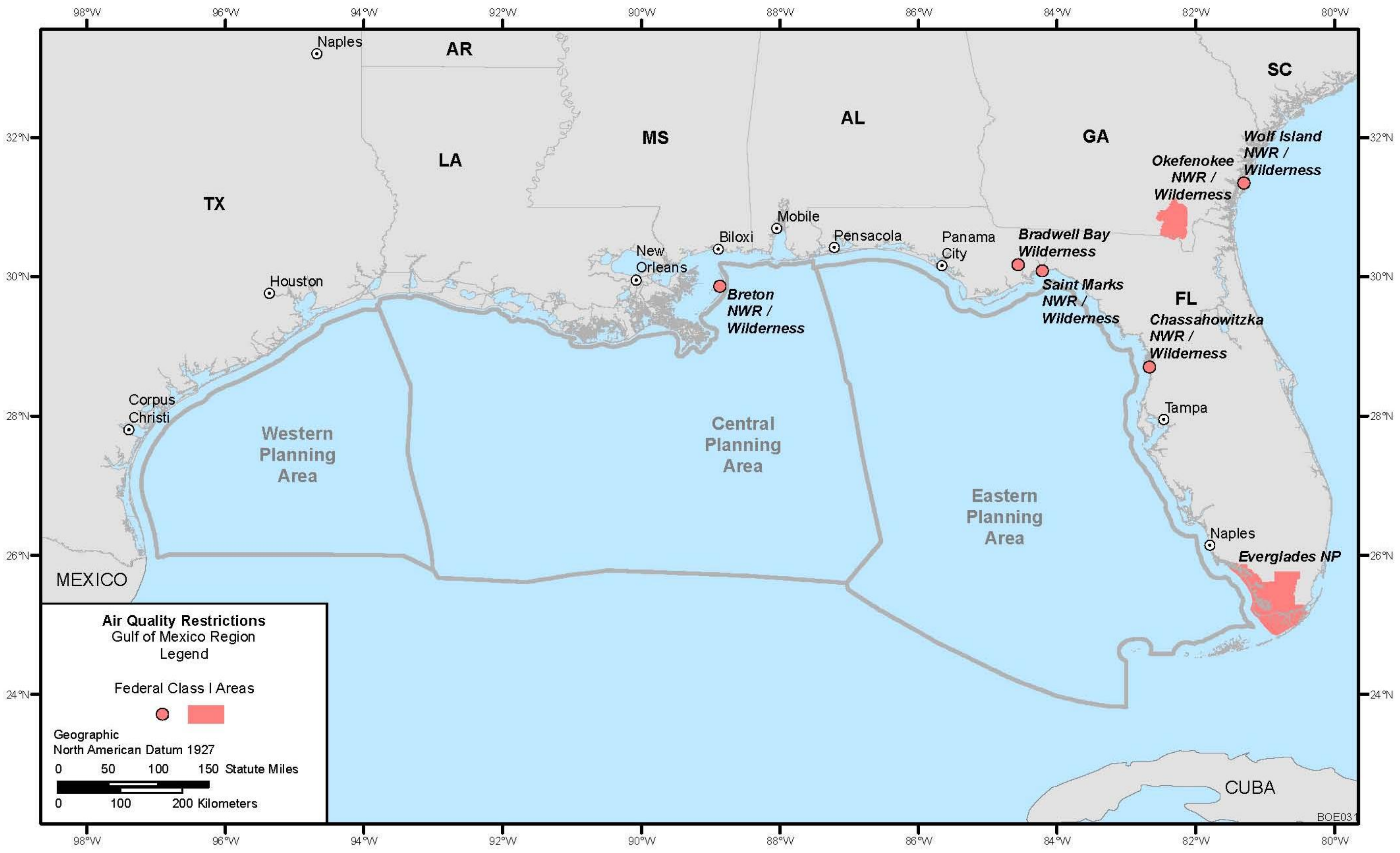

FIGURE 3.5.2-1 Mandatory Class I Federal Areas along the GOM

3.5.2.1.1 Deepwater Horizon Event. On April 20, 2010, the explosion and subsequent fire of the British Petroleum (BP) DWH platform in the GOM caused estimated 4.9 million barrels (Mbbl) of oil to be released into the GOM until July 15, 2010, when the wellhead was capped. The BP spill is by far the world's largest accidental release of oil into marine waters. It is estimated that burning, skimming, and direct recovery from the wellhead removed one quarter (25%) of the oil released from the wellhead (Lubchenco et al. 2010). One quarter (25%) of the total oil naturally evaporated or dissolved, and slightly less than one quarter (24%) was dispersed (either naturally or chemically) as microscopic droplets into GOM waters. The residual amount — just over one quarter (26%) — is either on or just below the surface as light sheen and weathered tar balls, has washed ashore or been collected from the shore, or is buried in sand and sediments. In summary, a third (33%) of the total leaked oil in the BP spill was captured or mitigated by the unified command recovery operations, including burning, skimming, direct recovery from the wellhead, and chemical dispersion. Half of the total leaked oil (naturally and chemically dispersed and residual) is currently being degraded naturally.

Evaporation from the oil spill itself resulted in VOCs in the atmosphere. If the spill is a subsurface spill, the lighter fractions of the released oil dissolve more easily in the water than the heavier fractions before reaching the surface (Ryerson et al. 2011), but this consideration would not apply to releases directly onto the surface. The VOC concentrations would occur anywhere there is an oil slick, and downwind of the slick. VOC concentrations would decrease with downwind distance. The lighter portions of VOCs would be most abundant in the immediate vicinity of the spill site. The heavier compounds would be emitted over a longer period of time and over a larger area. The formation of large concentrations of secondary organic aerosol (SOA), which affects air quality and climate change, was observed by measuring concentrations of groups of organic compounds downwind from the DWH oil spill (de Gouw et al. 2011). This SOA plume was formed from unmeasured, less volatile hydrocarbons that were emitted from a wider area around DWH. Other work measured individual compounds including BTEX, some of which could be hazardous to workers in the vicinity of the spill site. The hazard to workers can be reduced by monitoring and using protective gear, including respirators. During the DWH incident, air samples collected by individual offshore workers by BP, the Occupational Safety and Health Administration (OSHA), and the USCG showed levels of BTEX that were mostly under detection levels. All samples had concentrations below the OSHA Occupational Permissible Exposure Limits (PELs) and the more stringent American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) (BOEMRE 2011a).

At present, a number of scientists, physicians, and health care experts are concerned with potential public health effects as a result of DWH event in the GOM; they found that the VOC benzene, a cancer-causing agent, has been found to be above Louisiana's ambient air quality standards (BOEMRE 2011a). However, the Louisiana benzene standard is an annual average of short-term samples, and while benzene in several samples related to the DWH event was indeed above the Louisiana annual standard value of 12 $\mu g/m^3$ (or 3.76 ppb), the long-term average in the monitoring period was well below the standard; that is, the Louisiana benzene standard was not exceeded (Louisiana Department of Environmental Quality 2010, 2011). The sources causing the elevated short-term levels could include not only the DWH event but also onshore sources such as vehicle traffic and refineries.

3.5.2.1.2 Climate Change Effects. Climate changes are under way in the United States and globally, and are projected to continue to grow substantially over next several decades unless intense, concerted measures are taken to reverse this trend. Climate-related changes include rising temperature and sea level, increased frequency and intensity of extreme weathers (e.g., heavy downpours, floods, and droughts), earlier snowmelts and associated frequent wildfires, and reduced snow cover, glaciers, permafrost, and sea ice. A thorough discussion of the impacts of climate change to the baseline environment can be found in Section 3.3. In this section, potential impacts of climate change on meteorology and air quality specific to the GOM are discussed based on the report released by U.S. Global Change Research Program (USGCRP) in June 2009 titled, *Global Climate Change Impacts in the United States* (USGCRP 2009), unless otherwise noted.

Overall, the annual average temperature in the Southeast, which encompass the GOM coastal areas, did not change significantly over the past century. However, since 1970, the annual average temperature has risen about 1.6°F (0.9°C), with the highest seasonal increase of 2.7°F (1.5°F) in winters. Recently, heat waves and extreme temperatures have been common, especially in the southern States. For example, the average temperature for the summer in Texas at 86.8°F (30.4°C) exceeded the previous seasonal statewide average temperature record for any State during any season (NCDC 2011f). In summer of 2011, persistent heat engulfed the nation and the number of daily maximum temperatures over 100°F (37.8°C) were recorded to range from 10 days to more than 70 days in most of Texas, with a maximum of 90 days at Laredo Airport located in the southernmost Texas. In the near term (2010–2029) and mid-century (2040–2059), projected average temperature changes along the GOM coastal areas range 1–3°F (0.6–1.7°C) and 2–4°F (1.1–2.2°C), respectively, from 1961–1979 baseline.

Over the century, precipitation in the Southeast has increased by an average of 6% but has decreased by about 8% since 1970, with a maximum decrease of about 29% in spring. Model predictions indicated that, due to the northward shift of storm tracks, northern areas will become wetter and southern areas, especially in the West, will become drier. Accordingly, most of the GOM coastal area is predicted to experience reductions in precipitation and increases in drought severity and duration in the future. The destructive potential of Atlantic hurricanes has increased since 1970 and is correlated with the increase in sea surface temperature. Anticipated future changes for the U.S. and surrounding coastal waters include more intense hurricanes with related increases in wind, rain, and storm surges, but the frequency of landfalling hurricanes has not been established.

The two criteria air pollutants of most concern for public health and the environment are surface ozone and particulate matter. Air quality in the GOM is anticipated to be affected by climate change. While the Clean Air Act has improved air quality, higher temperatures and associated stagnant air masses due to a weaker global circulation and a decreasing frequency of mid-latitude cyclones (Jacob and Winner 2009) are expected to make it more challenging to meet air quality standards, particularly for ground-level ozone (a component of smog). A warmer climate is projected to increase the natural emissions of VOCs, accelerate ozone formation, and increase the frequency and duration of stagnant air masses that allow air pollutants to accumulate. This will worsen air quality, exacerbate respiratory diseases, and cause decreased crop yields.

Wildfires in the U.S. are already increasing due to warming. In GOM coastal areas, rising temperature and less precipitation (and thus prolonged droughts) have caused drying of soils and vegetation, which increase the potential for wildfires. More wildfires would result in air emissions, including criteria pollutants and toxic air pollutants, which could adversely impact air quality, visibility, and human health. In addition, greenhouse gas (GHG) emissions released from wildfires and associated loss of vegetation acting as a GHG sink could accelerate climate changes.

3.5.2.2 Alaska – Cook Inlet

For more detailed information on Federal air regulations and programs, please see Section 3.5.2.1.

The Alaska SAAQS are identical to the NAAQS (18 AAC 50.010). In addition, Alaska has set standards for some pollutants that are not addressed by the NAAQS, that is, reduced sulfur compounds and ammonia.

Except for a few population centers such as Anchorage, Fairbanks, and Juneau, the existing air quality in Alaska is relatively pristine with pollutant concentrations that are well within the ambient standards. However, in rural areas and communities, road dust, windblown dust, and wildfires can cause particulate concentrations to exceed NAAQS levels during certain seasons of the year. For example, PM_{10} levels at Butte exceeded the 24-hour NAAQS of 150 $\mu g/m^3$ nine times between April 1998 and December 2010 due to road dust, but $PM_{2.5}$ NAAQS levels were not exceeded (ADEC 2011a). Fugitive dust from roads in villages in the Northwest Arctic Borough has also been found to cause particulate levels to exceed the NAAQS values (ADEC 2011b). Currently, Kenai Peninsula and Kodiak Island Boroughs, which surround the Cook Inlet Planning Area, have no air monitoring stations for criteria pollutants but are in unclassifiable/attainment for all criteria pollutants (40 CFR 81.302).

Eagle River in the Municipality Anchorage and Juneau are currently in nonattainment for the PM_{10} NAAQS, while Fairbanks is in nonattainment for $PM_{2.5}$ NAAQS. Although $PM_{2.5}$ is still a problem, recent air monitoring data indicated that neither Eagle River nor Juneau continues to violate the PM_{10} standard. The Alaska Department of Environmental Conservation (ADEC), together with the USEPA and related boroughs, are currently in the process of changing the status from nonattainment to maintenance. The most important sources of particulate matter in Alaska include volcanic ash, windblown dust from dry glacial riverbeds, wildfires during summertime, fugitive dust from unpaved roads, re-entrainment of winter sanding materials from paved roads, and wood smoke as well as fuel combustion (ADEC 2010b). In particular, increased exposure to particulate matter occurs during extended wintertime temperature inversions. In addition, Anchorage and Fairbanks are designated as maintenance areas for CO NAAQS.

Data for 2006–2010 shows concentrations above the 24-hour $PM_{2.5}$ NAAQS level in four years and above the annual $PM_{2.5}$ NAAQS level for one year in Fairbanks. Concentrations above the 24-hour $PM_{2.5}$ level were also recorded for one year in Juneau and for two years in

Butte. The 24-hour PM_{10} NAAQS level was exceeded in one year in Eagle River and in two years in Butte. No data was reported above the CO or ozone standard levels (USEPA 2012).

There are four PSD Class I areas in Alaska (40 CFR 81.402): the Bering Sea WA in the St. Mathew Island group off southwestern Alaska; the Denali NP in south central Alaska; the Simeonof WA in the Shumagin Islands off the Alaska Peninsula; and the Tuxedni WA in Cook Inlet. All WAs are administered by the U.S. Fish and Wildlife Service (USFWS), while the Denali NP is administered by the National Park Service. The Tuxedni WA is the only Class I area that is located in close proximity to the northern portion of Cook Inlet Planning Area (about 10 km [6 mi] away), as shown in Figure 3.5.2-2. All other Class I areas in Alaska are located beyond 100 km (61 mi) from the Cook Inlet Planning Area.

3.5.2.2.1 Climate Change Effects. Climate changes are under way in the U.S. and globally, and are projected to continue to grow substantially over next several decades unless intense concerted measures are taken to reverse this trend. Climate-related changes include rising temperature and sea level, increased frequency and intensity of extreme weathers (e.g., heavy downpours, floods, and droughts), earlier snowmelts and associated frequent wildfires, and reduced snow cover, glaciers, permafrost, and sea ice. A thorough discussion of the impacts of climate change to the baseline environment can be found in Section 3.3. In this section, potential impacts of climate change on meteorology and air quality specific to the Cook Inlet are discussed based on the report released by U.S. Global Change Research Program (USGCRP) in June 2009 titled, *Global Climate Change Impacts in the United States* (USGCRP 2009).

In particular, Alaska has many resources vulnerable to climate change, such as sea ice, glaciers, permafrost, and thus may be subject to more pronounced potential impacts than any other parts of U.S. Over the past 50 yr, Alaska experienced more temperature increases than the rest of U.S. Its annual average temperature has increased by 3.4°F (1.9°C), with the highest seasonal increase of 6.3°F (3.5°C) in winters. By the middle of the century, the annual average temperature in Alaska is projected to rise about 3.5 to 7°F (1.9 to 3.9°C). The higher temperatures are already contributing to earlier snowmelt, reduced sea ice, widespread glacier retreat, and permafrost warming. This warming could produce benefits in some sectors, such as longer growing season, a longer period of outdoor and commercial activity such as tourism, increased shipping, and resource extraction, and detriments in others, such as increased likelihood of summer drought and wildfires due to longer summers and higher temperatures, coastal erosion, and flooding associated with coastal storms, and major shifts of biota habitats. Open water with a lower albedo absorbs sunlight better than the reflective surface of ice with a higher albedo. Albeit limited to northern Cook Inlet, any decrease in sea ice due to warming could lead to an decrease in albedo and thus an increase in ocean surface temperature, which causes sea ice to melt more, the so-called ice-albedo positive feedback.

Over the past 50 yr, precipitation has increased an average of 5% in the U.S. Model predictions indicate that, due to northward shift of storm tracks, northern areas will become wetter and southern areas, especially in the West, will become drier. Over this century, the

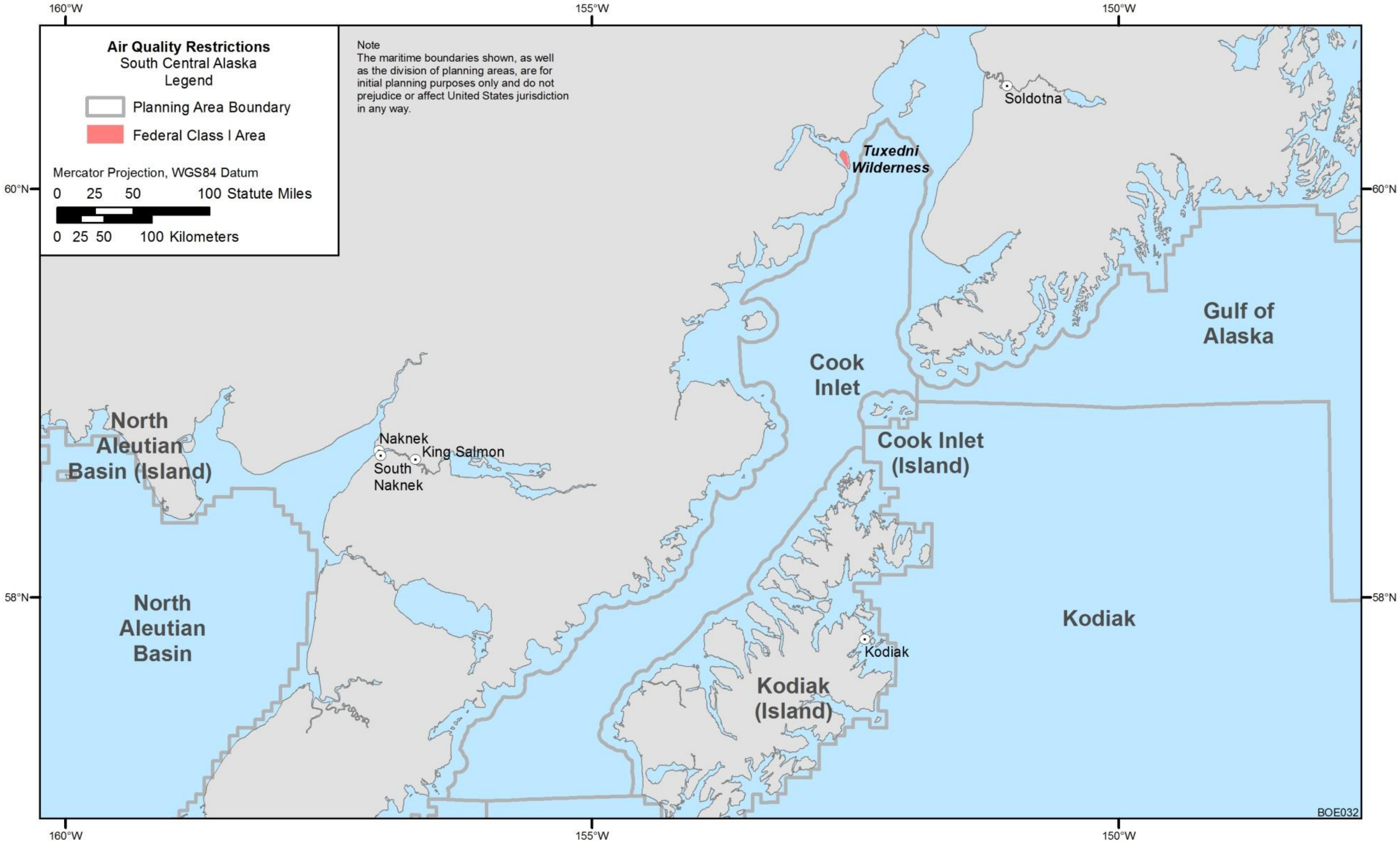

FIGURE 3.5.2-2 Mandatory Class I Federal Area in Cook Inlet, Alaska

temperature rise in sea surface temperature and reduced ice cover are likely to lead to northward shifts in Pacific storm tracks and increased impacts on Alaskan coastlines, many of which are low in elevation.

Two criteria air pollutants of most concern for public health and the environment are surface ozone and particulate matter. Air quality in the Cook Inlet is anticipated to be affected by climate change. Associated with climate change, more wildfires would result in air emissions, including criteria pollutants and toxic air pollutants, which could adversely impact air quality, visibility, and human health. In addition, greenhouse gas (GHG) emissions released from wildfires and associated loss of vegetation as a GHG sink could accelerate climate changes. To some degree, higher temperatures could increase ground-level ozone levels, which are primarily related to ambient temperature. Ozone level increases can worsen air quality, exacerbate respiratory diseases, and cause decreased crop yields. However, this minimal increase in ozone due to climate change is not anticipated to be high enough to contribute to exceeding the NAAQS.

3.5.2.3 Alaska – Arctic

Please see Section 3.5.2.1 for more detailed information on Federal air regulations and programs and 3.5.2.2 for Alaska-specific information.

Alaska has low air emissions. There are few industrial emission sources and, outside of Anchorage and Fairbanks, no sizable population centers. Barrow with a year 2010 population of about 4,600 is the largest city in North Slope Borough (USCB 2011i). The primary industrial emissions are associated with oil and gas production, power generation, small refineries, paper mills, and mining. The existing air quality in Alaska is considered to be relatively pristine, with pollutant concentrations in most areas that are well within the NAAQS. Currently, North Slope Borough, which borders the Beaufort Sea and Chukchi Sea Planning Areas, has no continuous air government-operated monitoring stations for criteria pollutants but is designated as an unclassifiable/attainment area for all criteria pollutants (40 CFR 81.302). There are monitors operated by the oil and gas industries as part of their permit conditions, the data from which is submitted to ADEC. Although data were not processed to provide the statistics required for comparison with the NAAQS, one $PM_{2.5}$ sample of 35.6 $\mu g/m^3$ exceeded the NAAQS level and four 1-hr NO_2 values exceeded the corresponding NAAQS level of 188 $\mu g/m^3$ (ADEC 2011c).

All four Class I areas in Alaska are located more than 690 km (430 mi) from the Beaufort Sea and Chukchi Sea Planning Areas (40 CFR 81.402). The entire Arctic region is classified Class II under Federal PSD regulations.

Over most of the onshore areas bordering the Arctic Ocean, there are only a few small, widely scattered emission sources. The only major local sources of industrial emissions are in the Prudhoe Bay-Kuparuk-Endicott oil production complex. The offshore Northstar facility located on an artificial island was the greatest single source of vented/flared gas on the North Slope in 2002 (Alaska Department of Administration 2004). However, repairs during 2004 resulted in a significant decrease of flaring at Northstar Island. This area was the subject of monitoring programs during 1986–1987 (MMS 2002b; Environmental Science and Engineering, Inc. 1987) and from 1990 through 1996 (ENSR Consulting and Engineering 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. The more recent observations are summarized in Table III.A-6 in MMS (2003b). All the values meet the NAAQS and SAAQS. The results demonstrate that ambient pollutant concentrations meet the ambient standards, even for sites subject to maximum concentrations.

Aside from notable warming trends and their associated impacts, the Arctic region experiences air pollution problems due to long-range transport of air pollutants from industrial northern Eurasia and North America, including Arctic haze followed by acidic depositions, tropospheric ozone, and buildup of toxic substances such as mercury or persistent organic compounds (Law and Stohl 2007). Local shipping emissions and summertime boreal forest fires may also be important pollution sources in the Arctic. In addition, large haze events in the Arctic can be caused by Asian dust originating from the Gobi and Taklamakan Deserts in Mongolia and northern China in springtime, as identified in Rahn et al. (1977).

During the winter and spring, winds transport pollutants to Arctic region across the Arctic Ocean from industrial Europe and Asia (Rahn 1982). These pollutants, primarily from coal burning and metal smelting, cause a phenomenon known as Arctic haze, a visible reddish-brown haze. The composition of aerosols producing regional haze consists of approximately 90% sulfate aerosols and 10% soot (Wilcox and Cahill 2003). Pollutant sulfate due to Arctic haze in the air in Barrow (that in excess of natural background) averages 1.5 $\mu g/m^3$. The concentration of vanadium, one of signature elements that fingerprint fossil fuel combustion, averages up to 20 times the background levels in the air and snowpack. Observations of the chemistry of the snowpack in the Canadian Arctic also provide evidence of long-range transport of small concentrations of organochlorine pesticides (Gregor and Gummer 1989). Concentrations of Arctic haze during winter and spring at Barrow are similar to those over large portions of the continental United States, but they are considerably higher than levels south of the Brooks Range in Alaska. Any ground-level effects of Arctic haze on the concentrations of regulated air pollutants in the Prudhoe Bay area are included in the monitoring data given in Table III.A-6 in MMS (2003b). Model calculations indicate that less than 10% of the pollutants emitted in the major source regions are deposited in the Arctic (Pacyna 1995). Maximum concentrations of some pollutants, sulfates and fine particles, were observed during the early 1980s and decreases in concentrations were observed at select stations at the end of the 1980s due to emissions decreases in some source regions and a meteorological shift. However, the decline in emissions from Russia may be reversing as a consequence of economic revitalization and an increasing reliance on coal, as natural gas becomes more valuable for export (Wilcox and Cahill 2003). Despite this seasonal, long-distance transport of pollutants into the Arctic, regional air quality still is far better than ambient air quality standards.

3.5.2.3.1 Climate Change Effects. Climate changes are underway in the U.S. and globally, and are projected to continue to grow substantially over next several decades unless intense concerted measures are taken to reverse this trend. Climate-related changes include rising temperature and sea level, increased frequency and intensity of extreme weathers (e.g., heavy downpours, floods, and droughts), earlier snowmelts and associated frequent wildfires, and reduced snow cover, glaciers, permafrost, and sea ice. A thorough discussion of the impacts of climate change to the baseline environment can be found in Section 3.3. In this section, potential impacts of climate change on meteorology and air quality specific to the Arctic are discussed based on the report released by U.S. Global Change Research Program (USGCRP) in June 2009 titled, *Global Climate Change Impacts in the United States* (USGCRP 2009).

In particular, Alaska has many resources vulnerable to climate change, such as sea ice, glaciers, permafrost, and thus may be subject to more pronounced potential impacts than any other parts of U.S. Over the past 50 yr, Alaska experienced more temperature increase than the rest of U.S. Its annual average temperature has increased by 3.4°F (1.9°C), with highest seasonal increase of 6.3°F (3.5°C) in winters. By the middle of the century, annual average temperature in Alaska is projected to rise about 3.5 to 7°F (1.9 to 3.9°C). The higher temperatures are already contributing to earlier snowmelt, reduced sea ice, widespread glacier retreat, and permafrost warming. This warming could produce benefits in some sectors, such as longer growing season, a longer period of outdoor and commercial activity such as tourism, increased shipping, and resource extraction, and detriments in others, such as increased likelihood of summer drought and wildfires due to longer summers and higher temperatures, coastal erosion, and flooding associated with coastal storms, and major shifts of biota habitats. Open water with a lower albedo absorbs sunlight better than the reflective surface of ice with a higher albedo. Any decrease in Arctic sea ice due to warming could lead to a decrease in albedo and thus an increase in ocean surface temperature, which causes sea ice to melt more, the so-called ice-albedo positive feedback.

Over the past 50 yr, precipitation has increased an average of 5% in the U.S. Model predictions indicate that, due to northward shift of storm tracks, northern areas will become wetter and southern areas, especially in the West, will become drier. Over this century, temperature rise in sea surface temperature and reduced ice cover are likely to lead to northward shifts in Pacific storm tracks and increased impacts on Alaskan coastlines, many of which are low in elevation.

Two criteria air pollutants of most concern for public health and the environment are surface ozone and particulate matter. Air quality in the Beaufort and Chukchi Seas is anticipated to be affected by climate change. Associated with climate change, more wildfires would result in air emissions, including criteria pollutants and toxic air pollutants, which could adversely impact air quality, visibility, and human health. In addition, greenhouse gas (GHG) emissions released from wildfires and associated loss of vegetation as a GHG sink could accelerate climate changes. To some degree, higher temperatures could increase ground-level ozone levels, which are primarily related to ambient temperature. Ozone level increases can worsen air quality, exacerbate respiratory diseases, and cause decreased crop yields. However, this minimal increase in ozone due to climate change is not anticipated to be high enough to contribute to exceeding the NAAQS.

3.6 ACOUSTIC ENVIRONMENT

3.6.1 Gulf of Mexico

For a more detailed discussion on the acoustic environment of the GOM, please see MMS (2004), which is incorporated here for reference.

3.6.1.1 Sound Fundamentals

Light does not travel far in the ocean due to its absorption and scattering. Even in the clearest water most light is absorbed within a few tens of meters, and visual communication among marine species is very limited in water, especially in deep or murky water, and/or at night. Accordingly, auditory capabilities have evolved to overcome this limitation of visual communication for many marine animals. Sound, which is mostly used by marine animals for such basic activities as finding food or a mate, navigating, and communicating, plays a crucial role in their survival in the marine environment. The same advantages of sound in water have led humans to deliberately introduce sound into the ocean for many valuable purposes, e.g., communication (e.g., submarine-to-submarine), feeding (e.g., fish-finding sonar), and navigation (e.g., depth-finders and geological and geophysical surveys for minerals) (Hatch and Wright 2007). However, some sounds, such as the noise generated by ships and by offshore industrial activities, including oil and gas activities, are also introduced into the ocean as a byproduct.

Any pressure variation that the human ear can detect is considered as sound, and noise is defined as unwanted sound. Sound is described in terms of amplitude (perceived as loudness) and frequency (perceived as pitch). The ear can detect pressure fluctuations changing over seven orders of magnitude. The ear has a protective mechanism in that it responds logarithmically, rather than lineally. To deal with these two realities (wide range of pressure fluctuations and the response of the ear), sound pressure levels[4] are typically expressed as a logarithmic ratio of the measured value to a reference pressure, called a decibel (dB). By convention, the reference pressures are 20 micropascal (µPa) for airborne sound, which corresponds to the average person's threshold of hearing at 1000 Hz, and 1 µPa for underwater sound. Accordingly, sound intensity in dB in water is not directly comparable to that in dB in air.

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[4] There are two primary but different metrics for sound measurements: sound pressure level (SPL) and sound exposure level (SEL). SPL is the root mean square of the sound pressure over a given interval of time, given as dB re 1 µPa for underwater sound. In contrast, SEL is the total noise energy from a single event and is the integration of all the acoustic energy contained within the event. SEL takes into account both the intensity and the duration of a noise event, given as dB re 1 $\mu Pa^2 \times s$ for underwater sound. In consequence, SEL is similar to SPL in that total sound energy is integrated over the measurement period, but instead of averaged over the entire measurement period, a reference duration of 1 s is used.

There are primarily three ways to characterize the intensity of a sound signal (OMP 2010). The "zero-to-peak pressure" denotes the range between zero and the greatest pressure of the signal, while "peak-to-peak pressure" denotes the range between negative and positive extremes of the signal. The "root-mean-square (rms) pressure" is the square root of the average of the square of the pressures of the sound signal over a given duration. Due to the sensitivity of marine animals to sound intensity, the rms pressure is most widely used to characterize underwater sound waves. However, for impulsive sounds, rms pressure is not appropriate to use because it can vary considerably depending on the duration over which the signal is averaged. In this case, peak pressure of impulsive sound, which could be associated with the risk of causing physical damage in auditory systems of marine animals, is more appropriately used (Coles et al. 1968). Unless otherwise noted, *source levels* of underwater sounds are typically expressed in the notation "dB re 1 µPa-m," which is defined as the pressure level that would be measured at a reference distance of 1 m from a source. In addition, zero-to-peak and peak-to-peak sound pressure levels are denoted as $dB_{0\text{-}p}$ and $dB_{p\text{-}p}$ re 1 µPa-m, respectively. In addition, the *received levels* (estimated at the receptor locations) are presented as "dB re 1 µPa" at a given location (e.g., 5 km [3 mi]).

3.6.1.2 Sound Propagation

Understanding the impact of sound on a receptor requires a basic understanding of how sound propagates from its source. Underwater sound spreads out in space, is reflected, refracted, and absorbed. Sound propagates with different geometries under water, especially in relatively shallow nearshore environments. Vertical gradients of temperature, pressure, and salinity in the water as well as wave and current actions can also be expected to constrain or distort sound propagation geometries. Several important factors affecting sound propagation in water include spreading loss, absorption loss, scattering loss, and boundary effects of the ocean surface and the bottom (Malme 1995).

Among these, spreading loss, which does not depend on frequency, is the major contributor to sound attenuation. As propagation of sound continues, its energy is distributed over an ever-larger surface area. The surface of the water and the ocean floor are effective boundaries to sound propagation, acting either as sound reflective or absorptive surfaces. Spherical and cylindrical spreading are two simple approximations used to describe the sound levels associated with sound propagations away from a source. In spherical propagation, sound from a source at mid-depth in the ocean (i.e., far from the sea surface or sea bottom) propagates in all directions with a 6-dB drop per doubling of distance from the source. In cylindrical spreading, sound propagates uniformly over the surface of a cylinder, with sound radiating horizontally away from the source, and sound levels dropping 3 dB per doubling of distance. The surface of the water and the ocean floor are effective boundaries to sound propagation, acting either as sound reflective or absorptive surfaces. Consequently, some underwater sound originating as a point source will initially propagate spherically over some distance until the sound pressure wave reaches these boundary layers; thereafter, the sound will propagate cylindrically. Therefore, some sound levels tend to diminish rapidly near the source (spherical propagation) but slowly with increasing distances (cylindrical propagation).

Directionality refers to the direction in which the signal is projected. Many underwater noises are generally considered to be omnidirectional (e.g., construction, dredging, explosives). However, geophysical surveys, such as seismic airgun arrays, are focuses downward, while some geological surveys are fanned. Although airgun arrays are designed to direct a high proportion of the sound energy downward, some portion of the sound pulses can propagate horizontally in the water, depending on array geometry and aspect relative to the long axis of the array (Greene and Moore 1995). In any case, sound attenuation of directional sound with distance is lower than the spreading loss for omnidirectional sources discussed above.

As sound travels, some sound energy is absorbed by the medium such as air or water (absorption losses) which represents conversion of acoustic energy to heat energy. Absorption losses depend strongly on frequency, becoming greater with increasing frequencies, and vary linearly with increasing distance, and are given as dB/km. Sound scattering is affected by bubbles, suspended particles, organisms, or other floating materials. Like absorption losses, scattering losses vary linearly with distance, and are given as dB/km.

Whenever sound hits the ocean surface or seafloor, it is reflected, scattered, and absorbed and mostly loses a portion of its sound energy. Hard materials (like rocks) will reflect or scatter more sound energy, while soft materials (like mud) will absorb more sound energy. Accordingly, the seafloor plays a significant role in sound propagation, particularly in shallow waters.

Typically, a high-frequency sound cannot travel as far as a low-frequency sound in water because higher frequencies are absorbed more quickly. An exception is the rapid attenuation of low frequencies in shallow waters (Malme 1995). Shallow water acts as a waveguide bounded on the top by the air and on the bottom by the ocean bottom. The depth of the water represents the thickness of the waveguide. Sound at long wavelengths (low frequencies) does not fit in the waveguide and is attenuated rapidly by the effects of interference at the boundaries.

3.6.1.3 Ambient Noise

Ambient noise is defined as typical or persistent environmental background noise lacking a single source or point. In the ocean, there are numerous sources of ambient noise, both natural and anthropogenic, which are variable with respect to season, time of day, location, and noise characteristics (e.g., frequency). Natural sources include wind and waves, seismic noise from volcanic and tectonic activity, precipitation, marine biological activities, and sea ice (Greene 1995) while anthropogenic sources include transportation, dredging and construction, oil and gas drilling and production, geophysical surveys, sonar, explosions, and ocean scientific studies (Greene and Moore 1995). Depending on the ambient noise levels and their frequency distributions, basic activities by marine animals or specific human activities could be significantly hampered. As the ambient noise level increases, sounds from a specific source disappear below the ambient level and become undetectable due to loss of prominence of the signal at shorter ranges. In particular, anthropogenic sound could have effects on marine life, including behavior changes, masking, hearing loss, and strandings. Due to its importance to the sensitivity of instrumentation for research and military applications, ambient noise has been of considerable interest to oceanographers and naval forces. Recent concerns over potential impacts of strong sources of sound from scientific and military activities have driven considerable public and political interest in the issue of noise in the marine environment (NRC 2003a; Greene 1995).

For most of the world oceans, shipping and seismic exploration noise dominate the low-frequency portion of the spectrum (Hildebrand 2009). In particular, noise generated by shipping has increased as the number of ships on the high seas has increased Along the west coast of North America, long-term monitoring data suggest an average increase of about 3 dB per decade in low-frequency ambient noise (Andrew et al. 2002; McDonald et al. 2006, 2008).

Various activities and processes, both natural and anthropogenic, combine to form the sound profile within the ocean. Except for sounds generated by some marine animals using active acoustics, most ambient noise is broadband (composed of a spectrum of numerous frequencies without a differentiating pitch). Virtually the entire frequency spectrum is represented by ambient noise sources.

According to the Office of Marine Programs (OMP 2010) of the University of Rhode Island, distant shipping is the primary source of ambient noise in the 20- to 500-Hz range. Spray and bubbles associated with breaking waves are the major contributions to ambient noise in the 500- to 100,000-Hz range. At frequencies greater than 100,000 Hz, “thermal noise” caused by the random motion of water molecules is the primary source. Ambient noise sources, especially noise from wave and tidal action, can cause coastal environments to have particularly high ambient noise levels. Ice movements are a large source of noise in the Arctic and in Cook Inlet.

Per classical Wenz curves (Wenz 1962), which are plots of average ambient noise spectra, seismic background and turbulent-pressure fluctuations are prevailing noises in the frequency range of 1 to 100 Hz. Ocean traffic has noise between 10 and 1,000 Hz. Bubble and spray resulting from sea surface agitation (such as breaking waves, spray, bubble formation and collapse, and rainfall), whose noise increases with wind speed, accounts for the frequency range of 100 to 20,000 Hz. With peaks ranging between 100 and 1,000 Hz, Wenz curves provided noise spectrum level distributions for varying sea states.[5] At frequencies greater than 10,000 Hz, thermal noise contributes increasingly to ambient levels with frequency, but absolute levels are much lower than those below these frequencies. As intermittent and local effects, earthquakes and explosions consist of noise signals from 1 to 100 Hz. Volcanic and tectonic noise generated by earthquakes on land or in water propagates as low-frequency, locally generated “T-phase” waves, with energy levels generally below 100 Hz (Greene 1995). Biota, such as fishes, certain shrimps, and marine mammals, can produce signals ranging from less than 10 Hz to well over 100,000 Hz. Shipping and industrial activities along with sea ice have signals between 10 and 10,000 Hz. In addition to noise caused by breakup, sea ice makes noise when temperature changes result in cracking. Underpressure from wind and currents also results in significant

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[5] Sea state is a measure of the intensity of the ocean’s movement and is characterized by such parameters as wind speed, wave height, wave periodicity, and wave length. Sea states vary from “0,” which represents calm conditions, to “9,” which is characterized by wind speeds of more than 33 m/sec (108 ft/sec) and wave heights of more than 14 m (46 ft).

low-frequency noise, and iceberg melting results in "seltzer" noise. Precipitation covers the frequency range of 100 to 25,000 Hz.

Sources of ambient noise in the OCS include wind and wave activity, including surf noise near the land-sea interface; precipitation noise from rain and hail; lightning; biological noise from marine mammals, fishes, and crustaceans; and distant shipping traffic (Greene 1995). Several of these sources may contribute significantly to the total ambient noise at any one place and time, although ambient noise levels above 500 Hz are usually dominated by wind and wave noise. Consequently, ambient noise levels at a given frequency and location may vary widely on a daily basis. A wider range of ambient noise levels occurs in water depths less than 200 m (shallow water) than in deeper water. Ambient noise levels in shallow waters are directly related to wind speed and indirectly to sea state (Wille and Geyer 1984).

3.6.1.4 Anthropogenic Noise

Table 3.6.1-1 summarizes the various types of man-made noises in the ocean. Sources include transportation, dredging, construction, hydrocarbon and mineral exploration, geophysical surveys, sonar, explosions, and ocean science studies. Noise levels from most human activities are greatest at relatively low frequencies (<500 Hz).

3.6.1.4.1 Transportation. Transportation-related noise sources include aircraft (both helicopters and fixed-wing aircraft) and surface and subsurface vessels. While icebreakers, snowmobiles (snowmachine traffic), and hovercrafts are operating in the Arctic region, of these three, only hovercrafts are used in Cook Inlet, and none are used in the GOM.

Aircraft. The primary sources of aircraft noise are their engine(s) (either reciprocating or turbine) and propellers or rotors. Sound energy from both helicopters and propeller-driven aircraft concentrates at relatively low frequencies (usually below 500 Hz) due to dominant tones, which are harmonics of the blade rates[6] of the propellers and rotors (Hubbard 1995). Sounds from jets (i.e., turbojet or turbofan) that do not drive propellers or rotors do not include prominent tones at low frequencies but broadband noise across a wide range of frequencies.

In general, large, multi-engine aircraft tend to be noisier than small aircraft. Broadband (45–7,070 Hz) source levels from aircraft flyovers range from 156 dB re 1 μPa-m for Twin Otter with two turboprops to 175 dB re 1 μPa-m for C-130 military transport aircraft with four turboprops. A four-engine P-3 Orion with multi-bladed propellers has estimated source levels of 160–162 dB re 1 μPa-m in the 56–80 Hz band and 148–158 dB re 1 μPa-m in the 890–1,120 Hz band. A Twin Otter generates source levels of 147–150 dB re 1 μPa-m at the 82 Hz tone. Helicopters are typically noisier and produce a larger number of acoustic tones and higher broadband noise levels than do fixed-wing aircraft of similar size. Estimated source levels

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[6] The blade rate is defined as the number of turns of a propeller or turbine per second multiplied by the number of blades.

TABLE 3.6.1-1 General Types of Anthropogenic Sound in the Ocean and Estimated Levels of Maritime Activity

Activity	Sources	Source Level[a] (dB re 1 µPa-m)	Frequency Range (Hz)[b]	Gulf of Mexico Level of Activity
Transportation	Aircraft (fixed-wing and helicopters)	156–175	45–7,070	Moderate flight activity, estimated to be in the range of several hundred flights annually (most low-level flights for oil and gas support, aerial surveys)
	Small vessels (boats, ships)	145–170	37–6,300	High activity level; hundreds to thousands of fishing vessels, pleasure craft, small ships daily; millions of angler trips per year (MMS 2004: Appendix F, Section II.B); oil and gas support vessel activity, estimated to be 304,807 to 319,921 trips per year, with most concentrated in the Central Planning Area.
	Large vessels (commercial vessels, supertankers)	169–198	6.8–428	In the U.S. GOM in 1999, tankers and other freight vessels completed a total of approximately 279,000 vessel trips in the GOM and Gulf Intracoastal Waterway waters
	Ice breakers	171–191	10–1,000	None
	Hovercraft and vehicles on ice	130	224–7,070	None; related watercraft would include "jet skis," whose numbers are estimated to range into the thousands
Dredging and construction	Dredging	150–180	10–1,000	Precise levels unknown, although harbor maintenance activity is very common for major GOM ports; very limited in shipping channels
	Tunnel boring	Low	10–500	Unknown; expected to be rare in the GOM
	Other construction operations	Low	<1000	Unknown; expected to be limited in the GOM
	Pile driving	228	Broadband (peak at 100–500 Hz)	Precise levels unknown; used to set platforms

TABLE 3.6.1-1 (Cont.)

Activity	Sources	Source Level[a] (dB re 1 µPa-m)	Frequency Range (Hz)[b]	Gulf of Mexico Level of Activity
Oil and gas drilling and production	Drilling from islands and caissons	140–160	20–1,000	None in the GOM
	Drilling from bottom-founded platforms	119–127 (received)	5–1,200	Variable; may range from tens to hundreds of wells drilled from GOM platforms annually; January 2001 drilling activity levels: 61 wells. MMS notes 40,361 approved applications to drill in the GOM Federal waters
	Drilling from vessels	154–191	10–10,000	Low level of activity, on the order of tens of drill ships operating in GOM waters annually
	Offshore oil and gas production	Low	50–500	4,019 production platforms on 7,564 active leases in Federal waters of the GOM, as of July 31, 2001; as of September 2, 2003, there were 3,476 active offshore production platforms in the GOM Federal waters
	Support activity	See small vessels	See small vessels	304,807 to 319,921 trips per year, with most (~90%) concentrated in the Central Planning Area; ~10% of support vessel activity occurs in the Western Planning Area, while 0.2 to 0.3% is projected for the Eastern Planning Area
Geophysical surveys	Airguns	216–259[c]	<120	Tens to 30+ surveys per year, may have as many as five surveys running concurrently (MMS 2004: Appendix D, Section V)
	Sleeve guns	220–230	40–300	10–30 surveys per year usually limited to one OCS block (Brinkman 2012)

TABLE 3.6.1-1 (Cont.)

Activity	Sources	Source Level[a] (dB re 1 µPa-m)	Frequency Range (Hz)[b]	Gulf of Mexico Level of Activity
Geophysical surveys (Cont.)	Vibroseis	187 to 210[c] instantaneous level dependent upon sweep length (i.e., ~18–22 dB less than an airgun pulse)	10–70	Estimated to be rare (MMS 2004: Append D, Section II.D)
	Other techniques (sparkers, boomers)	212–221[c]	800–1,200	Less than 10 per year (Brinkman 2012)
Navigation and target detection (sonars, pingers)	Fathometers	180+	12,000+	Potentially high, given the presence of thousands of ships and boats in the GOM
	Military active sonars	230+	2,000–57,000	Unknown; expected to be periodic, infrequent (e.g., tens to 100 or more annually)
	Transponders	180–200	7,000–60,000	Unknown; expected to be periodic, infrequent (e.g., several hundred per year)
Explosions	Military ordinance	>279[c]	Peak	Low; live fire testing very limited in the GOM
	Ship and weapons testing	>294[c] (10,000 lb charge)	Broadband	Periodic, infrequent
	Offshore demolition (structure removals)	267–279[c] (based on charge weights)	Peak	53–130 removals per year

TABLE 3.6.1-1 (Cont.)

Activity	Sources	Source Level[a] (dB re 1 µPa-m)	Frequency Range (Hz)[b]	Gulf of Mexico Level of Activity
Ocean science studies	Seismology	Not applicable	Not applicable	Unknown, expected to be very limited study of earthquakes in the GOM, if any
	Acoustic propagation	220	50–64	Unknown, expected to be very limited
	Acoustic tomography	Not applicable	Not applicable	None expected
	Acoustic thermometry	195	57.5–92.5	None expected

[a] Root mean square pressure level unless otherwise noted.

[b] Frequency range represents the lowest and highest frequencies over which the estimated source level data (reported either for dominant tones or center frequency of the 1/3 octave bands) are available.

[c] Zero-to-peak pressure level.

Sources: Adapted from Greene and Moore (1995) and various sources including Brinkman (2012) and MMS (2004), as noted.

for a Bell 212 helicopter are about 149–151 dB re 1 μPa-m at the 22 Hz tone (Greene and Moore 1995).

Underwater sounds from passing aircraft are transient. Levels and durations of sounds received underwater from passing aircraft depend on the noise strength of the aircraft, the altitude and aspect of the aircraft, water depth, bottom conditions, the temperature-salinity profile of the water column, and receiver depth. The peak received noise level in water, as an aircraft passes directly overhead, decreases with increasing altitude and increasing receiver depth. At incident angles greater than 13° from the vertical, much of the incident noise from passing aircraft is reflected and does not penetrate the water with calm seas, deep water, or shallow water with a nonreflective bottom. However, some airborne sound may penetrate water at angles greater than 13° from the vertical when rough seas provide suitable angles for additional transmission, but only above certain frequencies (Lubard and Hurdle 1976).

Accordingly, the duration of audibility of a passing aircraft is far longer in air than in water. As explained previously, bottom type and water depth may strongly affect the level and frequency content of aircraft noise by either reflectivity or absorption of sound. Due to multiple reflections, lateral propagation underwater during aircraft flyover is better in shallow than in deep water, especially in the case of a reflective bottom (e.g., basalt); thus, its noise can be heard longer in shallow than in deep water.

Small and Large Vessels. Vessels are primary contributors to overall background noise in the sea, given their large numbers, wide distribution, and mobility (Greene and Moore 1995). Sound levels and frequency characteristics of vessel noises underwater are generally related to vessel size, speed, and mode of operation, although there exist wide variations among vessels of similar classes depending on vessel design. Larger vessels generally emit stronger and lower-frequency sounds than smaller vessels do because of their greater power, large drafts,[7] and slow-turning engines and propellers, and those underway with a full load or those pushing or towing a load are noisier than unladen vessels. The primary noise sources from all machine-powered vessels are related to propeller, propulsion, and other machinery. Propeller cavitation is usually the dominant underwater noise source of many vessels (Ross 1976). In general, propeller cavitation produces most of the broadband noise, with dominant tones resulting from the propeller blade rate. Propeller singing, typically a result of resonant vibration of the propeller blade(s) with a strong tone between 100 and 1,000 Hz, is an additional source of propeller noise. Cavitation bubbles absorb vibrational energy, so propeller singing ceases in case of strong cavitation. Noise from propulsion machinery is generated by engines, transmissions, rotating propeller shafts, and mechanical friction. These sources reach the water through the vessel hull. Other sources of vessel noise include a diverse array of auxiliary machinery, flow noise from water dragging along a vessel's hull, and bubbles breaking in the vessel's wake (Greene and Moore 1995).

Small boats produce noise of about 150–170 dB re 1 μPa-m at frequencies mostly below 1,000 Hz. At the 1/3 octave-band's center frequency of 1,000 Hz, a tug pulling a barge generates

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[7] The draft denotes the vertical distance between the waterline and the bottom of the ship's hull.

164 dB re 1 μPa-m when empty and 170 dB re 1 μPa-m when loaded. A tug and barge underway at 18 km/hr (11 mph) can generate broadband (45–7,070 Hz) source levels of 171 dB re 1 μPa-m. A small crew boat produces 156 dB re 1 μPa-m at the 90 Hz tone. A small boat with an outboard engine generates 156 dB re 1 μPa-m at the 1/3 octave-band's center frequency of 630 Hz, with almost the same levels as that ranging from 400 to 800 Hz. An inflatable boat with a 25 horsepower outboard engine produces 152 dB re 1 μPa-m at the 1/3 octave-band's center frequency of 6,300 Hz (Greene and Moore 1995).

Fishing in coastal regions also contributes sound to the overall ambient noise. Sound produced by these smaller boats is typically at a higher frequency, around 300 Hz. A 12-m (39-ft) long fishing boat, underway at 7 knots, generates a broadband source level of 151 dB re 1 μPa-m in the 250–1,000 Hz range. Trawlers generate source levels of 158 dB re 1 μPa-m at the 1/3 octave-band's center frequency of 100 Hz, with almost the same levels as that ranging from 100 to 250 Hz (Greene and Moore 1995).

Few data on 1-m (3-ft) source levels are available for small ships, such as support and supply ships. A supply ship underway can generate broadband (45–7,070 Hz) source levels of 181 dB re 1 μPa-m. In general, broadband (20-1000 Hz) source levels for most small ships are about 170 to 180 dB re 1 μPa-m (Greene and Moore 1995), which is for ships between boats and large vessels.

Shipping traffic, including large commercial vessels and supertankers, is most significant at frequencies from 20 to 300 Hz. Source levels from a freighter can be 172 dB re 1 μPa-m in the dominant tone of 41 Hz. Large vessels such as tankers, bulk carriers, and container ships can range from 169 dB (at the 428 Hz tone) to 181 dB (at the 33 Hz tone) re 1 μPa-m, while a very large container ship generates as much as 181–198 dB re 1 μPa-m (at tones below 40 Hz). Supertankers generate peak source levels of 185–190 dB re 1 μPa-m at about a 7 Hz tone. Noise levels of supertankers are highest at the lowest frequency measured (near 2 Hz), while strong broadband components caused by propeller cavitation are centered at frequencies ranging from 40 to 100 Hz (Greene and Moore 1995).

In shallow water, shipping traffic located more than 10 km (6 mi) away from a receiver generally contributes only to background noise. However, in deep water, low-frequency components of traffic noise up to 4,000 km (2,485 mi) away may contribute to background noise levels (Greene 1995).

3.6.1.4.2 Dredging and Construction. Marine dredging and construction activities are common within the coastal waters of the OCS. Underwater noises from dredge vessels are typically continuous in duration (for periods of days or weeks at a time) and strongest at low frequencies. Marine dredging sound levels vary greatly, depending upon the type of dredge (such as transfer, hopper, and clamshell dredges), and hopper dredges were noisier than transfer dredges (Greene 1985a, 1987). Transfer dredges can generate broadband (45–890 Hz) source levels of 172 to 185 dB re 1 μPa-m, and 1/3 octave-band (between 10 and 1,000 Hz) source levels ranging from 150 to 180 dB re 1 μPa-m with peaks in the 100–200 Hz range (Greene and Moore 1995). A clamshell dredge generates broadband (20–1,000 Hz) source levels of about

167 dB re 1 μPa-m while pulling a loaded clamshell back to the surface. Because of rapid attenuation of low frequencies in shallow water, dredging noise can diminish below typical broadband ambient levels of about 100 dB re 1 μPa within 25 km (16 mi) of dredges, but stronger tones from some dredges can be detectable beyond 25 km (16 mi) under certain conditions (Greene and Moore 1995).

Sounds from various onshore construction activities vary greatly in levels and characteristics. These sounds are most likely within shallow waters. Onshore construction activities may also propagate into coastal waters, depending upon the source and ground material (Greene and Moore 1995).

Pile driving during construction activities is of special concern because it generates signals with a very high source level and broad bandwidth. In general, the source level and frequency content of the sounds produced by pile driving depend on a variety of factors, including the type and size of the impact hammer and the pile, the properties of the seafloor, and the depth of the water. Thus, the actual sounds produced would vary from location to location.

Pile driving is expected to generate sound levels in excess of 200 dB and to have a relatively broad bandwidth from 20 Hz to the ultrasonic range above 20 kHz, with peak energy between 100 and 500 Hz (Madsen et al. 2006; Thomsen et al. 2006). Due to the impulsive nature of the sound, the radiation pattern is assumed to be rather omnidirectional (Madsen et al. 2006). Measurements from offshore wind farms in German Bight indicated that the broadband peak sound pressure level during pile driving were 189 $dB_{0\text{-}p}$ re 1 μPa (SEL = 166 dB re 1 $\mu Pa^2 \cdot s$) at 400 m (1,300 ft) distance, resulting in a peak broadband source level of 228 $dB_{0\text{-}p}$ re 1 μPa-m (SEL = 206 dB re 1 $\mu Pa^2 \cdot s$-m) (Madsen et al. 2006). The 1/3 octave-band sound pressure level was highest at 315 Hz (peak = 218 $dB_{0\text{-}p}$ re 1 μPa-m) with considerable sound energy above 2 kHz.

Sound propagation modeling for three projects predicted underwater noise levels greater than 160 dB re 1 μPa (NMFS threshold for behavioral disturbance/harassment from a noncontinuous noise source) at distances ranging from 3.4 to 7.2 km (2.1 to 4.5 mi) (BOEMRE 2011b). Pile-driving noise can travel a long distance; even at 80 km (50 mi) distance, the sound pressure levels at frequencies below 4 kHz are well above background noise, about 40–50 dB (Thomsen et al. 2006).

3.6.1.4.3 Oil and Gas Drilling and Production. Offshore drilling and production involve a variety of activities that produce underwater noises. Offshore drilling can be, in large part, made from three types of facilities: (1) natural or man-made islands; (2) bottom-founded platforms; and (3) drilling vessels, including semisubmersibles and drillships. Irrespective of type of facilities, most noises associated with offshore oil drilling and gas production are generally below 1,000 Hz (Greene and Moore 1995).

Compared with other drilling facilities, underwater noise emanating from drilling on natural or manmade islands is generally low, primarily due to poor transmission of sound through the rock and fill islands. And thus noise is inaudible at ranges beyond a few kilometers.

During drilling operations at the Sandpiper Island, Miles et al. (1987) estimated the source level of 145 dB re 1 μPa-m at a predominant 40-Hz tone, which is presumed related to diesel electric generator operation.

Underwater noises emanating from drilling activities from fixed, metal-legged platforms are considered weak due to noise sources on decks well above the water and small surface areas in contact with water. The strongest tones are generally at very low frequencies, near 5 Hz, for which received levels of 119 to 127 dB re 1 μPa at near-field measurement locations were reported (Gales 1982).

Drillships show somewhat higher noise levels than semisubmersibles as a result of mechanical noises generated through the hull of a drillship that is well coupled to the water. The drillship *Canmar Explorer II* generated broadband (45–7,070 Hz) source levels of 174 dB re 1 μPa-m. The specialized ice-strengthened floating platform *Kulluk* is by far the noisiest among drillships, producing broadband (45–1,780 Hz) source levels of 185 dB re 1 μPa-m (Greene and Moore 1995). Across the 20 to 1,000 Hz range, its 1/3 octave-band source levels are higher than that for *Canmar Explorer II*, with a maximum difference of about 15 dB. Measurements from *Kulluk* operating in another area indicated that it produced broadband (10–10,000 Hz) source levels of 191 dB re 1 μPa-m while drilling and 179 dB re 1 μPa-m while tripping (extracting or lowering the drillstring) (Hall et al. 1994).

In the shallow waters, the overall noise (20 to 1,000 Hz band) from most drilling operations would be at levels below the median ambient noise (about 100 dB re 1 μPa) at ranges greater than 30 km (19 mi) (Greene 1987).

Offshore oil and gas production is made from natural/manmade islands or from bottom-standing metal platforms. Sounds from production on islands or platforms can attenuate rapidly due to the reasons explained above for platforms and islands. Underwater sound levels from these activities are relatively low compared with other manmade activities. In addition, support activities associated with oil and gas operations such as supply/anchor handling and crew boats and helicopters also contribute to the noise from offshore activities.

3.6.1.4.4 Geophysical Surveys. Marine geophysical (seismic) surveys are commonly conducted to delineate oil and gas reservoirs below the surface of the land and seafloor. These operations direct high-intensity, low-frequency sound waves through layers of subsurface, which are reflected at boundaries between geological layers with different physical and chemical properties. The reflected sound waves are recorded and processed to provide information about the structure and composition of subsurface geological formations (McCauley 1994). In an offshore seismic survey, a high-energy sound source is towed at a slow speed behind a survey vessel. Until the mid-1960s, explosive charges were the standard sources for marine seismic exploration, but nonexplosive seismic survey sources, such as airguns, smaller sleeve exploders, and boomers, are currently in use, among which airguns are commonly used (Greene and Moore 1995, Brinkman 2012). An airgun is a pneumatic device that produces acoustic output through the rapid release of a volume of compressed air, which forms bubbles. The airgun is designed to direct the high-energy pulses of low-frequency sound (termed a “shot”) downward toward the seafloor. Airguns are usually used in sets, or arrays, rather than singly (McCauley 1994). Reflected sounds from below the seafloor are received by an array of sensitive hydrophones on cables (collectively termed “streamers”) that are towed behind a survey vessel or attached to cables placed on or anchored to the seafloor.

Airgun arrays are the most common source of seismic survey noise. Airguns produce energy primarily at 10–120 Hz, with some energy up to 500–1,000 Hz, which is lower than low-frequency energy but much higher than ambient noise levels. A typical full-scale airgun array produces a broadband source level of 248–255 $dB_{0\text{-}p}$[8] re 1 μPa-m (Johnston and Cain 1981; Greene 1985b), with the most powerful airgun array producing 259 $dB_{0\text{-}p}$ re 1 μPa-m (Greene and Moore 1995). Typical seismic arrays being used in the GOM produce source levels (sound pressure levels) of approximately 240 $dB_{0\text{-}p}$ re 1 μPa-m. Despite downward focusing of the seismic airgun pulses toward the ocean bottom, portions of their energy propagate horizontally, which is of greater concern. In waters 25–50 m (82–164 ft) deep, sound produced by airguns can be detected 50–75 km (31–47 mi) away, and these detection ranges can exceed 100 km (62 mi) during quiet times with efficient propagation, or in deeper water (Greene and Moore 1995).

3.6.1.4.5 Navigation and Target Detection. Active sonar systems are used for the detection of objects underwater. These range from depth-finding sonars (fathometers), found on most ships and boats, to powerful and sophisticated units used by the military. Sonars emit transient, and often intense, sounds that vary widely in intensity and frequency. Unlike most other manmade noises, sonar sounds are mainly at moderate to high frequencies, ranging from a few hundred hertz for long-range search sonar to several hundred kilohertz for side-scan sonars and military sonars, which attenuate much more rapidly than lower frequencies (Greene and Moore 1995). Acoustic pingers used for locating and positioning of oceanographic and geophysical equipment also generate noise at high frequencies.

Source levels of depth sounders are over 180 dB re 1 μPa-m at over 12 kHz, while those of bottom profilers are about 200–230 dB re 1 μPa-m in the 0.4–30 kHz range. Military sonars for search and surveillance operate at 2–57 kHz, with source levels of over 230 dB re 1 μPa-m (Greene and Moore 1995).

3.6.1.4.6 Explosions. Underwater explosions in open waters are the strongest point sources of anthropogenic sound in the sea. Sources of explosions include both military testing and non-military activities, such as offshore structure removals. Explosives produce rapid onset pulses (shock waves) followed by a succession of oscillating low-frequency bubble pulses, if the explosion occurs sufficiently deep from the surface (Staal 1985). Shock waves change to conventional acoustic pulses as they propagate.

High-explosive detonations have velocities of 5,000–10,000 m/s with pulse rise times of about 20 μsec and short-pulse durations of 0.2–0.5 ms. Although the wave is initially

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[8] For an ideal sinusoid, the zero-to-peak value is about 6 dB lower than peak-to-peak value and about 3 dB higher than the rms value.

supersonic, it is quickly reduced to a normal acoustic wave. Bubble-pulse frequency decreases as charge mass increases and as charge depth decreases. The spectra are dominated by a broad peak over a lower frequency band (<100 Hz), with strong infrasonic (<20 Hz) energy. Even a small 0.5-kg (1-lb) charge of TNT generates source levels of 267 dB_{0-p} re 1 μPa-m, while a 20-kg (44-lb) charge of TNT produces 279 dB_{0-p} re 1 μPa-m, with dominant frequencies below 50 Hz. Detonation of very large charges during ship shock tests with a 4,536-kg (10,000-lb) charge produces source levels of more than 294 dB_{0-p} re 1 μPa-m (Greene and Moore 1995; MMS 2005a).

3.6.1.4.7 Ocean Science Studies. Ocean science studies examine characteristics of the water masses and ocean bottom layer. In addition to the seismic surveys that are mentioned above, these include investigating sound transmission and the properties of ocean water masses (acoustic oceanography), the latter of which include tomographic studies.

Two notable closely related ocean science studies are presented to describe typical source levels. In January 1991, the Heard Island Feasibility Test (HIFT) in the southern Indian Ocean was carried out to establish the limits of usable, long-range acoustic transmissions (Munk et al. 1994). In the study, a vertical array of five sources, centered at 57 Hz (bandwidth 14 Hz), generated broadband source levels of about 220–221 dB re 1 μPa-m. These signals were detected halfway around the world (at ranges of up to ~20,000 km [12,427 mi]). The Acoustic Thermometry of Ocean Climate (ATOC) study was made in the northern Pacific Ocean over the decade 1996–2006, and was designed to monitor long-term ocean temperature trends. The coded signals with a source level of 195 dB re 1 μPa-m transmitted broadband signals centered at 75 Hz (bandwidth 35 Hz) to receivers scattered in the northern Pacific Ocean at a maximum range of about 5,500 km (3,418 mi) (Dushaw et al. 2009).

3.6.1.5 Climate Change Effects

Potential impacts of climate change on the acoustic environment are relatively minor. Since the sound attenuation rate depends on seawater acidity, it has been suggested that increasing ocean acidification resulting from rising anthropogenic CO_2 emissions will result in decreased sound absorption (Hester et al. 2008). Increases in ambient low-frequency noise have already been reported, attributable largely to an overall increase in human activities, such as shipping that are unrelated to climate change (Andrew et al. 2002). Due to the combined effects of decreased absorption and anticipated increases in overall human activities, ambient noise levels will increase considerably within the auditory range of 10–10,000 Hz, which are critical for environmental, biota, military, and economic interests (Hester et al. 2008). There will also be changes in frequency spectrum distributions.

3.6.2 Alaska – Cook Inlet

For a more detailed discussion on the acoustic environment of Cook Inlet, please see MMS (2003a), which is incorporated here for reference.

General underwater noise sources are covered in detail in Section 3.6.1, Acoustic Environment: Gulf of Mexico, while those limited to Arctic Alaska are discussed in Section 3.6.3, Alaska – Arctic. In this section, noise sources specific to Cook Inlet will be presented.

3.6.2.1 Sources of Natural Sound

In Cook Inlet, underwater sound is generated by a variety of natural sources, such as ice, the action of wind, waves, and biological activity. Ambient noise levels and the acoustic environment in the Cook Inlet vary greatly among seasons and even daily. To a lesser degree than in the Arctic, ice plays a role in the ambient noise levels. In contrast to the Arctic environment, strong tidal fluctuations and currents function as additional sources of ambient noise in Cook Inlet. Cook Inlet has one of the largest tides in the North American continent, and thus tidal noises can be important contributors to ambient levels, especially at low frequencies. Wind and wave action also contribute to ambient noise. Measurements at several seaward locations around Anchorage that are removed from industrial activities indicated that the mean ambient underwater broadband (10–20,000 Hz) levels span a fairly wide range, from 95 to 120 dB re 1 µPa (Blackwell and Greene 2002).

Marine mammals in Cook Inlet also contribute to ambient noise. Echolocation clicks have the highest source levels among marine mammal sounds. The echolocation signals from beluga whales have source levels of about 206–225 dB re 1 µPa-m, with peak frequencies between 40 and 60 kHz and between 100 and 120 kHz (Au et al. 1985, 1987; Au 1993). Under controlled conditions, a trained beluga had good echolocation abilities at distances up to at least 80 m (262 ft) (Au et al. 1987). However, maximum distances at which echolocation pulses can be detectable by hydrophone (one-way travel) are much greater than the maximum target distance at which the emitting animal can detect echoes (two-way travel).

Humpback whales in southeast Alaskan waters produce five categories of sounds, with frequencies ranging between 20 and 2,000 Hz (Thompson et al. 1986). Source levels ranged from 162 (low-frequency pulse trains) to 192 dB re 1 µPa-m (surface impacts resulting from fluke or flipper slaps).

Fin whales typically produce calls around 20 Hz, which have source levels of about 160–186 dB re 1 µPa-m with extremes of 200 dB and ≤140 dB (Patterson and Hamilton 1964; Northrop et al. 1968, 1971; Watkins 1981; Watkins et al. 1987; Cummings and Thompson 1994). Calls at 20 Hz can be transmitted up to 185 km (115 mi) away (Cummings and Thompson 1971).

There are many other species of marine mammals in the marine environment of Cook Inlet whose vocalizations contribute to ambient sound. These include but are not limited to, other whales (such as gray whales), dolphins, sea lions, sea otters, and seals (see Section 3.8.1.2). Sea lions, sea otters, seals, and marine and coastal birds all produce sound that can be heard above water.

3.6.2.2 Sources of Anthropogenic Sound

The primary sources of anthropogenic sounds in the Cook Inlet include aircraft overflights, vessel activities and traffic, oil and gas activities, including seismic surveys and production operations and other miscellaneous human activities such as construction of pipelines and production facilities, pile driving for a new dock at Anchorage port, and possibly new bridge construction. Port of Anchorage and Anchorage International Airport, which are important transportation and distribution hubs, and Elmendorf Air Force Base are located more than 145 km (90 mi) northeast of the Cook Inlet Planning Area (see Figure 3.2.1-1). Cook Inlet experiences considerable aircraft traffic throughout the year, including commercial passenger, cargo, private, and military aircraft (Moore et al. 2000c). In particular, Kenai and Homer airports, located east of the planning area, processed about 114,000 flight operations in 2001, about half of which were attributable to air-taxi operations. More than 10 helicopters are also based at these two airports. In Cook Inlet, significant noise originates from heavy vessel traffic, including cargo vessels, freighters, tankers, supply ships, support vessels, tugboats, barges, seismic-survey vessels, and fishing boats (for recreational, commercial, subsistence, and personal use). As for natural sound, anthropogenic sound varies spatially and temporally within the Cook Inlet.

Considering the size and/or traffic volume of vessels, noise from boat traffic associated with oil and gas activities is likely less than that from the fishing and commercial traffic occurring within the Cook Inlet. However, shipping traffic is more pronounced in Cook Inlet than in the Arctic Ocean. Shipping traffic dominates the spectra of ambient noise between 20 and 300 Hz. Fishing vessels produce high-frequency sound peaking at 300 Hz, whereas larger cargo vessels produce more lower frequency sounds (Greene and Moore 1995).

Blackwell and Greene (2002) measured underwater noise levels at six locations 0.3–19 km (0.2–12 mi) from the Phillips A oil platform in Cook Inlet. The highest broadband noise level was 119 dB re 1 µPa at 1.2 km (0.75 mi) from the platform. Background levels were reached by the farthest measuring location (19 km [12 mi]). Several tones at frequencies of 60–105 Hz were likely due to the platform. Other work found that drilling platforms and combined drilling/production platforms in California produce little underwater sound because of the small surface area in contact with the water and the placement of machinery on decks well above the water (Gales 1982).

3.6.2.3 Climate Change Effects

Potential impacts of climate change on the acoustic environment are relatively minor. Since the sound attenuation rate depends on seawater acidity, it has been suggested that increasing ocean acidification resulting from rising anthropogenic CO_2 emissions will result in decreased sound absorption (Hester et al. 2008). Increases in underwater low-frequency noise have already been reported, attributable largely to an overall increase in human activities, such as shipping that are unrelated to climate change (Andrew et al. 2002). Although sea ice is limited to northern Cook Inlet during winter through early spring, reduced sea ice associated with climate change could provide a longer open water season for shipping and resource extraction, which could increase sound levels in Cook Inlet. Due to the combined effects of decreased absorption, the anticipated increase in overall human activities, and the longer open water season, ambient noise levels will increase considerably within the auditory range of 10–10,000 Hz, which are critical for environmental, biota, military, and economic interests (Hester et al. 2008). There will also be changes in frequency spectrum distributions.

3.6.3 Alaska – Arctic

For a more detailed discussion on the acoustic environment of the Arctic region, please see MMS (2008b) and MMS (2006c), which are incorporated here for reference.

General underwater noise sources are covered in detail in Section 3.6.1, Acoustic Environment: Gulf of Mexico, while those limited to Cook Inlet are discussed in Section 3.6.2, Acoustic Environment: Alaska – Cook Inlet. In this section, noise sources specific to Arctic Alaska will be presented.

In the Arctic Project Areas including the Beaufort and Chukchi Seas, underwater sound is generated by a variety of natural and anthropogenic sources. The Arctic waters are a unique acoustic environment mainly due to the presence of ice, which can contribute significantly to ambient sound levels and affects sound propagation.

3.6.3.1 Sources of Natural Sound

Natural sound in the Alaskan Arctic predominantly originates from ice and the action of wind, waves, and biological activity (Greene 1995). Ambient levels of natural sound can vary dramatically between and within seasons at a particular location and can vary from location to location. As an example, MMS (2006c) found that ambient sound in the Beaufort Sea in September 1998 ranged widely, between about 63 and 133 dB re 1 μPa. The presence, thickness, and movement of sea ice significantly influence the ice's contribution to ambient sound levels, as does the period of open water when wind and waves contribute to ambient sound levels. Richardson 2011 found broadband (10–450 Hz) background levels of 90–110 dB re 1 μPa about 430 m (1,410 ft) from Northstar Island in the Beaufort Sea. The background levels were correlated with wind speed.

3.6.3.1.1 Sea Ice. The Arctic waters are a unique acoustic environment mainly due to the presence of ice, which can contribute significantly to ambient sound levels and affects sound propagation. Ice cracking due to thermal stresses caused by temperature changes generates noise, and ice deformation under pressure from wind and currents produces significant low-frequency noise (Greene 1995). Data are limited, but in at least one instance it has been shown that ice-deformation sounds had frequencies of 4–200 Hz (Greene 1981). While sea ice can produce significant sound, it also can also function to dampen ambient sound.

Ambient noise levels in the project area can vary drastically between seasons and can also vary with sea ice conditions. In winter and spring, shore-fast ice produces significant thermal cracking sounds (Milne and Ganton 1964). The spectrum of cracking noise typically displays a broad range from 100 to 1000 Hz, and the spectrum level has been observed to vary as much as 15 dB within 24 hours due to the diurnal change of air temperature. The NRC (2003a; citing Urick 1984) reported that variability in air temperature over the course of the day can change received sound levels by 30 dB between 300 and 500 Hz. Spring noise spectra peaked at about 90 dB re 1 $\mu Pa^2/Hz$ at infrasonic frequencies (0.5–2 Hz) (Milne and Ganton 1964). In the 2–20 Hz range, noise spectra decrease with increasing frequency, while in the 20–8,000 Hz range, the levels of 50 dB re 1 $\mu Pa^2/Hz$ remain constant. Winter noises include wind-induced noise as well as thermal cracking sounds. Winter noise, equivalent to Knudsen spectrum for sea state three, is higher than during any other season. For late summer ice, relative motion of the floes is the primary factor for ambient sound. As icebergs melt, they produce additional background noise with a spectrum level flat at about 62 dB re 1 $\mu Pa^2/Hz$ at a range of 180 m from an iceberg, decreasing to about 58 dB at 10 kHz (Urick 1971). In addition to noise caused by breakup, sea ice makes noise when temperature changes result in cracking. Underpressure from wind and currents also results in significant low-frequency noise, and iceberg melting results in “seltzer” noise.

The Arctic Ocean is almost uniformly cold from top to bottom, and pressure always increases with depth. Thus, sound speed is the lowest at or near the surface. All sound rays in the Arctic surface channel are refracted upward and are then reflected from the under-ice surface (Malme 1995). Low-frequency noise loses its energy by conversion of acoustic waves into flexural waves of the ice sheet. At higher frequencies, under-ice roughness plays a primary role in sound propagation. Smooth annual ice may enhance propagation as compared with open water conditions. However, increased cracking, ridging, and other forms of roughness generally cause more transmission losses than under open water conditions. As ice forms, especially in very shallow water, the sound propagation properties of the underlying water are affected in a way that can reduce the transmission efficiency of low-frequency sound (Blackwell and Greene 2002). At frequencies less than 500 Hz, where most acoustic energy from aircraft and surface vehicles is concentrated, the ice layer is acoustically thin and causes little attenuation of sound (Malme 1995).

The presence of sea ice also affects the timing, nature, and possible locations of human activities such as shipping; research; barging; whale hunting; oil- and gas-related exploration (e.g., seismic surveys and drilling); military activities; and other activities that introduce noise into the marine environment. Because of sea ice and its effects on human activities, ambient sound levels in the Beaufort and Chukchi Seas can vary dramatically between seasons and with sea ice conditions. The presence of ice also impacts which marine species are present, another factor that influences ambient sound levels.

There is some concern that climate change will alter the acoustic environment in the Arctic drastically. Arctic sea ice is declining rapidly. Its extent has fallen at a rate of 3 to 4% per decade over the last three decades, and this trend is very likely to continue (USGCRP 2009). If Arctic warming continues, it is likely that changes in the acoustic environment also will occur in many parts of the waters off Alaska (Tynan and DeMaster 1997; Brigham and Ellis 2004).

Climate warming potentially could: (1) increase noise and disturbance related to increased shipping and other vessel traffic and possibly increased seismic exploration and development; (2) expand commercial fishing and/or cause a change in areas where intensive fishing occurs; (3) decrease year-round ice cover; (4) change subsistence-hunting practices; and (5) change the distribution of marine mammal species (MacLeod et al. 2005).

3.6.3.1.2 Wind and Waves. During the open water season in the Arctic, wind and waves are important interrelated sources of ambient sounds with levels tending to increase with increased wind (and thus sea state) and wave height, all other factors being equal (Greene 1995). Areas of water with 100% sea ice cover can reduce or completely eliminate sounds from waves or surf. However, the marginal ice zone in the area near the edge of large sheets of ice usually is characterized by quite high levels of ambient sound compared to other areas, in large part due to the impact of waves against the ice edges and the breaking up and rafting of ice flows (Milne and Ganton 1964).

3.6.3.1.3 Marine Mammals (and Birds). Marine mammals can contribute significantly to the background sounds in the acoustic environment of the Beaufort and Chukchi Seas; however, frequencies and levels depend highly on seasons. For example, bearded seal sounds dominate ambient noise in many Arctic areas during spring; source levels of bearded seal songs have been estimated to be up to 178 dB re 1 μPa-m, with dominant frequencies of 1–2 kHz (Cummings et al. 1983). Parts of some calls were recorded up to a distance of 25 km (16 mi) underwater (Cleator et al. 1989). Ringed seal calls have a source level of 95–130 dB re 1 μPa-m, with the most energy below 5 kHz (Thomson and Richardson 1995). Its source levels are low compared with those of other marine mammals and the detection range may not exceed 1 km (0.6 mi) (Cummings et al. 1984). Bowhead whales, which are present in the Arctic region from early spring to mid- to late fall, produce sounds with estimated source levels ranging 128 to 189 dB re 1 μPa-m in frequency ranges from 20 to 3,500 Hz. Thomson and Richardson (1995) summarized that most bowhead whale calls are "tonal frequency modulated (FM)" sounds at 50–400 Hz. A few callings of bowhead whales are detectable up to 20 km (12 mi) away, although most localizable whales are ≤ 10 km (6.2 mi) away (Cummings and Holliday 1985; Clark et al. 1986; LGL and Greeneridge 1987). Based on monitoring near BP's Northstar Island in the Beaufort Sea, some whale calls were detected at up to 40 km (25 mi) (Aerts and Richardson 2008).

There are many other species of marine mammals in the Arctic marine environment whose vocalizations contribute to ambient sound including, but not limited to, the gray whale, walrus, beluga whale, spotted seal, fin whale (in the southwestern areas), and, potentially but less likely, the humpback whale. Walruses, seals, and seabirds (especially in the Chukchi Sea near colonies) all produce sound that can be heard above water.

3.6.3.2 Sources of Anthropogenic Sound

The primary sources of anthropogenic sounds in the Arctic include vessel activities and traffic, oil and gas activities, including seismic surveys, production, and other miscellaneous activities. During much of the year in many marine areas, there are few near-field marine noise sources of human origin and limited, but increasing, land-based and nearshore-based sources of noise.

Anthropogenic sources of sound in the project area include vessels; navigation and scientific research equipment; airplanes and helicopters; human settlements; military activities; and marine development, including those sounds from the oil and gas activities. Ambient sound levels from anthropogenic sources can also fluctuate temporally and spatially as much as variations in natural sounds. Table 3.6.1-1 provides a comparison of man-made sound levels from various sources and their typical source levels associated with the marine environment.

3.6.3.2.1 Vessel Activities and Traffic. The types of vessels that typically produce noise in the Beaufort and Chukchi Seas include barges, skiffs with outboard motors, icebreakers, tourism and scientific research vessels, and vessels associated with oil and gas exploration, development, and production. In the Beaufort and Chukchi Seas, vessel traffic and associated noise presently is limited primarily to open water season between late spring and early autumn.

In shallow water, vessels more than 10 km (6.2 mi) away from a receiver generally contribute only to background noise levels (Greene 1995). In deep water, traffic noise up to 4,000 km (2,485 mi) away may contribute to background noise levels. Shipping traffic is most significant at frequencies from 20 to 300 Hz (Greene 1995). Barging associated with activities such as onshore and limited offshore oil and gas activities, fuel and supply shipments, and other activities contributes to overall ambient noise levels in some regions of the Arctic. Smaller boats, such as aluminum skiffs with outboard motors during fall subsistence whaling and fishing also generate noise, typically at a higher frequency around 300 Hz (Greene and Moore 1995).

Icebreaking vessels used in the Arctic for activities including research and oil and gas activities produce louder, but also more variable, sounds than those associated with other vessels of similar power and size (Greene and Moore 1995). Icebreaking noise is up to 15 dB higher than when the same ship is underway in open water, primarily due to strong propeller cavitation. However, physical crushing of ice contributes little to the overall increase in noise. In general, spectra of icebreaker noise are wide and highly variable over time. Icebreaking generates broadband (10–1,000 Hz) source levels of 184 and 191 dB re 1 μPa-m during movement ahead and astern, respectively (Greene and Moore 1995). Even with rapid attenuation of sound under heavy ice conditions, the elevation in noise levels attributed to icebreaking can be substantial out to at least 5 km (3 mi). In some instances, icebreaking sounds are detectable from more than 50 km (31 mi) away.

Hovercraft can operate on open water or ice, and tracked or standard vehicles can often operate on shore-fast ice. Recordings indicated that the hovercraft operating around the Northstar Island generate strong in-air sounds, but were considerably quieter underwater than conventional vessels of similar size (Blackwell and Greene 2005). Hovercraft have replaced much of the helicopter traffic to the Northstar facility. At the closest point of approach (6.5 m [21 ft]), underwater broadband (10–10,000 Hz) levels reached 133 and 131 dB re 1 µPa at depths of 1 and 7 m (3 and 23 ft), respectively, with the peak near 87 Hz, which corresponds to the blade rate of the thrust propeller.

In general, noise generated on ice is transmitted into the water directly below but does not propagate well laterally (Greene and Moore 1995). For sources on ice, sound levels are affected by ice conditions (temperature, snow cover) and are generally much lower than those generated by vessels on water. Snow absorbs sound, and thus transmits less sound energy to water, and water depth also affects sound transmission from sources on ice.

Northstar is the first offshore oil production island in the Beaufort Sea, which is located about 19 km (12 mi) northwest of the Prudhoe Bay. Around the Northstar Island, vessels were the main contributors to the underwater sound field. During both the ice-covered and the open water seasons, helicopters and a hovercraft were used to transport personnel and equipment to and from the Northstar Island (Richardson 2011). During the ice-covered season, tracked vehicles and standard vehicles were additional modes of transportation over an ice road to the Northstar Island. During the open water season, vessels such as tugs, self-propelled barges, crew boats, and other vessel operations (e.g., oil spill-response training) were additional modes of transportation. Broadband sounds from vessel traffic were often detectable as much as 30 km offshore. Sound measurements for the entire 2001–2010 late summer/early fall seasons indicated that broadband (10–450 Hz) ambient levels ranged from 81 to 141 dB re 1 µPa at about 450 m (1,476 ft) north to northeast of Northstar.

3.6.3.2.2 Seismic Noise. The oil and gas industry in Alaska conducts marine (open water) surveys (e.g., airgun array) in the summer and fall, and on-ice seismic surveys (e.g., Vibroseis) in the winter to locate geological structures potentially capable of containing petroleum accumulations and to better characterize ocean substrates or sub-sea terrain.

Airgun arrays are the most common source of seismic survey noise. Airguns produce energy primarily at 10–120 Hz, with some energy up to 500–1,000 Hz, which is lower than low-frequency energy but much higher than ambient noise levels. A typical full-scale airgun array produces a broadband source level of 248–255 $dB_{0\text{-}p}$ re 1 µPa-m (Johnston and Cain 1981; Greene 1985b), with the most powerful airgun array of 259 $dB_{0\text{-}p}$ re 1 µPa-m (Greene and Moore 1995). Typical seismic arrays being used in the Arctic produce source levels (sound pressure levels) as high as 248 $dB_{0\text{-}p}$ re 1 µPa-m (Greene and Richardson 1988).

While the seismic airgun pulses are directed toward the ocean bottom, sound propagates horizontally for several kilometers (Greene and Richardson 1988; Hall et al. 1994). However, depending on the source and other factors, seismic noise could be detected much farther away from the source. In waters 25–50 m (82–164 ft) deep, sound produced by airguns can be detected 50–75 km (31–47 mi) away, and these detection ranges can exceed 100 km (62 mi) under favorable propagation conditions or in deeper water (Greene and Moore 1995) and, particularly during summer, over 3,000 km (1,864 mi) in the open ocean (Nieukirk et al. 2004).

Vibroseis is a method of seismic profiling on shore-fast ice, usually over shallow water, which propagates energy into the earth over an extended period of time, in contrast to the near-instantaneous energy provided by impulsive sources. In this activity, hydraulically driven pads mounted beneath a line of trucks are used to vibrate, and thereby energize, the ice. Noise incidental to the activity is introduced by the vehicles associated with this activity. Greene and Moore (1995) summarized that typical signals associated with the vibroseis sound source used for an on-ice seismic survey sweep from 10 to 70 Hz, but harmonics extend to about 1.5 kHz. Vibroseis produces source levels of about 187–210 $dB_{0\text{-}p}$ re 1 µPa-m and would reduce to the ambient level at distances of 3.5–5 km (2–3 mi) (Holliday et al. 1984).

3.6.3.2.3 Noise from Other Oil and Gas Activities. Offshore exploration and production drilling platforms (freestanding or drill ships) use machinery and equipment that emit noise into the marine environment. While most of this noise is relatively localized, organisms can be attracted to or be displaced away from these sites.

Onshore oil production facilities (and associated buildings, pipelines, roads, etc.) have equipment (machinery and vehicles) or people that generate noise. As of the end of 2011, there are no oil production facilities in the Chukchi Sea. There is one operating oil production facility on an artificial island and several others in planning and construction stages in the Beaufort Sea. There are two other developments on causeways. While sounds originating from drilling activities on islands can reach the marine environment, noise typically propagates poorly from artificial islands, as it must pass through gravel into the water (Greene and Moore 1995). During unusually quiet periods, drilling noise from icebound islands with a low source level and low frequency would be audible at a range of about 10 km (6 mi), when the usual audible range would be about 2 km (1 mi). Broadband noise reduced to ambient levels within about 1.5 km (0.9 mi), and low-frequency tones were measurable to about 9.5 km (6 mi) under low ambient noise conditions, but were essentially undetectable beyond about 1.5 km (0.9 mi) with high ambient noise. Much of the production noise from oil and gas operations on gravel islands is substantially attenuated within 4 km (2.5 mi) and often not detectable beyond 9.3 km (6 mi) away.

Based on measurements of noise from Northstar obtained during March 2001 and February–March 2002 (during the ice-covered season), Blackwell et al. (2004) found that background levels were reached underwater at 9.4 km (6 mi) during drilling and at 3–4 km (2–2.5 mi) without. Depending on the wind but irrespective of drilling, in-air background levels were reached at 5–10 km (3–6 mi) from Northstar. Without vessels and under calm sea (sea state ≤ 1), median underwater sound from a gravel island like Northstar generally reached background levels at about 2–4 km (1.2–2.5 mi) from Northstar (Richardson 2011).

3.6.3.2.4 Snowmachines and Ice Roads. The two principal sources of transportation activity on the North Slope are the oil industry and the Iñupiat communities (MMS 2008b). Small snowmobiles have high-speed two-cycle engines. These are noisy in air and create sounds at higher frequencies than larger, slower machinery. The amount of sound passing through ice into the water below is expected to vary greatly depending on snow, ice, and temperature conditions. The spectrum of snowmobile sound as received under the ice includes much energy near 1–1.25 kHz, but levels vary widely: spectrum levels about 90 dB re 1 µPa^2/Hz at 148 m (486 ft) in one study, versus only 55–60 dB at about 200 m (656 ft) in another (Greene and Moore 1995).

The oil industry builds ice roads in winter to access areas that otherwise would be inaccessible to large equipment. Fresh water from local lakes is used to build a thick, flat road surface capable of supporting large machinery. Ice-road construction begins as early as December and is usually completed by mid-winter. Water may be used for maintenance throughout the useful life of the ice road (BLM 2012).

3.6.3.2.5 Miscellaneous Sources. Acoustical systems are associated with some research, military, commercial, or other vessel use of the Beaufort or Chukchi Seas. Such systems include multi-beam sonar, sub-bottom profilers, and acoustic Doppler current profilers. Active sonar is used for the detection of objects underwater. These systems range from depth-finding sonar, found on most ships and boats, to powerful and sophisticated units used by the military. Sonar emits transient, and often intense, sounds that vary widely in intensity and frequency. Although not commonly used in the Arctic, acoustic pingers used for locating and positioning oceanographic and geophysical equipment also generate noise at frequencies greater than about 10–20 kHz. LGL Ltd. (2005) describes many examples of acoustic navigational equipment.

Small snowmobiles are used for transportation on the North Slope (MMS 2008b). These are noisy in air and create sounds at higher frequencies than larger, slower machinery. The amount of sound passing through ice into the water below is expected to vary greatly depending on snow, ice, and temperature conditions (Greene and Moore 1995).

The oil industry builds ice roads in winter to access areas that otherwise would be inaccessible to large equipment. Ice-road construction begins after freezeup and is built over tundra and shorefast ice to facilitate exploration and development while minimizing impacts (MMS 2008b).

3.6.3.3 Climate Change Effects

Potential impacts of climate change on acoustic environment are relatively minor. Since the sound attenuation rate depends on seawater acidity, it has been suggested that increasing ocean acidification resulting from rising anthropogenic CO_2 emissions will result in decreased sound absorption (Hester et al. 2008). Increases in underwater low-frequency noise have already been reported, attributable largely to an overall increase in human activities, such as shipping, that are unrelated to climate change (Andrew et al. 2002). In addition, reduced sea ice associated with climate change could provide a longer open water season for shipping and resource extraction, which could increase sound levels in the Beaufort and Chukchi Seas. Due to the combined effects of decreased absorption, the anticipated increase in overall human activities, and the longer open water season, ambient noise levels will increase considerably within the auditory range of 10–10,000 Hz, which are critical for environmental, biota, military, and economic interests (Hester et al. 2008). There will also be changes in frequency spectrum distributions.

3.7 MARINE, COASTAL, AND OTHER ADJACENT HABITATS

A habitat is defined as an area or environment where an organism or ecological community normally lives. Marine and coastal habitats occur as characteristic arrangements of geologic, hydrologic, oceanographic, and biologic features and processes that create environments favorable for the establishment, flourishing, and continued survival of the flora and fauna of marine and coastal areas. This section focuses on the geologic, biologic, and oceanographic features that define marine and coastal habitats of particular concern. Habitats of particular concern are so designated because of their ecosystem importance, their association with high productivity and/or faunal populations, and/or their high scientific interest. These habitats will be evaluated within an ecoregional geographic framework, as shown for the GOM in Figure 3.7-1, and discussed in Section 3.2.

3.7.1 Coastal and Estuarine Habitats

3.7.1.1 Gulf of Mexico

Habitats are divided into coastal and marine categories. Coastal habitats occur in estuarine areas along virtually the entire U.S. GOM coast. The EIS uses the EDAs from NOAA’s Coastal Assessment Framework (http://coastalgeospatial.noaa.gov) database to show the areas where the coastal habitats that are considered in the EIS are located (Figure 3.7-1). Marine habitats occur seaward of the coastal habitats that occur within estuarine watersheds. While a convenient boundary between coastal and marine habitats is the most seaward coastal feature, which typically would be barrier islands or beaches in the GOM, the actual boundary between predominantly coastal and predominantly marine habitats is a transition zone blurred by the influence of estuarine discharges onto the continental shelf. Figure 3.7-1 shows that the central coastal ecoregion estuarine influence extends to the edge of the continental shelf as a result of the discharge of the Mississippi River, while it is much more restricted on the continental shelf offshore Florida and Texas.

GOM coastal habitats are associated with a nearly continuous estuarine ecosystem that is made up of 31 major estuarine watersheds that extend across the coastal waters of the northern GOM. Coastal and nearshore habitats of concern within these areas include barrier islands and beaches, wetlands (marsh, bottomland swamp, mangrove, and scrub/shrub communities), and seagrasses. These habitats occur within estuarine watersheds in and around bays, lagoons, and river mouths where marine and fresh waters intermix, as well as extending further offshore in some areas but commonly to depths of about 30 m (98 ft). Coastal and nearshore habitats of the GOM can be subdivided into three GOM Estuarine Ecoregions (Figure 3.7.1-1), each with distinguishing characteristics, arrangements of habitat components, and freshwater inflows with

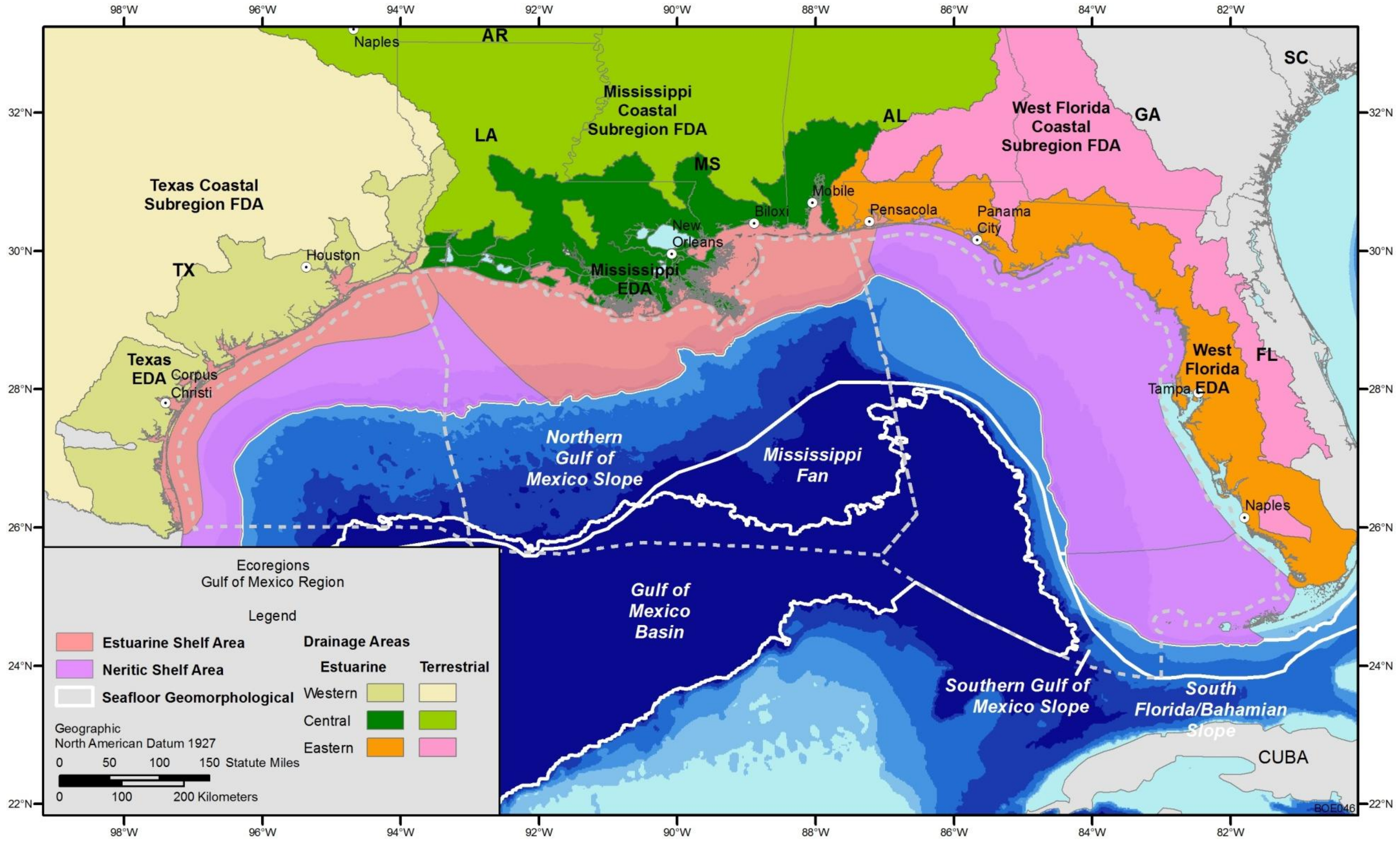


FIGURE 3.7-1 Ecoregions of the GOM Region

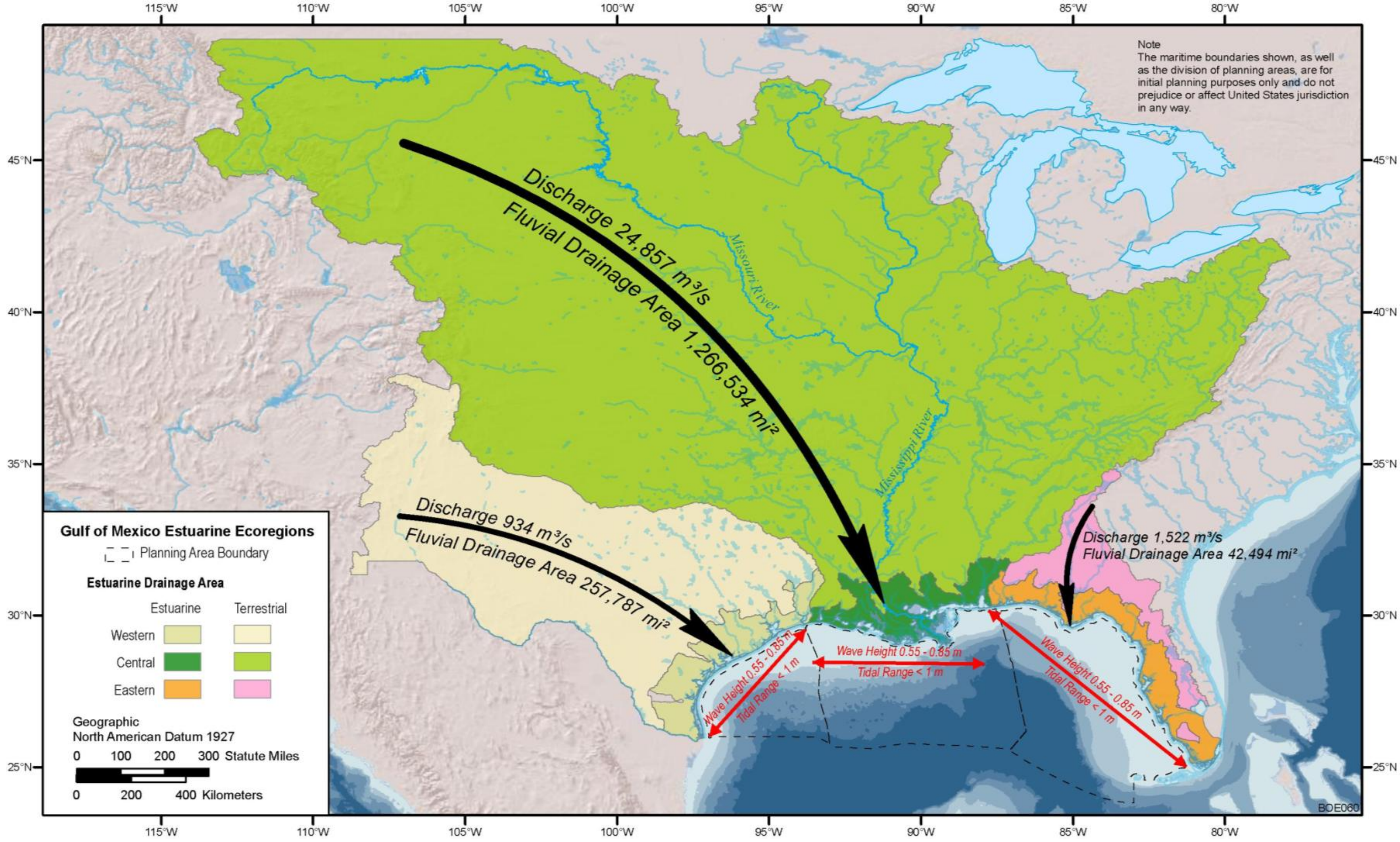


FIGURE 3.7.1-1 Estuarine and Fluvial Drainage Areas of the Gulf of Mexico Region

associated nutrient and sediment loads: a western coastal ecoregion, extending from near the Mexico–Texas border to just east of the Louisiana border; the Central GOM Estuarine Region, extending to just east of the Florida border; and the Eastern GOM Estuarine Region, extending to the southern tip of Florida. These ecoregions are similar to the geographic/hydrologic regions of Yanez-Arancibia and Day (2004) and are consistent with estuarine influenced zones identified on the GOM continental shelf in the Marine Ecoregions of North America (CEC 2008).

Figure 3.7.1-1 emphasizes coastal habitats. It shows terrestrial, estuarine, and continental shelf estuarine areas and values for fluvial and marine processes/quantities. Fluvial drainage areas are shown because they depict the land area that drains into the estuarine portion of the watershed. The estuarine drainage areas show where coastal habitats potentially affected by OCS oil and gas activities occur. While OCS activities would not be expected to extend upstream into the terrestrial portion of the watershed, the terrestrial watershed characteristics have important influences on estuarine habitats. Terrestrial discharges introduce dissolved and suspended materials into estuarine and marine waters that can serve either as nutrients that enrich marine and coastal productivity or as pollutants that degrade habitat quality. The terrestrial discharges also carry suspended and bed load sediments from the land into estuarine areas where they are redistributed through the coastal zone to provide the substrate for many coastal habitats. Marine processes are also at work on the seaward side of estuarine areas through the action of waves, tides, and currents. These processes affect the redistribution of terrestrial sediments in the coastal zone, coastal erosion and deposition patterns, and mixing of fresh and salt water within the coastal zone and onto the continental shelf. To a large degree, the variations in the interactions among these terrestrial and marine processes and properties within the GOM explain the distinctions among the three coastal ecoregions that characterize the northern GOM.

Figure 3.7.1-1 indicates that marine processes affecting estuarine habitats, such as tidal range, wave height, and longshore sediment transport, are fairly uniform across the GOM coast. In contrast, there is substantial variation in terrestrial drainage properties among the coastal ecoregions. Fluvial discharge, for example, varies by a factor of over 25 across the three coastal ecoregions. The effect of the amount of fresh water discharged through the central GOM estuarine costal ecoregion is apparent on Figure 3.7.1-1, which shows the entire continental shelf area offshore of the Mississippi River Delta as being estuarine influenced compared to smaller estuarine areas on the continental shelf offshore of the eastern and western coastal ecoregions.

The sizes and configurations of the fluvial drainage areas also affect governance issues that would apply to managing coastal environments and habitats and present and future programs for mitigating and restoring coastal habitats there. The central coastal fluvial drainage area is sub-continental in size and under the jurisdiction and regulatory authority of numerous State governments, Federal agencies, and interagency programs. Furthermore, the hydrology of the Mississippi River system in the central GOM fluvial drainage area supports numerous navigational, agricultural, recreational, and industrial activities and enterprises that together create a complex set of governance and trade-off issues that would affect the management of coastal and marine habitats there. The western and eastern fluvial drainage areas, in contrast, are nearly contained within the boundaries of a single State, which would act to simplify governance issues affecting coastal habitat management there.

3.7.1.1.1 Barriers. Coastal barrier landforms consist of barrier islands, major bars, sand spits, and beaches that extend across the nearshore waters from the Texas–Mexico border to southern Florida. These elongated, narrow landforms are composed of sand and other unconsolidated, predominantly coarse sediments that have been transported to their present locations by rivers, waves, currents, storm surges, and winds.

Coastal landforms are transitory in nature and are constantly being modified by the same forces that led to their original deposition. The GOM coast shoreline is constantly changing as a result of the action of wind-driven waves and longshore currents that cause sediment transport. The coastline has a narrow tidal range, and energy forces tend to be storm dominated, with episodic high wave energy. These landforms are continually modified by waves, currents, storm surges, and winds. Coastal currents in the GOM transport sediments in a counter-clockwise direction from east to west, and contribute to sediment accretion as well as erosion of coastal landforms. Over extended periods of time, landforms may move landward (transgressive), seaward (regressive), or laterally along the coast. Sediments are also transported to coastal areas from rivers that discharge to the GOM. Barrier islands and sand spits protect wetlands and other estuarine habitats located behind them from the direct impacts of the open ocean, and slow the dispersal of freshwater into the GOM, thus contributing to the total area and diversity of estuarine habitat.

On barrier landforms, the nonvegetated foreshore slopes up from the low-tide line to the beach berm-crest. The backshore is found between the beach berm-crest and the dunes, and it may be sparsely vegetated. The berm-crest and backshore may occasionally be absent because of storm activity. The dune zone of a barrier landform consists of one or more low dune ridges that may be stabilized by vegetation such as grasses and scrubby woody vegetation. During storms, waves can overwash lower barrier landforms, and vegetation communities on these are often sparse and in early successional stages. On higher, more stabilized landforms, vegetation behind the dunes consists of scrubby woody vegetation, marshes, and maritime forests. Fresh- and saltwater ponds may occur on landward flats or between dunes. On the landward side of islands and spits, low flats grade into intertidal wetlands or mudflats.

Barrier islands are prevalent along the Texas coast from the Bolivar Peninsula southward to the Mexican border. Barrier islands and sand spits present in this region of the Texas coast were formed from sediments supplied by major deltaic headlands. The barrier islands in this region are arranged symmetrically around old, eroding delta headlands, and tend to be narrow and sparsely vegetated, exhibiting a low profile with numerous washover channels. The barrier islands and beaches are moving generally to the southwest. Net coastal erosion has been occurring in some areas. Inland beaches of sand and shells are found along the shores of bays, lagoons, and tidal streams.

The Chenier Plain is transitional between the Central estuarine ecoregion, which is heavily influenced by the Mississippi River Delta building processes, and the Western estuarine ecoregion, where the river influence greatly diminishes. Most barrier shorelines of the Mississippi River Delta complex in Louisiana occur along the outward remains of a series of old abandoned river deltas and are transgressive. Only a minor portion of the sediments of the Mississippi River, now channelized, enter longshore currents and contribute to barrier landforms.

Most dune areas of the delta consist of low single-line dune ridges that are sparsely to heavily vegetated, depending on the length of time between major storms.

Short time intervals between storms can cause reductions in the size and resiliency of barrier islands and shorelines. Although barrier islands and shorelines have some capacity to regenerate over time, the process is very slow and often incomplete. The past decade has seen an increase in tropical storm activity for the project area. Figure 3.7.1-2 shows hurricane landfalls from 1994 to 2009. Hurricane Katrina in 2005 caused severe erosion and land loss for the coastal barrier islands of the Deltaic Plain. Hurricane Katrina was the fifth hurricane to impact the Chandeleur Island chain in 8 yr. The Chandeleur Islands were reduced by Hurricane Katrina from 14.6 km^2 (5.64 mi^2) to 6.5 km^2 (2.5 mi^2), and then to 5.2 km^2 (2.0 mi^2) by Hurricane Rita (Di Silvestro 2006).

The Mississippi River Delta in Louisiana has the most rapidly retreating beaches in North America. Most of the barrier beaches of southeast Louisiana are composed of medium to coarse sand. Mudflats occur in lower intertidal areas. Gentle slopes of subtidal substrates in much of the area reduce wave energies and erosion. The Statewide average shoreline retreat for 1956–1978 was 8.29 m/yr (27.2 ft/yr) (van Beek and Meyer-Arendt 1982). More recent analyses reveal that Louisiana shorelines are retreating at an average rate of 4.2 m/yr (13.8 ft/yr) and range from a gain of 3.4 m/yr (11.2 ft/yr) to a loss of 26.3 m/yr (86.2 ft/yr) (USGS 1988). In comparison, the average shoreline retreat rates for the GOM, Atlantic seaboard, and Pacific seaboard were reported at 1.8, 0.8, and 0.0 m/yr (5.9, 2.6, and 0.0 ft/yr), respectively. The highest reported rates of Louisiana's coastal retreat have occurred along the coastal plain of the Mississippi River. Regressive shorelines occur, however, at the mouth of the Atchafalaya River, where sediment discharges from that river are forming new deltas.

Wide beaches and a large dune system are located on the Alabama coast. The Mississippi Sound barrier islands, along the coast of Mississippi and Alabama, have formed as a result of westward sand migration resulting in shoal and sand bar growth (Otvos 1980). The islands are separated from each other by fairly wide, deep channels, and are offset from the coast by as much as 16 km (10 mi). They are generally regressive and stable in size, and slowly migrating westward in response to the westward moving longshore current. These islands have high beach ridges and prominent sand dunes, and sand shoals typically occur adjacent to the islands. The dunes and margins of ponds on the islands are well vegetated, with mature southern maritime forests of pine and palmetto behind some dunes areas. Although some of these islands may experience washover during significant storms, washover channels are not common.

Exceptions include a number of barrier islands of Mobile Bay's ebb-tidal delta, portions of which are low-profile transgressive islands frequently overwashed by storms. They continually change shape under storm and tidal pressures. Their sands generally move northwesterly into the longshore drift, nourishing beaches down drift. These sediments may also move landward during flood tides (Hummell 1990).

Barrier islands and sand beaches occur along the southwest Florida coastline, north of the Everglades, except in the Big Bend area. The Big Bend area, one of the lowest energy coastlines in the world, is devoid of typical barrier islands and beaches. Because of the low energy and

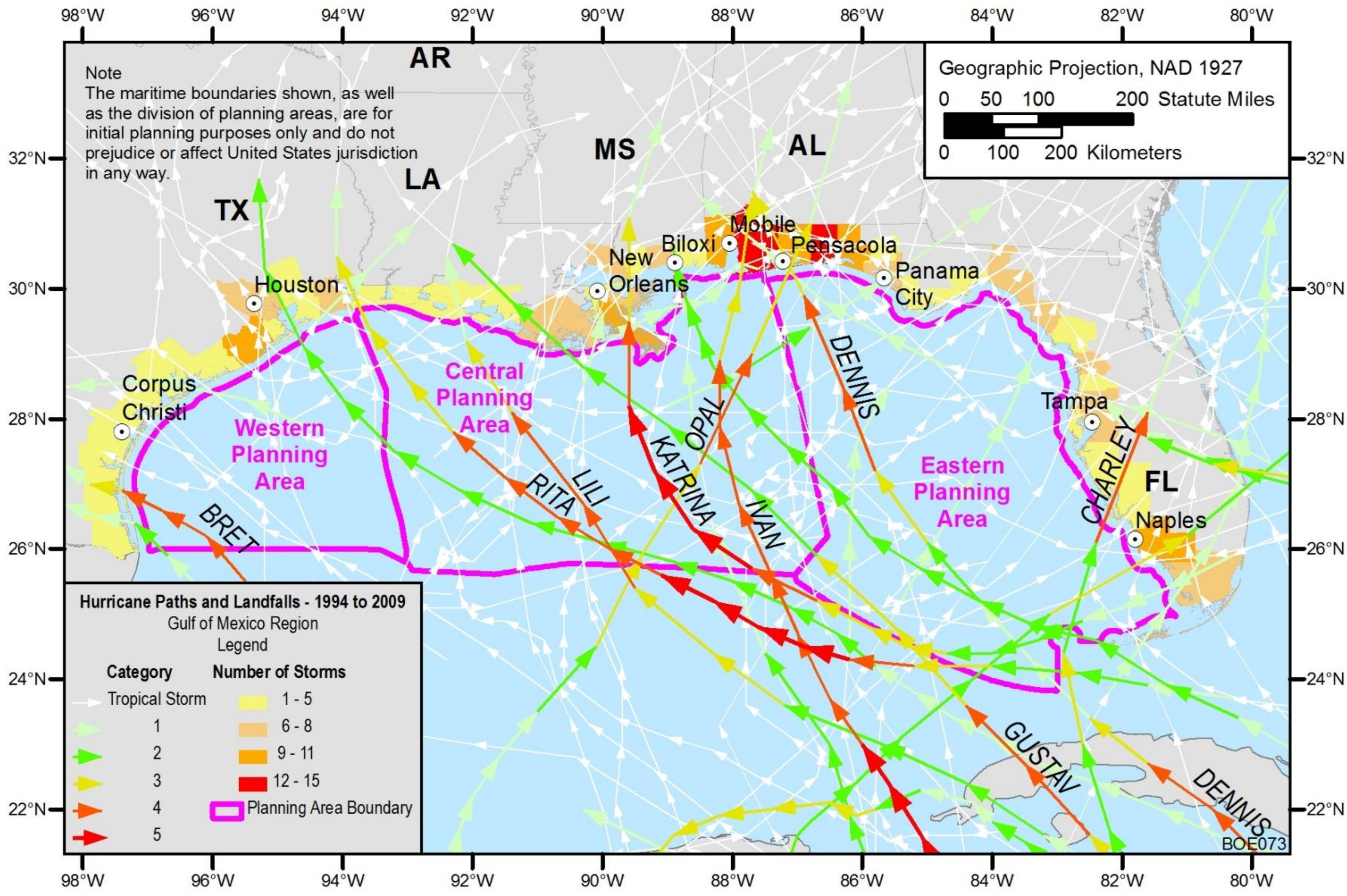


FIGURE 3.7.1-2 Hurricane Paths and Landfalls 1994–2009

minimal erosive forces, forested wetlands occur down to the water's edge. The barrier islands and mainland beaches of the Florida Panhandle typically are stable, with broad, high-profile beaches backed by high dunes. The Florida Keys, at the southern tip of Florida, are limestone islands, an unusual landform type that does not occur elsewhere in the GOM, and provide unique habitats in the region (MMS 1996a).

3.7.1.1.2 Wetlands. Wetland habitats along the coast of the GOM consist of fresh, brackish, and salt marshes; mudflats; forested wetlands of bottomland hardwoods, cypress tupelo swamps, and mangrove swamps. Wetland habitats may occupy only narrow bands along the shore, or they may cover vast expanses of the coastline. Marshes and mangrove swamps are primarily intertidal habitats. Forested wetlands are generally found inshore, above the tidal influence. Coastal wetland areas of the GOM States are given in Table 3.7.1-1 and wetland density is shown in Figure 3.7.1-3.

Coastal wetlands are characterized by high organic productivity, including the production and export of detritus, and efficient nutrient recycling. They provide habitat for numerous species of plants, invertebrates, fish, reptiles, birds, and mammals. Freshwater marshes generally support a greater diversity of plant and animal species than do brackish and salt marshes.

The coast of the Chenier Plain, which includes western Louisiana and eastern Texas from the Bolivar Peninsula just north of Galveston Bay, is composed of sand beaches and extensive intertidal mudflats. The mudflats are the result of mud and fine particles being transported from the Mississippi and the Atchafalaya Rivers. A subtidal mud bottom extends a great distance seaward in shallow water, reducing wave energy and resulting in minimal longshore sediment transport (USDOI and USGS 1988), and helping to protect coastal wetland communities. The shoreline is in a state of transgression (moving landward). Thin accumulations of sand, shell, and caliche nodules form beaches that are migrating landward over tidal marshes. These beaches have poorly developed dunes and numerous washover channels. Barrier beaches in the Chenier

TABLE 3.7.1-1 Gulf of Mexico Coastal Wetland Inventory

State	Marsh[a]	Estuarine Scrub-Shrub[a]	Forested Scrub-Shrub[a]	Total[a]	% Total
Texas	183,900	1,100	3,000	188,000	14
Louisiana	723,500	4,100	1,900	729,500	55
Mississippi	23,800	400	–	24,200	2
Alabama	10,400	1,100	800	12,300	1
Florida	108,100	255,100	13,100	363,900	28
Total	1,041,700	261,800	18,800	1,319,900	–

[a] Measured in ha.

Source: USEPA 1992.

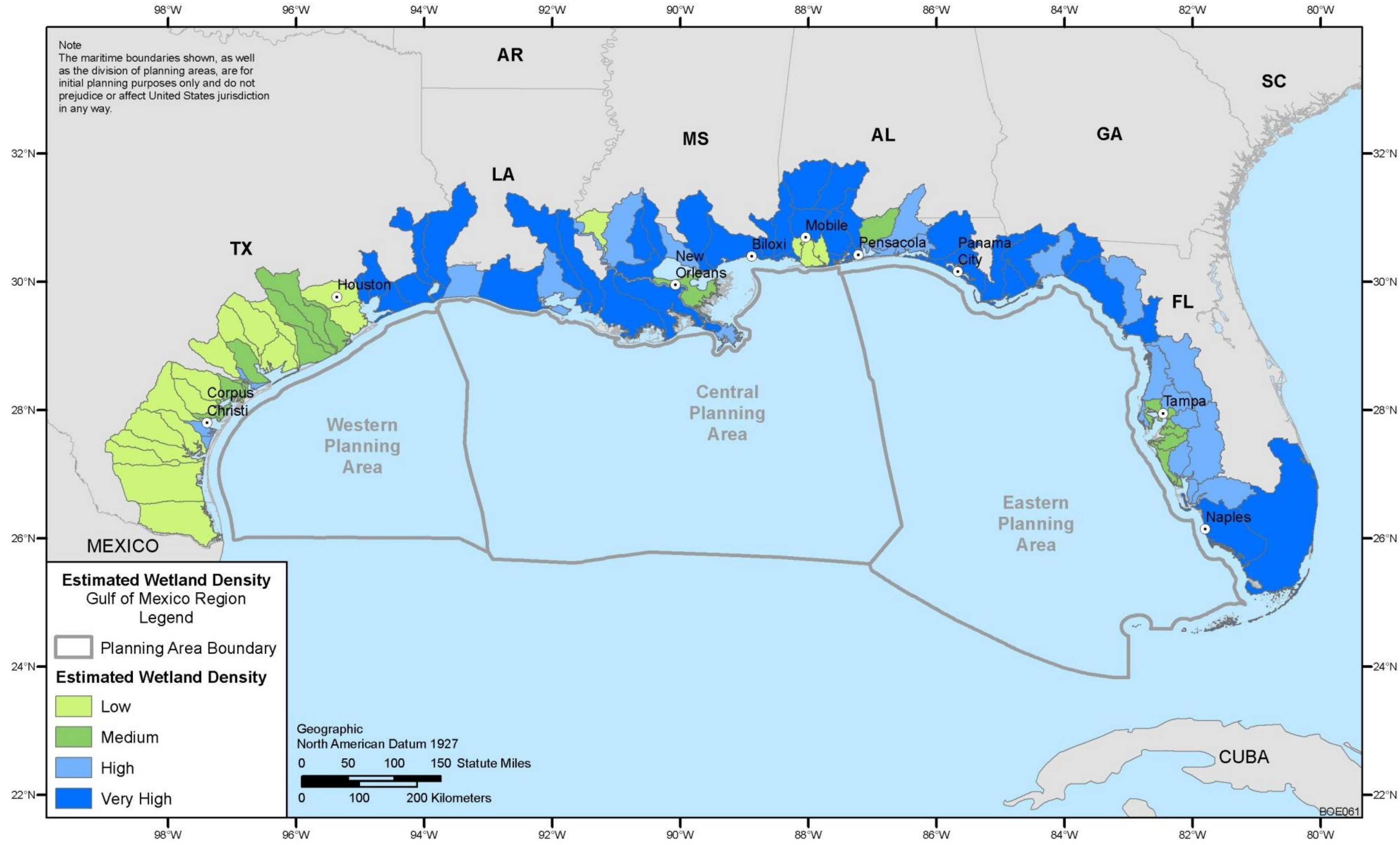


FIGURE 3.7.1-3 Estimated Wetland Density of the Gulf of Mexico Region (Stedman and Dahl 2008)

Plain area are narrow, low, thin sand deposits present along the seaward edge of the coastal marsh, and have poorly developed dunes and numerous washover channels. In some western areas of the Chenier Plain, the beach and subtidal substrates are composed of shelly sand (Fisher et al. 1973). Subtidal substrates in the eastern portions are mud and muddy sand. Most of the shoreline of the Chenier Plain is sediment starved and transgressive.

Along the Texas coast, from the Mexican border to the Bolivar Peninsula, estuarine marshes occur in discontinuous bands around bays and lagoons, on the inner sides of barrier islands, and in the deltas and tidally influenced reaches of rivers. Salt marshes, composed primarily of smooth cordgrass (*Spartina alterniflora*), are evident nearest the mouths of bays and lagoons in areas of higher salinities. Salt-tolerant species such as saltwort (*Batis maritima*) and glasswort (*Salicornia* spp.) are among the dominant species. Brackish water marshes, some of which are infrequently flooded, occur farther landward. Freshwater marshes occur along the major rivers and tributaries, lakes, and catchments (White et al. 1986). Broken bands of black mangroves (*Avicennia germinans*) also occur in this area (Brown et al. 1977; White et al. 1986). Mud and sand flats occur around shallow bay margins and near shoals, increasing toward the south as marshes decrease. Freshwater swamps and bottomland hardwoods are uncommon, and do not occur in the southern third of this coastal area.

Localized sedimentation conditions have favored deposition in the area of the Chenier Plain, which is a series of sand and shell ridges separated by progradational mudflats, marshes, and open water lakes. Few tidal passes are located along the Chenier Plain, and the tidal movement of saline water is reduced. Salt marshes are not widely distributed on the Chenier Plain. They are generally directly exposed to GOM waters and are frequently inundated. Brackish marshes are dominant in estuarine areas and are the most extensive and productive in the Louisiana portion of this coastal area. Marsh-hay cordgrass (*Spartina patens*) is generally the dominant species.

Freshwater wetlands are extensive on the Chenier Plain. While tidal influence is minimal, these wetlands may be inundated by strong storms. Some inland freshwater marshes, bottomland swamps, and hardwood forests were inundated by hurricane Rita with up to 1.5 m (4 ft) of saltwater. Detritus tends to collect in freshwater marshes and may form thick accumulations, sometimes forming floating marshes in very low energy areas. Forested wetlands of cypress-tupelo swamps, black willow stands, and bottomland hardwoods occur only in the floodplains of major streams.

Wetlands in the Mississippi Deltaic Plain are associated with a series of overlapping riverine deltas. These wetlands developed in shallow areas that received flow and sediments from the Mississippi River. The effects of sea-level rise and high, natural subsidence of these organically rich sediments are continually impacting these wetlands (van Beek and Meyer-Arendt 1982). Extensive salt and brackish marshes occur throughout the southern half of the plain and east of the Mississippi River. Farther landward, extensive intermediate and freshwater marshes are found. In freshwater areas, cypress-tupelo swamps occur along the natural levees and in areas that are impounded by dredged materials, levees, or roads. Bottomland hardwoods occur on natural levees and in drained levee areas. Extensive freshwater marshes, swamps, and hardwood forest also occur in Atchafalaya Bay in association with the delta sediments. Sparse stands of black mangrove are scattered in some high-salinity areas of the Mississippi Deltaic Plain.

Most marshes around Mississippi Sound and associated bays occur as discontinuous wetlands associated with estuarine environments. The more extensive coastal wetland areas in Mississippi are associated with the deltas of the Pearl River and Pascagoula River. The marshes in Mississippi are more stable than those of either Alabama or Louisiana, reflecting a more stable substrate and continued active sedimentation in the marsh areas. In Alabama, most of the wetlands are located in Mobile Bay and along the northern side of Mississippi Sound. Forested wetlands are the predominant wetland type along the coast of Alabama; large areas of estuarine marsh and smaller areas of freshwater marsh also occur (Wallace 1996). Major causes of marsh loss in Alabama have included industrial development, navigational dredging, natural succession, and erosion-subsidence (Roach et al. 1987).

From 1956 to 2006, the land loss rate for coastal Louisiana was 69.7 km^2/yr (26.9 mi^2/yr), for a total net loss of 3,494 km^2 (1,349 mi^2) (Barras et al. 2008). The net land loss rate has declined, however, from previous years: a loss of 562 km^2 (217 mi^2) from 2001 to 2006, at 16.4 km^2/yr (6.3 mi^2/yr) from 2001 to 2004, and 256.4 km^2/yr (99.0 mi^2/yr) from 2004 to 2006. Although the net land loss rate is expected to continue to decline from 2000 to 2050, averaging 26.7 km^2/yr (10.3 mi^2/yr), Louisiana can be expected to lose about 1,329–1,813 km^2 (513–700 mi^2) of coastal wetlands over that time period, in spite of predicted gains from natural processes and current restoration projects (USGS 2003; LCWCRTF 2003; USACE 2004). Historic and projected future land losses for coastal Louisiana (developed before hurricanes Katrina and Rita) are shown in Figure 3.7.1-4.

Losses of coastal wetlands have been occurring along the GOM coast for decades, resulting in the conversion of wetland habitats to open water. Coastal land loss is a particular problem in Louisiana. Many factors contribute to the coastal land loss problem there, including the effects of large storm events, subsidence, sea-level rise, saltwater intrusion, drainage and development, canal construction, herbivory, sediment deprivation, reduced flooding, and induced subsidence and fault reactivation. Upstream alterations of the Mississippi River drainage system are factors of particular importance because the construction of dams on upstream tributaries has resulted in approximately a 50% reduction in sediment load transported to the GOM (Turner and Cahoon 1988), and flood control levees constructed along the Mississippi River have prevented seasonal overbank flooding and sediment deposition in coastal marshes. Projects undertaken through the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA, or Breaux Act) program (LCWCRTF 2003), Coast 2050 Plan (LCWCRTF 1998), and Louisiana Coastal Area Plan (USACE 2004) are designed to contribute to ecosystem-scale restoration and sustainability.

Land losses along the Louisiana coast result from numerous factors, some of which are relatively recent in origin, while others have been ongoing for many years. Coastal wetlands are lost due to the effects of large storm events, and erosion of barrier islands reduces wetland protection (LCWCRTF 2001). In addition, hydrologic alterations have resulted in changes in salinity and inundation, causing a dieback of marsh vegetation and a subsequent loss of substrate (LCWCRTF 2001). The sediment load of the Mississippi River has been reduced by about 50%

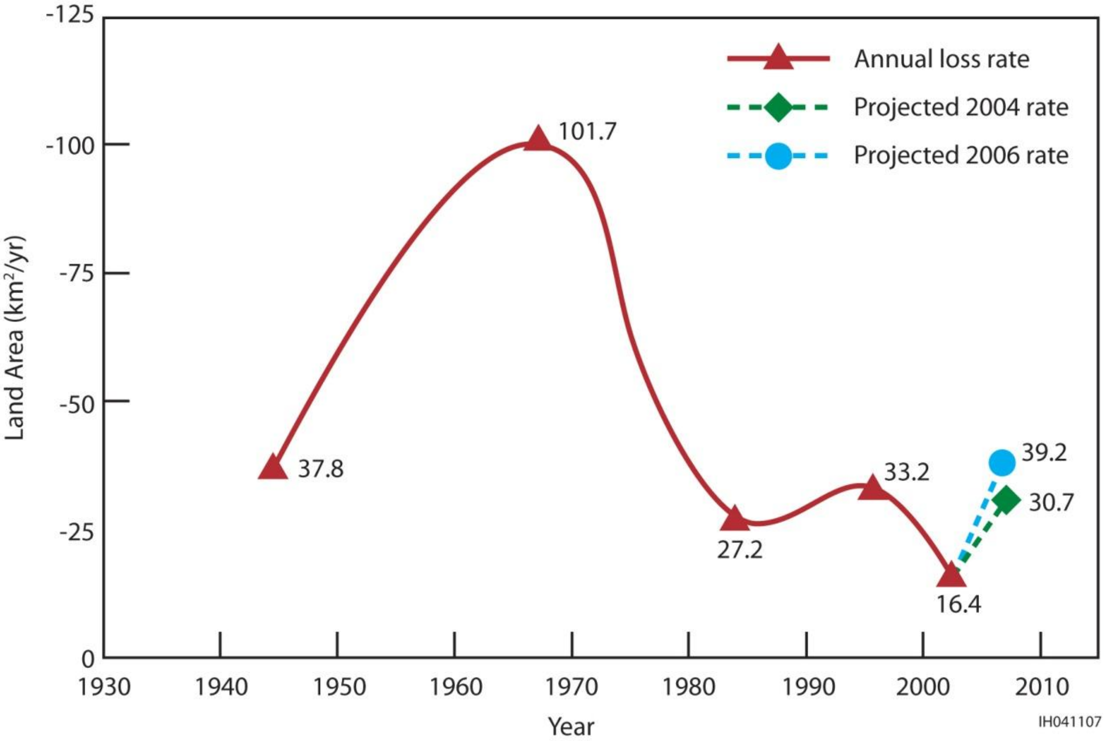


FIGURE 3.7.1-4 Annual Rates of Land Area Change in Coastal Louisiana (Barras et al. 2008)

since the 1950s as a result of upstream tributary dam construction and reduced soil erosion in the watershed. Furthermore, levees constructed along the Mississippi River have, for many years, prevented seasonal overbank flooding and the sediment deposition in coastal marshes. The Louisiana coastal marshes require an adequate addition of sediment annually to continue building vertically in pace with ongoing subsidence and sea level change (LCWCRTF 1998, 2003; USACE 2004). As a result, coastal marshes are being converted to open water.

Subsidence is a natural process resulting from the compaction of highly organic sediment deposits underlying the coastal marshes, and has been occurring for centuries. The rate of subsidence is 0.15–1.31 m (0.49–4.30 ft) per century in the delta area and 0.08–0.61 m (0.26–2.00 ft) per century on the western Louisiana Coast (USACE 2004). The rise in sea level is attributed to the melting of ice sheets and glaciers, and increased ocean temperatures, induced by global climate change. Sea levels have risen 0.12 cm/yr (0.05 in./yr) over the past century, and may rise as much as 20 cm (7.9 in.) by 2050 (LCWCRTF 1998, 2001; USACE 2004). Relative sea-level rise is a combination of the rise in sea level and local subsidence, and the average rate is currently estimated to be 1.03–1.19 m (3.38–3.90 ft) per century along the Louisiana Coast (USACE 2004). The rate of relative sea-level rise on the deltaic plain is occurring at a higher rate than in most coastal areas, and the rapid rise in relative sea level exacerbates the effects of reduced sedimentation in the wetlands.

Numerous canals have been constructed within the coastal marshes for navigation and shoreline access and, because of widening over time, contribute to the breakup of marsh (LCWCRTF 2003). Spoil banks along the canals cover wetland areas and prevent the effective draining of adjacent areas, resulting in higher water levels or more prolonged tidal inundation. Canals also create a means for salt water intrusion into brackish and freshwater wetlands and increased tidal processes, resulting in shifts in species composition, habitat deterioration, erosion, and wetland loss (LCWCRTF 1998, 2003).

Marsh loss in Louisiana has also resulted from sudden marsh dieback, or brown marsh. Large areas of coastal marsh vegetation have died, particularly in 2000 and 2009. Brown marsh results from a combination of factors related to extensive drought conditions, primarily reduced soil moisture combined with physical and chemical changes in the soil (Lindstedt and Swenson 2006). Most areas affected in 2000 have recovered.

Induced subsidence and fault reactivation attributed to oil and gas extraction below the coastal marshes have also been identified as causes of coastal wetland loss in some locations in Louisiana (USGS 2001; Morton et al. 2002, 2003). Large-volume extraction of hydrocarbon fluids and formation water has likely caused compaction of the overlying rock strata and downward displacement along nearby faults, resulting in land surface subsidence and conversion of marsh to open water, particularly during the years of high petroleum production.

In coastal Louisiana, it is difficult to establish possible linkages from deep onshore and nearshore hydrocarbon production to subsidence and wetland loss because wetland loss is ubiquitous and caused by numerous processes and conditions, both natural and anthropogenic (Morton et al. 2002). Thus, it is increasingly complex and difficult to establish the extent to which onshore subsidence and land loss is caused by hydrocarbon fluids and formation water extraction in offshore Federal waters.

A number of coastal habitat protection and restoration projects have been initiated along the GOM coast to address the issue of erosion and land losses. Many of these projects have focused on rebuilding barrier islands and coastal beaches for shoreline maintenance, as well as protection of coastal salt marshes. Modern techniques for navigation channel dredging and maintenance use the dredged sediments to nourish adjacent coastal landforms, minimizing potential erosion impacts. MMS, now BOEM, in cooperation with State and local agencies, has been involved in developing habitat restoration projects using OCS sand resources.

3.7.1.1.3 Seagrasses. Seagrasses are unique marine flowering plants of which there are approximately 60 species worldwide (den Hartog 1970; Phillips and Menez 1988). With the exception of some species that occur in rocky intertidal habitats (e.g., west coast of the United States), they grow in shallow, subtidal, or intertidal unconsolidated sediments. Overall the importance of seagrasses and their role in many coastal ecosystems has been extensively documented (see reviews by Phillips 1984; Zieman 1982a; Thayer et al. 1984; Zieman and Zieman 1989). As submerged wetlands, they form one of the most productive plant communities on the planet, providing a wide range of ecological services (e.g., water filtration, shoreline erosion protection, nursery grounds for recreationally and commercially valuable animals, carbon sequestration).

Field et al. (in prep.) has reviewed and compiled existing Geographic Information System (GIS) data for seagrasses from Maine to Texas, and the results for the GOM are summarized here. Seagrasses are distributed across all the GOM States, but the majority, 88% (727,096 ha), are found in Florida (Yarbro and Carlson 2011). This does not include the large amounts of paddle grass (*Halophila decipiens*) that exist on the West Florida shelf that cannot be mapped with any existing remote sensing technology. However, Iverson and Bittaker (1986) and Hale et al. (2004) conducted extensive surveys of this offshore (out to about the 30 m isobath), which totaled over 8,500 km^2 of seagrass beds (2.09×10^6 acres). Texas has extensive seagrass broad shallows, ranked second in the GOM with 11% of the total (92,854 ha), 74% of which are in the broad shallows of Laguana Madre. The remaining States have considerably less seagrass coverage: Louisiana with 0.5% of the GOM total (4,511 ha); Mississippi, 0.08% (622 ha); and Alabama, 0.06% (498 ha) (Field et al. in prep.).

Frequency of mapping techniques vary, making it difficult to evaluate Gulfwide seagrass resources. Long-term trends indicate that in many areas from Texas to Florida, seagrass habitats have decreased (Handley et al. 2007), although specific areas have shown gains in recent years (Yarbro and Carlson 2011).

Hurricane impacts, such as the influx of salt water in low salinity estuaries, can produce changes in seagrass community quality and composition. The distribution of seagrass beds in coastal waters of the Western and Central GOM has diminished during recent decades. Primary factors believed to be responsible include dredging, dredged material disposal, trawling, water quality degradation, hurricanes, and a combination of flood protection levees that have directed freshwater away from wetlands, saltwater intrusion that moved growing conditions closer inland, and infrequent freshwater diversions from the Mississippi River into coastal areas during the flood stage.

Primarily because of low salinity and high turbidity, robust 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. Seagrasses in the Western GOM are widely scattered beds in shallow, high-salinity coastal lagoons and bays. Lower-salinity, submerged beds of aquatic vegetation are found inland and discontinuously in coastal lakes, rivers, and the most inland portions of some coastal bays. The distribution of seagrass beds in coastal waters of the Western and Central GOM has diminished during recent decades.

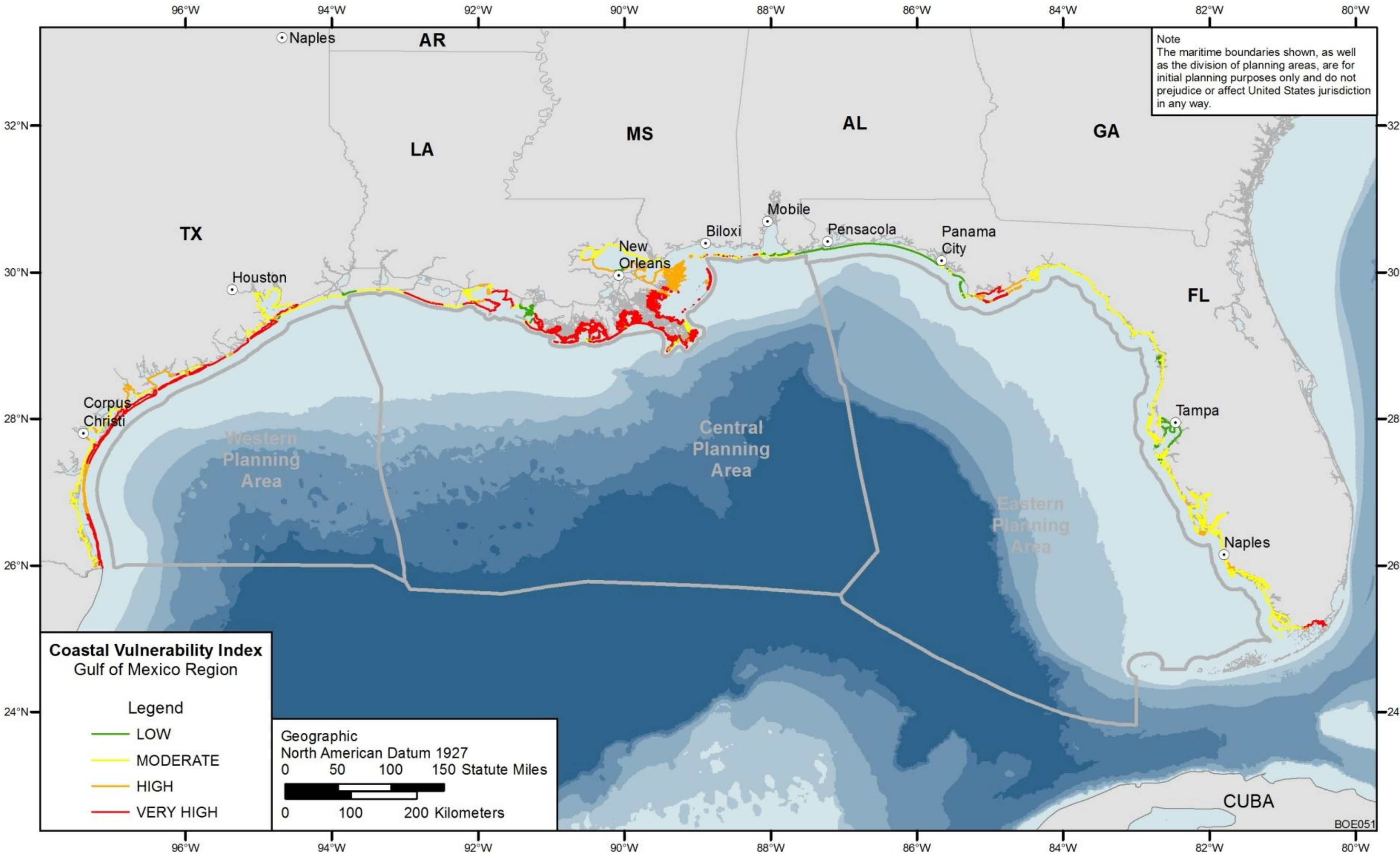
The turbid waters and soft, highly organic sediments of Louisiana’s estuaries and offshore areas limit widespread distribution of higher salinity seagrass beds. Consequently, only a few areas in offshore Louisiana support seagrass beds. In Mississippi and Alabama, seagrasses occur within the Mississippi Sound. Widgeon grass (*Ruppia maritima*), an opportunistic species, is tolerant of low salinities and occurs in some estuaries.

3.7.1.1.4 Climate Change Effects. Coastal habitats would be affected by global climate change. Factors associated with global climate change include changes in temperature, 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, and increases in episodic erosion, storm damage, risk of flooding, and defence 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 (CVI) 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) (see Figure 3.7.1-5, which shows the CVIs of Pendleton et al. [2010] from Galveston to Panama City, and CVIs of Thieler and Hammar-Klose [2000] for the remainder of the coast).

Saltwater intrusion/increased salinity and sea level rise can result in mortality of salt-intolerant species, resulting in reductions in habitat area and changes in species composition of coastal habitats. Effects observed include declines in coastal bald cypress (*Taxodium disticum*) forests in Louisiana and migration of mangroves into adjacent wetland communities in Florida (Nicholls et al. 2007). In some areas, existing plant communities may be displaced farther inland (Nicholls et al. 2007). Enhanced coastal erosion, coastal flooding, and loss of coastal wetlands, particularly in Louisiana and Florida, are projected impacts of sea level rise and increased frequency of storm surges, both of which are associated with climate change (IPCC 2002).

Land losses would likely increase due to the effects of climate change. The acceleration of sea level rise and increases in storm intensity as a result of climate change would exacerbate the current level of coastal land loss in the Mississippi deltaic plain, an already expected additional loss of 1,300 km^2 (501.9 mi^2) if current global, regional, and local processes continue (Nicholls et al. 2007). 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). Combined with potential rates of subsidence in the area of the Mississippi Delta Plain, relative sea level rise may range from 0.5 to 1.4 m (1.6 to 4.6 ft) by 2100 (Blum and Roberts 2009). In the absence of sediment input, resulting submergence in the delta region could range from 10,000 to 13,500 km^2/yr (3,861 to 5,212 mi^2/yr) by 2100 (Blum and Roberts 2009).

3.7.1.1.5 Effects of Deepwater Horizon Event. 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



Note
The maritime boundaries shown, as well as the division of planning areas, are for initial planning purposes only and do not prejudice or affect United States jurisdiction in any way.

FIGURE 3.7.1-5 Coastal Vulnerability Index of the Gulf of Mexico Region (Pendleton et al. 2010; Thieler and Hammar-Klose 2000)

Commission 2011b). The greatest impacts were in Louisiana. More than 209 km (130 mi) of coastal habitat were moderately to heavily oiled, only 32 km (20 mi) of which occurred outside of Louisiana (National Commission 2011b). 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; in the intertidal zone; and in the subtidal zone, remaining there 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). Remnant oil continued to be observed buried at various depths in some near-shore beaches in November 2011(Hayworth et al. 2011). Oil was also deposited along the coast in marshes such as those of the Mississippi River Delta and Chandeleur Sound, mudflats, and mangroves, oil contacted seagrass beds such as those behind the Chandeleur Island chain, and submerged aquatic vegetation communities such as those in Plaquemines and St. Bernard Parishes, Louisiana. These habitats also were also affected by prevention and cleanup efforts (National Commission 2011b; Martinez et al. 2011). Loss of marsh habitat along its edge as a result of oiling was observed. A full understanding of the effects of the spill is expected to take years but is not needed at the programmatic stage to make a reasoned choice among alternatives (see Section 1.4.2, Incomplete and Unavailable Information).

3.7.1.2 Cook Inlet

Coastal and nearshore habitats of concern within the Cook Inlet Planning Area include beaches, marshes, tidal flats, scarps, riverine mouths/deltas, and marine algae. Coastal habitats of Cook Inlet are given in Table 3.7.1-2. These habitats occur within estuarine watersheds in and around bays, lagoons, and river mouths where marine and fresh waters intermix. Coastal and nearshore habitats of Cook Inlet can be subdivided into two ecoregions (Figure 3.2.2-2), each with distinguishing characteristics, arrangements of habitat components, and freshwater inflows with associated nutrient and sediment loads: the Cook Inlet, extending from the northeastern Alaska Peninsula to the southern tip of the Kenai Peninsula, and the Gulf of Alaska, extending south along Kodiak Island and the Alaska Peninsula. These are based on the Level III Marine Ecoregions of the Commission for Environmental Cooperation (CEC 2008). Four terrestrial ecoregions are located along the coast of the Cook Inlet Planning Area: the Cook Inlet, the Alaska Range (along the southwestern coastline), Coastal Western Hemlock-Sitka Spruce Forests (on the southeastern coastline and northern Kodiak Island), and the Alaska Peninsula Mountains (along the Alaska Peninsula and southern Kodiak Island) (USEPA 2011e).

TABLE 3.7.1-2 Coastal Habitats of the Cook Inlet Planning Area

Habitat: ESI Rank	Habitat Area and Shoreline Length
Salt- and brackish-water marshes: 10A	11,338 mi^2; 672 mi
Sheltered tidal flats: 9A	104,977 mi^2; 356 mi
Sheltered scarps in mud or clay: 8A	279 mi
Exposed tidal flats: 7	280,010 mi^2; 426 mi
Gravel beaches: 6A	167 mi
Mixed sand and gravel beaches: 5	317 mi^2; 792 mi
Coarse-grained sand beaches: 4	36 mi
Fine- to medium-grained sand beaches: 3A	7 mi
Exposed wave-cut platforms in bedrock, mud, or clay: 2A	10,252 mi^2; 449 mi
Exposed, solid man-made structures: 1B	1 mi
Exposed rocky shores: 1A	25 mi^2; 284 mi

In Cook Inlet, the amount of sea ice varies annually. In general, sea ice forms in October to November, increases from October to February from the West Foreland to Cape Douglas, and melts in March to April. Sea-ice formation is controlled in upper Cook Inlet primarily by air temperature and in lower Cook Inlet by the temperature and inflow rate of the Alaska Coastal Current (Poole and Hufford 1982).

Coastal forest occurs along much of Alaska's south central coast and on the coastal islands, and is predominantly evergreen forest composed of Sitka spruce and western hemlock (BLM 2002). Deciduous forest occurs primarily along floodplains, streams, and in disturbed areas. Many areas around Cook Inlet also support white spruce and black spruce forest, as well as wet tundra, referred to as "muskegs," with sedges, mosses, and scattered shrubs (ADNR 1999). Also occurring along or near the shoreline are forested wetlands, wetlands with emergent vegetation, and shrub wetlands that are not tidally influenced but that have saturated soils or are flooded seasonally or continuously (BLM 2002).

Extensive freshwater marshes and salt marshes composed of sedge and grass wet meadow communities occur on river deltas along the coast. Coastal habitat in the Gulf of Alaska includes several large estuaries and wetlands (MMS 2002a).

In some areas of the south Alaskan coastline, numerous peninsulas and islands with irregular shorelines form bays, lagoons, and steep prominences (BLM 2002). Much of the shoreline consists of steep slopes with a narrow zone of tidal influence.

Coastal habitats throughout the Gulf of Alaska, including Cook Inlet, include intertidal and shallow subtidal communities (O'Clair and Zimmerman 1986). Intertidal wetlands include unvegetated rocky and soft sediment (sand or mud) shores, as well as coastal salt marshes with emergent vegetation and wetlands with submerged or floating vegetation (BLM 2002). These wetlands are all periodically inundated or exposed by tides. Large areas of soft-sediment shores are common in Cook Inlet (McCammon et al. 2002). Salt marshes and other wetlands occur throughout the coastal margins of the Cook Inlet (ADNR 1999).

Submerged or floating vegetation community types in estuaries include eelgrass communities and marine algae communities (BLM 2002). Eelgrass communities are common in protected bays, inlets, and lagoons with soft sediments (Viereck et al. 1992; McCammon et al. 2002). Marine algae communities often occur along exposed rocky shores on much of the coast (Viereck et al. 1992). Large kelps form dense communities in shallow subtidal areas along much of the Gulf of Alaska coast (McCammon et al. 2002). Marine algae communities dominate the low intertidal areas, to about 3 m (10 ft) in depth, and do not occur below about 5 m (16 ft) in depth (MMS 2003a).

Coastal salt marshes occur on soft sediments along low-energy shorelines. Coastal marshes may contain a number of vegetation community types that are tidally influenced, ranging from irregularly exposed to irregularly inundated (BLM 2002). The higher areas of coastal marshes may support sedge-scrub wet meadow communities (Viereck et al. 1992). These communities are not generally inundated by tides, but may be flooded during storm surges. Upper areas of coastal marshes may also support a hairgrass community (ADNR 1999).

The lower, outer areas of coastal salt marshes typically consist of sedge and grass communities (Viereck et al. 1992). The inland portion of these marshes often includes the taller and denser communities of salt-tolerant sedges. The seaward margin often adjoins a sparse community of salt-tolerant alkali grass, often associated with salt-tolerant forbs (Viereck et al. 1992). Halophytic herb wet meadow communities occur in early successional stages on seaward portions of beaches and coastal marshes where inundation occurs at least a few times per month (Viereck et al. 1992).

Brackish ponds occasionally occur within coastal marshes of deltas, tidal flats, and bays (BLM 2002; Viereck et al. 1992). These communities occur in shallow water and are periodically inundated by tides.

Coastal habitats along Cook Inlet are vulnerable to the effects of climate change. Sea level rise is expected to increase, inundating low-lying coastal habitats (Nicholls et al. 2007). Climate change is also expected to result in an increase in the incidence of pests and diseases, which could result in increased forest tree mortality (Anisimov et al. 2007).

Dynamic tidal currents in the inlet are related to the vulnerability of shoreline communities and their sensitivity to disturbance. The overall environmental sensitivity of Cook Inlet shorelines has been ranked independently by NOAA, the Alaska Regional Response Team, and recently by the *Exxon Valdez* Oil Spill Trustees/Cook Inlet Regional Citizens Advisory Council (Harper et al. 2004). In general, the vulnerability of shoreline habitats is rated as low if the shoreline substrate is impermeable (rock) and exposed to high wave energy or tidal currents, and is rated as high for vegetated wetlands and semipermeable substrates (mud) that are sheltered from wave energy and strong tidal currents. Sensitive shoreline habitats identified in lower Cook Inlet include marshes, sheltered tidal flats, sheltered rocky shores, and exposed tidal flats (NOAA 2002) (see Table 3.7.1-2). A study of the recovery rate of organisms on sheltered rocky shores in Cook Inlet concluded that 5–10 yr would be needed for full recolonization of rocky shorelines (Highsmith et al. 2001). Ongoing *Exxon Valdez* oil spill studies have shown that traces of spilled oil have persisted in Prince William Sound shoreline sediments and intertidal organisms for more than a decade (Short 2004; MMS 2003a).

3.7.1.3 Alaska – Arctic

Arctic coastal and nearshore habitats of concern include barrier islands and beaches, low tundra, marshes, tidal flats, scarps, peat shorelines, and marine algae. These habitats occur within estuarine watersheds along the coastline and in and around bays, lagoons, and river mouths where marine and fresh waters intermix. Coastal and nearshore habitats of the Arctic region can be subdivided into two ecoregions (Figure 3.2.2-3), each with distinguishing characteristics, arrangements of habitat components, and freshwater inflows with associated nutrient and sediment loads: the Chukchian Neritic Ecoregion, extending from near Point Hope to near Cape Lisburne, and the Beaufortian Neritic Ecoregion, extending from near Cape Lisburne to the border of Canada. These are based on the Level III Marine Ecoregions of the Commission for Environmental Cooperation (CEC 2008). Most of the coastline along the Chukchi Sea Planning Area, from near Cape Lisburne to near Point Barrow, lies within the Beaufortian Neritic Ecoregion. Two terrestrial ecoregions are located along the Arctic coast: the Arctic Foothills, from Kotzebue to near Cape Beaufort, and the Arctic Coastal Plain, from near Cape Beaufort to near the border of Canada (USEPA 2011e).

The fluvial discharge and freshwater flow into the Beaufortian ecoregion is much larger than the flow into Chukchian ecoregion. Fluvial discharge into the Chukchian ecoregion is relatively limited, with the Kukpuk River being the only major river system present, although there are numerous named and unnamed streams discharging into the Chukchi Sea. Numerous large rivers, such as the Kukpowruk River, Utukok River, and Kuk River along the Chukchi Sea, and the Colville River, Kuparuk River, Sagavanirktok River, and Canning River along the Beaufort Sea, discharge into the Beaufortian ecoregion.

Stream flows generally begin in late May or early June as a rapid flood event, with more than half of the annual discharge of a stream sometimes occurring over a period of several days to a few weeks (MMS 2008b). Fluvial discharges introduce dissolved and suspended materials into estuarine and marine waters that can serve either as nutrients that enrich marine and coastal productivity or as pollutants that can degrade habitat quality. Human society sometimes discharges into the environment constituents that also occur naturally in the ecosystem. These anthropogenic discharges, however, are different than the biogenic sources because they occur in greater concentrations and often suddenly; the chemical bondings are different than what is found in the natural system; the discharges occur outside the area where they would naturally occur; or they occur out of phase of the natural cycle of the same biogenic contributions to the system. Examples of anthropogenic constituents include sediment, metals, and hydrocarbons (see Section 3.4.3 for a further discussion of water quality). The fluvial discharges also carry suspended and bed load sediments that when deposited at the river mouths and redistributed through the coastal zone provide the substrate and foundation for many coastal habitats.

Arctic coastal habitats are greatly influenced by a short growing season and extremely cold winters. The onshore sediments are frozen during most of the year and are underlain by permafrost (permanently frozen soil). Growth and even biodegradation in coastal habitats are limited to only a few months per year (Prince et al. 2002).

Although differences exist in fluvial discharge, the coastal and estuarine habitats of both ecoregions are greatly affected by the dynamics of sea ice. The Arctic coastline is highly disturbed due to the movement of sea ice that frequently is pushed onshore, scouring and scraping the coastline. Sea ice dominates the coastal habitats during most of the year. Landfast ice, which is attached to the shore and freezes to the seafloor (grounded ice) in shallow water up to 2 m (7 ft) in depth, is relatively immobile (MMS 2010); however, landfast ice along the Chukchi Sea coast is not as stable as along the Beaufort Sea coast (MMS 2008b). Onshore pileups of ice often extend up to 20 m (66 ft) inland from the shoreline, while rideups of unbroken ice sheets over the ground surface occasionally extend more than 50 m (164 ft) and rarely beyond 100 m (328 ft) (MMS 2008b). Landfast ice begins forming in late October to late December along the Chukchi Sea, with breakup in late May to mid-June (MMS 2010); in the Beaufort Sea, landfast ice begins forming in September to October, with breakup beginning in early June to early July (MMS 2008b). The areal extent of sea ice in the Arctic has substantially decreased over the past several decades (MMS 2010). Decreases in ice cover can increase wave action and shoreline erosion. The duration of landfast ice has also decreased, with ice breaking up earlier in the spring (MMS 2008b).

Coastal habitats of the Arctic ecoregions are given in Table 3.7.1-3, with general characteristics in Table 3.7.1-4. The coastline of the Beaufort Sea includes eroding bluffs, sandy beaches, lower tundra areas with some saltwater intrusions, sand dunes, sandy spits, and estuarine areas where streams enter the Beaufort Sea (MMS 2002b, 2003b). The Chukchi Sea coastline consists of nearly continuous sea cliffs cut into permafrost (MMS 2010). While the cliffs are abutted by narrow beaches along most of the coastline, in some areas, barrier islands enclose shallow lagoons. Barrier islands occur along the Beaufort and Chukchi Sea coastlines and also support tundra communities. These islands are generally narrow (less than 250 m [820 ft] wide) and low-lying (less than 2 m [7 ft] in elevation) and are washed over in large storms (MMS 2003b). Deltas of the Colville, Sagavanirktok, Kadleroshilik, and Shaviovik Rivers support a complex mosaic of wet Arctic saltmarsh, dry coastal barrens, salt-killed tundra, typical moist and wet tundra, and dry, partially vegetated gravel bars.

Marine algae communities occur on hard bottom substrates in several areas along the Chukchi Sea coast, such as in Peard Bay, or southwest of Wainwright at a depth of 11–13 m (36–43 ft) (MMS 2010). The distribution and extent of these communities are likely limited by the presence of rock and other hard substrate (MMS 2010). Few known beds occur along the Beaufort Sea coast. These communities include many species of macroalgae (e.g., 15 species at the Stefansson Sound Boulder Patch); however, the community is dominated by a few common species (Iken 2009).

TABLE 3.7.1-3 Length of Coastal Habitats (mi) of the Alaskan Arctic Ecoregions

Habitat: ESI Rank	Chukchian Ecoregion[a]	Beaufortian Ecoregion
Salt- and brackish-water marshes: 10A	–	88
Inundated low-lying tundra: 10E	–	763
Sheltered tidal flats: 9A	–	24 mi^{2a}; 394
Sheltered, vegetated low banks: 9B	–	225
Peat shorelines: 8E	–	283
Sheltered scarps in mud or clay: 8A	–	1
Exposed tidal flats: 7	–	196
Riprap: 6B	<1	1
Gravel beaches: 6A	2	13
Mixed sand and gravel beaches: 5	76	488
Coarse-grained sand beaches: 4	–	72
Tundra cliffs: 3C	–	338
Fine- to medium-grained sand beaches: 3A	–	393
Exposed wave-cut platforms in bedrock, mud, or clay: 2A	–	–
Exposed, solid man-made structures: 1B	–	<1
Exposed rocky shores: 1A	18	19

[a] Square mileage represents total habitat area.

Several estuarine habitats within shallow bays, inlets, and lagoons occur along the Chukchi Sea coastline, including Kasegaluk Lagoon, Wainwright Inlet, Peard Bay, and Kugrua Bay (BLM and MMS 2003). These areas often have low-energy sand beaches and wetlands along their margins, and some support communities of marine algae, such as sea lettuce (*Ulva* spp.). Kasegaluk Lagoon is usually ice covered from mid-September through mid-July. During the summer, many animals concentrate around the passes between the ocean and the shallow lagoon.

Salt marshes occur along the Arctic coastline and support emergent vegetation communities. These coastal marshes are intertidal wetlands exposed at low tides and inundated by high tides and storm surges. The Arctic coastline experiences tides of small fluctuation, 6 to 10 cm (2.4 to 4 in.) along the Beaufort Sea (MMS 2003b); however, coastal water levels are driven primarily by wind stress and barometric pressure changes from the passage of storm centers and frontal passages (Gill et al. 2011). Storm surge and water level withdrawal on the coast can be considerable, about 1 m (3 ft) in amplitude (Gill et al. 2011). The Arctic coastline is subject to strong erosive forces (BLM 2002; MMS 2002a). Disturbance from sea ice action is common along the generally unstable and erosion-prone shoreline (MMS 2002a). Arctic coastal salt marshes are therefore smaller, often only a few meters in extent, and less common than on south Alaskan coasts (Macdonald 1977; Viereck et al. 1992). The most extensive salt marsh habitats along the coast occur in the deltas of the major rivers and a few protected bays.

TABLE 3.7.1-4 Characteristics of Coastal Habitats of the Alaskan Arctic Ecoregions

Habitat	Chukchian Ecoregion	Beaufortian Ecoregion
Barrier beaches and islands	Narrow beaches along coastline, predominantly fronting steep cliffs cut in bedrock, up to 260 m (853 ft) high at Cape Lisburne (MMS 2007c). Barrier islands occur only at Point Hope at Marryat Inlet/Kukpuk River delta and nearby Aiautak Lagoon; nearly continuous, composed of sand and gravel.	Narrow beaches along coastline; lower cliffs, where present, cut in bedrock (south of Utukok River) or perennially frozen ice-rich sediments (MMS 2007c). Barrier islands, typically enclosing lagoons, frequent along Chukchi and Beaufort Sea coasts, some, such as at Kasegaluk Lagoon, <3 m (10 ft) relief, and <2 m (7 ft) in Beaufort. Coastal relief along these marine depositional areas is generally <5 m (16 ft). Much of coast eroded by ice, waves, and currents, but active wave erosional coast is rare along Chukchi Sea where cliffs are generally <1 m (3 ft) high.
Wetlands	Little wetland occurrence along coastline except along Point Hope.	Estuarine wetland systems occur in enclosed and protected bays along the Chukchi Sea shoreline. Large estuarine wetland complexes in Chukchi Sea lagoons and other well protected areas, such as Omalik Lagoon, Kasegaluk Lagoon, Icy Cape, Peard Bay, Wainwright Inlet; include sand/silt flats and brackish-water sedge marshes. Few, scattered narrow marshes along remainder of coastline
Marine algae	–	Few known beds along coast, on hard bottom substrates; includes many species of macroalgae, e.g., 15 at the Stefansson Sound Boulder Patch; community dominated by a few common species (Iken 2009). Present along Chukchi Sea in Kasegaluk Lagoon, Peard Bay, near Skull Cliffs, and 25 km (16 mi) southwest of Wainright, in 11–13 m (36–443 ft) water.

Sources: MMS 2007c; Iken 2009.

The predominant community types of Arctic coastal salt marshes are dense halophytic (salt-tolerant) sedge wet meadow communities and sparse halophytic grass wet meadow communities (Meyers 1985; Viereck et al. 1992; Funk et al. 2004). The former occur where tidal inundation ranges from several times per month to once a summer, while the latter occur at lower elevations under regular or daily inundation from tides.

Halophytic sedge wet meadow communities often form the main body of the coastal marsh. Soils are fine-textured silts and clays, often overlying sand or gravel. The shoreward marsh community forms a broad transition zone with freshwater wetlands (Viereck et al. 1992). The substrate is typically peat. The seaward margin is often adjacent to a halophytic grass wet meadow community.

The seaward portions of beaches and areas of coastal marshes where inundation occurs at least a few times per month support halophytic herb wet meadow communities (Viereck et al. 1992). These also occur in brackish ponds within coastal marshes of deltas, tidal flats, and bays (Viereck et al. 1992).

The most important coastal estuarine wetlands along the Beaufort Sea coast include Elson Lagoon, just east of Point Barrow; Fish Creek Delta; Colville River Delta; Simpson Lagoon; Canning River Delta; Jago Lagoon–Hulahula River Delta; and Demarcation Bay. Along the Chukchi Sea coast, the primary estuaries include Peard Bay, Kasegaluk Lagoon, and Point Hope (MMS 2002a).

Nearshore areas of the Beaufort and Chukchi Seas are estuarine subtidal deepwater habitat and are generally unvegetated (BLM 2002). However, dense marine algae communities occasionally grow in shallow nearshore subtidal areas (less than about 11 m [36 ft) in depth) and generally in protected areas (such as behind barrier islands and shoals) with hard substrates (MMS 2003b).

Estuaries and coastal lagoons are characterized by large fluctuations in salinity and temperature. Salinity can range from 180 parts per trillion (ppt) in winter to 1–32 ppt in summer (Houghton et al. 1984). At ice breakup in spring, the large influx of freshwater from ice melt and terrestrial runoff can create hyposaline conditions approaching freshwater. Temperature also fluctuates widely and rapidly at breakup, ranging from 0°C to 14°C (Craig et al. 1984).

Effects of climate change on Alaskan Arctic habitats include decreases in sea ice cover, warming of permafrost, longer growing season, and changes in precipitation. Decreased sea ice has led to increased wave activity and accelerated coastal erosion and increases in shoreline erosion from storms, along with increased turbidity (MMS 2008b). Portions of the coast have experienced considerable erosive losses, up to 457 m (1,500 ft) over the past few decades (MMS 2008b). Coastal peat bluffs along the Chukchi Sea coast have experienced more rapid erosion. The erosion rate in areas of the Beaufort Sea coast has more than doubled between 1955 and 2005.

Increases in air temperature and precipitation have also occurred as a result of climate change, particularly in autumn and winter (MMS 2008b). Permafrost, occurring on much of the

Arctic Coastal Plain, creates an impermeable soil layer, limiting the water storage capability of the subsurface and, when near the surface, generally maintaining saturated soils above the permanently frozen layer, thereby maintaining lakes and wetland habitats. Permafrost is warming across the Arctic, with rapid warming in Alaska over the last 50 yr (Anisimov et al. 2007). Significant permafrost degradation has been observed in some areas. Increased permafrost temperatures at 15–20 m (49–66 ft) depths over the past 20 yr have been recorded (MMS 2008b). Increases in mean annual ground surface temperatures have been observed since the 1960s and, in some areas, discontinuous permafrost has begun thawing downward at a rate of 0.1 m/yr (0.3 ft/yr) (MMS 2008b). Thawing of permafrost tends to result in collapse of the soil structure of thaw-unstable soils and slumping of the soil surface, which may subsequently result in flooding. Deepening of the active layer, the upper soil layer that thaws each summer, and associated hydrologic change is accompanied by large changes in the plant community. Evaporation/precipitation ratios have also increased in the Arctic, resulting in the desiccation of some lakes (MMS 2008b). Earlier spring melt in the Arctic and later freeze-up has resulted in a longer growing season, along with changes in plant communities, such as an increased abundance of shrubs (Anisimov et al. 2007).

Projections for future climate change indicate continued increases in temperature and precipitation in the Arctic. The depth of the permafrost active layer is expected to increase by 15 to 25% on average by 2050, and 50% or more in the northernmost areas (Anisimov et al. 2007). Areas of continuous permafrost are likely to show increasing patchiness (Anisimov et al. 2007). An initial increase in the number and total area of wetlands and shallow lakes due to permafrost thawing may be followed over time by the loss of these habitats as permafrost continues to thaw, surface water increasingly drains into groundwater systems, and shallow groundwater tables continue to drop, resulting in the drying of wetland habitats and drainage of lakes (MMS 2008b; Anisimov et al. 2007). A longer growing season and warmer water temperatures of lakes that currently freeze to the bottom would likely change the chemical, mineral, and nutrient status. Arctic species may be at a competitive disadvantage as subarctic species ranges expand northward and changes in plant communities are likely to continue. Arctic tundra in Alaska may be replaced by boreal forest by 2100 (Anisimov et al. 2007).

Decreases in sea ice cover are also expected to continue. The Arctic sea ice is undergoing changes in extent, thickness, distribution, age, and melt duration (NSIDC 2010, 2011; Kwok and Cunningham 2010, 2011). The analysis of long-term datasets indicates substantial reductions in both the extent (area of ocean covered by ice) and thickness of the Arctic sea-ice cover during the past 20–40 yr. Generally, it is thought that the Arctic will become ice-free in the summer, but at this time there is considerable uncertainty about when that will happen (Stroeve et al. 2011; Tietsche et al. 2011; Zhang et al. 2010; Overland and Wang 2010). Changes in ice cover may affect primary and secondary productivity, thus influencing the structure of the biotic community in the Beaufort and Chukchi Seas. See also Section 3.3 for further discussion of sea ice. The suspended sediments associated with increased coastal erosion will likely affect marine algae communities. In addition, sea level is projected to rise an average of 0.73 m (2.4 ft) in the Arctic between 2000 and 2100, flooding low-lying coastal habitats (MMS 2008b). Coastal wetlands and estuaries would be threatened by inundation from rising sea levels, intensification of storms, and higher storm surges. Increased wave activity, relative sea level rise, and thawing of permafrost that binds coastal sediments lead to retreat of coastal habitats (Nicholls et al. 2007). Temperature, salinity, and oxygen levels of coastal estuaries would be affected by changes in rates and timing of river runoff. Seasonal ice cover on rivers and lakes is breaking up earlier each year, with a longer open water season (MMS 2008b). Observed changes in tundra habitats are expected to continue. Snow cover over tundra is expected to melt earlier and large-scale changes in permafrost are predicted to be likely.

No federally listed or candidate plant species occur in the Arctic region. Thirty-one species of rare vascular plants are known to occur on the North Slope (Cortes-Burns et al. 2009). Many of these species are found nowhere else in Alaska, and several are endemic to Alaska.

3.7.1.3.1 Chukchian Neritic. Habitats of the Chukchian ecoregion include narrow beaches along the coastline, predominantly fronting steep cliffs cut in bedrock, up to 260 m (853 ft) high at Cape Lisburne (MMS 2007c). Barrier islands occur only at Point Hope at the Marryat Inlet/Kukpuk River delta and nearby Aiautak Lagoon; the islands are nearly continuous, composed of sand and gravel. There is little or no wetland occurrence along the Chukchian ecoregion coastline other than the lagoon at Point Hope.

3.7.1.3.2 Beaufortian Neritic. Habitats of the Beaufortian ecoregion include narrow beaches along the coastline; lower cliffs, where present, are cut in bedrock (south of Utukok River) or perennially frozen ice-rich sediments (MMS 2007c). Barrier islands, typically enclosing lagoons, are frequent along Chukchi and Beaufort Sea coasts; some, such as at Kasegaluk Lagoon, have less than 3 m (10 ft) relief and less than 2 m (7 ft) in the Beaufort Sea. Beaufort islands are narrow, at less than 250 m (820 ft), and short (MMS 2008b). Coastal relief along these marine depositional areas is generally less than 5 m (16 ft). The Chukchi Sea coast is a high-energy shoreline when ice is absent. Erosion and flooding are associated with autumn and spring storms and ice movement (MMS 2008b). Much of the coast is eroded by ice, waves, and currents, but active wave erosional coast is rare along the Chukchi Sea, where cliffs are generally less than 1 m (3 ft) high (MMS 2007c).

Estuarine wetland systems occur in enclosed and protected bays along the Chukchi Sea shoreline. Large estuarine wetland complexes in Chukchi Sea lagoons and other well-protected areas, such as Omalik Lagoon, Kasegaluk Lagoon, Icy Cape, Peard Bay, and Wainwright Inlet, include sand/silt flats and brackish-water sedge marshes. A few scattered, narrow marshes occur along the remainder of the coastline. Beaufort Sea coastal waters are estuarine during a portion of the year, with freshwater inflows from numerous rivers and streams mixing with marine waters (MMS 2007c, 2008b). Maximum discharge is late May to early June, with melting of landfast ice in early June to July, initially near river deltas. The coastline includes bays and lagoons, as well as Stefansson Sound, enclosed by barrier islands.

3.7.1.3.3 Arctic Coastal Plain. The Arctic Coastal Plain (ACP) is relatively flat and borders the Beaufort Sea and the eastern portion of the Chukchi Sea, encompassing most of the Beaufortian ecoregion. The ACP includes a complex mosaic of vegetation types, the distribution and extent of which are strongly influenced by local soil characteristics, elevation, temperature, and moisture (BLM 2002). Freshwater wetlands, including a wide variety of vegetation types, cover nearly all of the coastal plain and foothills (ADNR 2008; BLM 2002; BLM and MMS 2003).

On the ACP, the presence of thick, continuous permafrost that is generally near the soil surface restricts soil drainage and results in saturated soils over most of the area (BLM 2002; BLM and MMS 2003). Wetland plant communities, characterized by sedges, grasses, dwarf shrubs, and mosses, are the predominant vegetation types of the ACP (BLM 2002; MMS 2002b, 2003b). Numerous small lakes and ponds are scattered across the landscape. Even small-scale variations in the land surface elevation alter patterns of species occurrence and influence the distribution of plant communities. These variations determine the occurrence of wet, moist, and dry tundra (BLM and MMS 2003). Flooded tundra and aquatic vegetation cover types also occur. Coastal plain soils generally consist of an organic mat over fine-textured mineral soil.

Over much of the near coastal area inland from Point Barrow, along the Beaufort Sea to the Canning River, wet graminoid moss communities, with moist communities on higher microsites, are the predominant plant communities (Raynolds et al. 2006). Wet sedge moss communities, with moist communities such as tussock-sedge and dwarf-shrub communities on higher microsites, extend over much of the ACP from near Point Lay on the Chukchi coast to the border of Canada. Non-tussock sedge, dwarf-shrub, moss tundra communities and Non-tussock sedge, dwarf-shrub, forb, moss tundra communities, both on mesic soils, occur at the margin of the ACP near the Arctic Foothills. Tussock-sedge, dwarf-shrub, moss tundra communities, occurring on sandy soils in complex with lakes and wet tundra, are the predominant community type over a large area south of Teshekpuk Lake, in the central portion of the ACP.

Ground patterns form polygons in much of the east-central portion of the ACP. Low polygons, enclosed by rims, are common and support wet sedge/moist sedge tundra in basins and dwarf shrub tundra on rims, with troughs between polygons (MMS 2002b). Near the coastline, high centered polygons bordered by deep troughs support moist sedge and dwarf shrub tundra.

Over much of the ACP, thaw lakes (typically 1–7 m [3–23 ft] in depth) shaped and oriented by wind direction cover 20–50% of the surface area (Gallant et al. 1995). Ponds are generally smaller and shallower. Lake margins and smaller ponds frequently support the fresh grass marsh vegetation type, generally in surface water depths of 0.2–2 m (0.7–7 ft) (Viereck et al. 1992).

Thaw lakes generally follow a cyclic pattern of draining and reforming (BLM 2002). Wet tundra communities, later becoming wet sedge meadow communities, commonly become established in drained basins (BLM 2002). Surface water in these areas may be present much of the growing season and may be up to 15 cm (0.5 ft) deep (Viereck et al. 1992).

Barren areas along major streams are composed of 60% barren peat, mineral soil, or gravel. These areas may have patches with sparse cover of forbs and dwarf shrubs. The margins of ACP rivers typically include gravel bars, sandbars, and sand dunes (BLM 2002). Active sand dunes support dunegrass communities, while floodplains support low willow shrub and seral herb communities. Large, braided rivers on the ACP, such as the Sagavanirktok River, include extensive areas that are predominantly unvegetated or sparsely vegetated. Some plant communities near the Sagavanirktok and Kadleroshilik Rivers are maintained in early and mid-successional stages by the deposition of windblown silt from the river channel (MMS 2002b; BLM 2002).

3.7.1.3.4 Arctic Foothills. Inland from the Chukchian ecoregion and southwestern Beaufortian ecoregion coast, the Arctic Foothills extend across northern Alaska between the ACP and the Brooks Range, reaching to the Beaufort Sea near the border of Canada. Thick permafrost extends over the hills and plateaus of the Arctic Foothills, and most soils are poorly drained with thick organic layers (BLM 2002). Although the foothills have more distinct drainage patterns and fewer lakes than the ACP, much of the landscape in the foothills consists of wetlands.

A wide variety of plant community types occurs on the foothills (Raynolds et al. 2006). Near the Chukchian ecoregion coast, the wet sedge moss communities (with moist communities on higher microsites), non-tussock sedge, dwarf-shrub, forb, moss communities (mesic soils), and prostrate dwarf-shrub, forb, lichen (dry limestone slopes) are the predominant community types. Farther inland, and extending along much of the southwestern Beaufortian ecoregion, the tussock-sedge, dwarf-shrub, moss community type, on mesic soils, is a predominant community type of the Arctic Foothills. Also occurring near the coast are erect dwarf-shrub, lichen communities on mesic sites and prostrate dwarf-shrub, lichen communities on dry granitic slopes. The foothills approach the Beaufort Sea along the northeastern coast of Alaska. Here, tussock-sedge, dwarf-shrub, moss (mesic soils); erect dwarf-shrub (mesic soils); and prostrate dwarf-shrub, sedge community types (dry limestone slopes) occur at or near the coast.

3.7.2 Marine Benthic Habitats

3.7.2.1 Gulf of Mexico

Marine benthic (bottom) habitats are areas of the seafloor used by organisms at some or all stages in their life for critical functions such as feeding, reproduction, and shelter. In the GOM Planning Areas, marine benthic habitats on the continental shelf and slope/deep sea habitats include soft sediments, hard bottom areas, chemosynthetic communities, warm-water coral reefs, and deepwater corals (Table 3.7.2-1).

3.7.2.1.1 Soft Sediments. Sediments of the Northern GOM are primarily composed of sand, silt, and clay. Thus soft bottom habitat is not a unique habitat of concern like the hard bottom, deepwater coral, and deepwater community habitats discussed below. However, soft sediments do provide habitat to most marine organisms in the GOM and are the site of fundamental ecosystem processes, such as the breakdown of organic matter, nutrient transformation and recycling, and the metabolization of natural and anthropogenic releases of

TABLE 3.7.2-1 Benthic and Pelagic Marine Habitat Types Found in the Northern Gulf of Mexico Shelf, Slope, Mississippi Fan, and Basin Marine Ecoregions within the Western and Central Planning Areas

Marine Habitat Type	Marine Ecoregion
Benthic	
Soft sediments	All ecoregions
Hard bottom areas	Shelf (Mississippi Estuarine Area, Western Gulf Neritic), Slope, and Basin
Coral reefs	Shelf (Western Gulf Neritic)
Deep/coldwater corals	Primarily Slope
Chemosynthetic communities	Primarily Slope
Man-made structures	Shelf (Mississippi Estuarine Area, Western Gulf Neritic), Slope
Pelagic	
Water column	All ecoregions
Sargassum	All ecoregions

hydrocarbons (Hazen et al. 2010). As the predominant sediment substrate type, soft sediment habitat will be most affected by oil and gas development and production activities.

Continental Shelf Soft Bottom Habitat. The Northern GOM Continental Shelf Marine Ecoregion extends from the coastline out to the shelf break at water depths ranging about 118 to 150 m (387 to 492 ft) and encompasses the Mississippi and Texas Estuarine Ecoregions and the Western Gulf Neritic Ecoregion. The major marine benthic habitat consists of soft muddy bottom. An exception is the sandy sediments along beaches and barrier islands.

Much of the organic matter in the upper water column is eventually deposited on the seafloor in seasonal pulses, following springtime peaks in river discharge and spring phytoplankton blooms. Once reaching the seafloor, organic matter is consumed by bacteria, meiofauna, and macrofauna. Consequently, soft sediments are important sites for detrital processing and the remineralization of critical elements like sulfur, nitrogen, and phosphate. Sediment-associated nutrients and organic matter may also be resuspended into the water column, where they support new water column primary and secondary production. This coupling between benthic and pelagic habitats is particularly strong in shallow areas of the continental shelf.

Biological interactions as well as physiochemical factors such as substrate, temperature, salinity, water depth, currents, oxygen, nutrient availability, and turbidity are critical in determining the distribution, composition, and abundance of continental shelf soft bottom communities. The major factor influencing the megafaunal distributions appears to be the differing substrates, with primarily carbonate sediments found east of DeSoto Canyon and along the west Florida shelf in the Eastern Planning Area and with more terrigenous muds found in the estuarine and neritic shelf sediments in the Eastern and Western Planning Areas (Defenbaugh 1976). Soft sediment infaunal communities on the GOM continental shelf are generally dominated, in both number of species and individuals, by surface-deposit-feeding polychaete worms, followed by crustaceans and mollusks (Continental Shelf Associates, Inc. 1992, 1996; Brooks and Giammona 1991; Baustian and Rabalais 2009). Common species on the sediment surface include sea anemones, brittle stars, portunid crabs, and penaid shrimp. These animals are typically distributed on the basis of water depth and sediment composition or grain size, with seasonal components also being present in shallower water areas.

Northern Gulf of Mexico Slope/Basin Ecoregion. Soft sediments of the continental slope and deep sea have a unique faunal community adapted to the cold, high-pressure, and low-productivity environment. Recent surveys from south Texas to the Florida panhandle revealed that echinoderms, sea anemones, nematodes, copepods, amphipod, polychaetes, and bivalves were common constituents of soft sediment assemblages in the deep sea. There were distinct faunal communities from east to west of the Mississippi River and from the upper slope to the abyssal plain (Rowe and Kennicutt 2009; Wei et al. 2010). The highest macroinvertebrate densities were found near the Mississippi River, followed by areas to the east. A general decrease in the abundance of fish, meiofauna, and macrofauna was observed from the upper continental slope to the abyssal areas in the GOM (Rowe and Kennicutt 2009). The number of invertebrate species was higher on the shelf/slope than the outer shelf, and the number of benthic invertebrate species was highest on the mid to upper slope. Overall, biomass, species number, and species composition were influenced by water depth, the proximity of locations to canyons and methane seeps, and the organic matter content of sediment (Rowe and Kennicutt 2009). Other physical and chemical parameters — such as oxygen concentration, temperature, salinity, and chemical contaminants within the sediments — did not appear to be related to community structure (Rowe and Kennicutt 2009).

The abundance patterns just described, such as the high density of macrofauna near the Mississippi River, are in large part attributable to food availability. The offshore GOM has low nutrient concentrations and surface water productivity. In such areas, most organic matter is therefore tightly recycled in the water column and much less is exported to sediment or higher trophic levels (Hagstrom et al. 1988; Buesseler 1998; Pomeroy et al. 2007; Hung et al. 2010). Organic matter that does fall below the photic zone breaks down as it sinks and reaches the seafloor in a highly degraded state. The continental slope/deep sea benthos is thus typically food starved; consequently, the size, biomass, and abundance of benthic consumers decline with depth as one goes from the continental shelf to the deep sea. Although much of the deep sea is relatively unproductive, deep sea cold seep communities are exceptions and will be discussed later in this section.

3.7.2.1.2 Warm Water Coral Reefs. Coral reefs are formed by reef-building coral species. Coral are suspension feeders, and their prey predominantly consist of planktonic organisms carried in the water column. Photosynthetic corals also harbor dinoflagellate algae that benefit the coral's physiology through products resulting from photosynthesis. Where they are present, coral reefs in the GOM serve ecological functions as important sites of primary productivity and as habitat for dense and diverse reef-associated communities.

Coral reefs are primarily concentrated on the west Florida shelf. Although not in the Western or Central Planning Areas, these reefs could be affected by accidental oil spills. Coral reefs are not found in the Central Planning Area and are relatively uncommon in the Western Planning Area, although individual corals are common in hard-bottom seafloor habitats in both areas. The East and West Flower Garden Banks in the FGBNMS, located in the Western Gulf Neritic Marine Ecoregion, are considered the only coral reefs present in the Western Planning Area (Figure 3.7.2-1). The East and West Banks are prominent topographic features covering approximately 50 and 74 km^2 (12,355 and 18,286 ac), respectively, and rising to a depth of 17 m (63 ft) below the water surface from surrounding water depths below 100 m (328 ft) (Hickerson et al. 2008). The banks formed over salt domes, which forced the overlying seabed upward, resulting in exposed carbonate that provided substrate for the colonization and growth of reef organisms. The crests of these features are carbonate rock formed by reef-building corals, coralline algae, and other lime-secreting creatures. The dominant community on these banks at water depths above 36 m (118 ft) is composed of reef-building corals (approximately 20 species), with an average cover of more than 50% (Bright et al. 1984; Dokken et al. 1999; Precht et al. 2008). In addition, more than 80 species of algae, approximately 250 species of macroinvertebrates, and more than 120 species of fishes are associated with these features (Dokken et al. 1999). Two Elkhorn coral (*Acropora palmata*) colonies have also been reported in the Flower Gardens. This species is primarily found in south Florida, the southern GOM, and the Caribbean, and is listed as threatened under the Endangered Species Act (Section 3.8.5.1). On the basis of data from 1978 to 2006, there do not appear to be any long-term trends in the percentage of coral cover at the FGBNMS (Hickerson et al. 2008; Robbart et al. 2009), and despite causing some physical damage to reef structure, recent hurricanes have not caused significant lasting damage to the FGBNMS (Robbart et al. 2009). Within a 6.4-km (4-mi) radius of the FGBNMS, there are currently 14 oil production platforms, and there is one gas production platform within the East Sanctuary boundary. Ongoing stressors on the FGBNMS include mechanical disturbance from anchors and discarded fishing gear, coastal runoff, and disease (Hickerson et al. 2008).

3.7.2.1.3 Deepwater Corals. Research from 2003 to the present has resulted in extensive data on the distribution of deepwater (or coldwater) corals and the compositions of their associated communities (CSA International, Inc. 2007). Deepwater corals are found on rock outcroppings in the Northern GOM Slope Ecoregion in waters typically deeper than 300 m (984 ft) (Figure 3.7.2-2). The primary deepwater species in the GOM is *Lophelia pertusa.* This highly branching species can develop from small bushes to thickets of hemispherical colonies. *Lophelia* aggregations typically develop on lithified outcroppings formed in the past by now-inactive hydrocarbon seeps. Although often located near cold hydrocarbon seeps, *Lophelia* corals and associated biota do not appear to use seep hydrocarbons as a food source; instead, they depend on plankton and organic matter falling from the upper water column (CSA International, Inc. 2007). *Lophelia* produce larvae whose dispersal ability is limited when compared with that of species that produce planktotrophic larvae. Consequently, gene flow appears to occur primarily within individual *Lophelia* thickets; nevertheless, enough long-distance dispersal occurs to maintain regional genetic distinctiveness (USGS 2008).

Lophelia beds provide complex benthic habitat that attracts deepwater fish and invertebrates in greater density than that found in the surrounding soft-bottom habitat. Surveys of *Lophelia* communities off the coast of Louisiana conducted in 2004 and 2005 indicated that polychaetes, brittle stars, sponges, and hydroids were the most common species (CSA

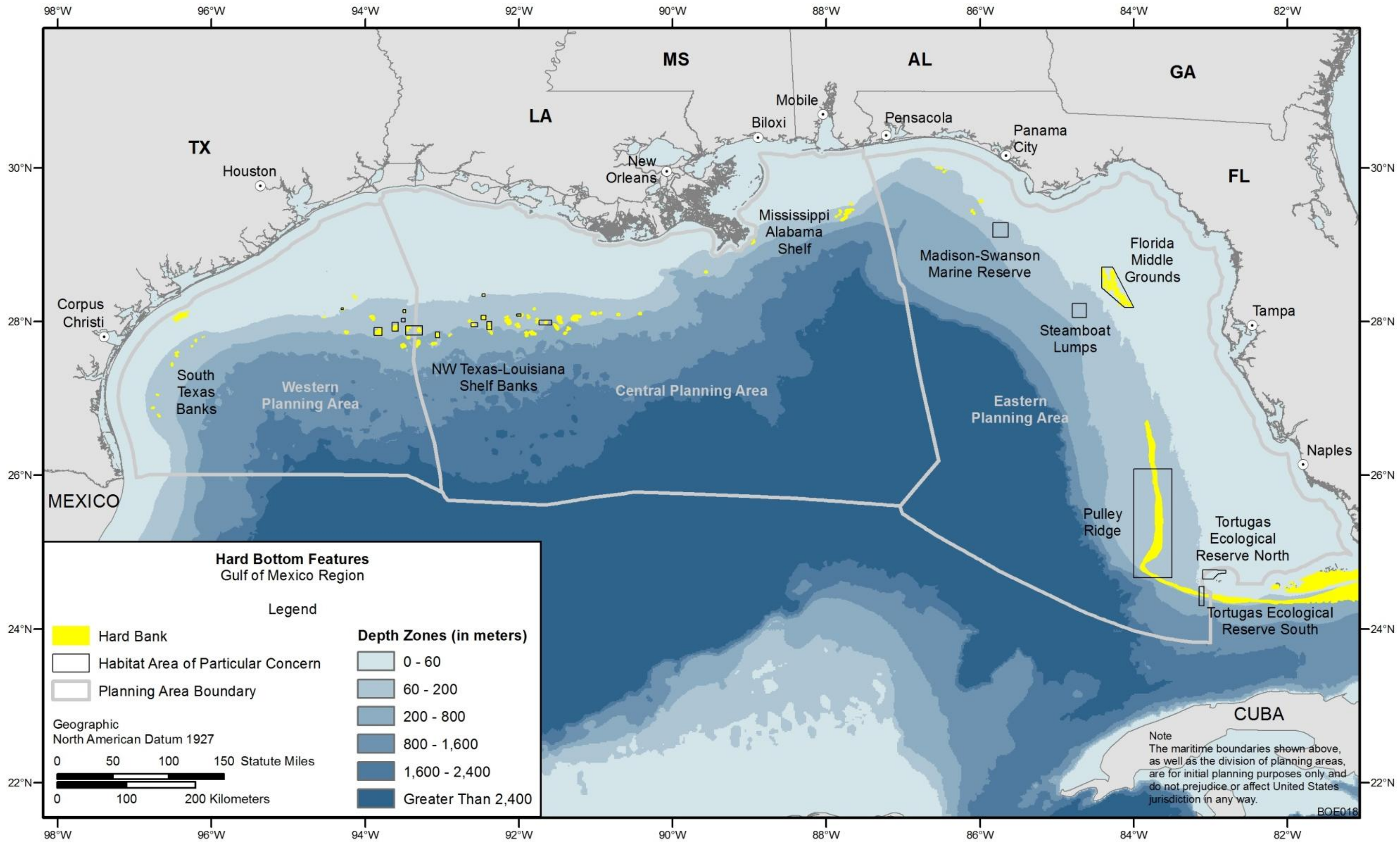


FIGURE 3.7.2-1 Location of Hard Bottom Features in the Western, Central, and Eastern Planning Areas

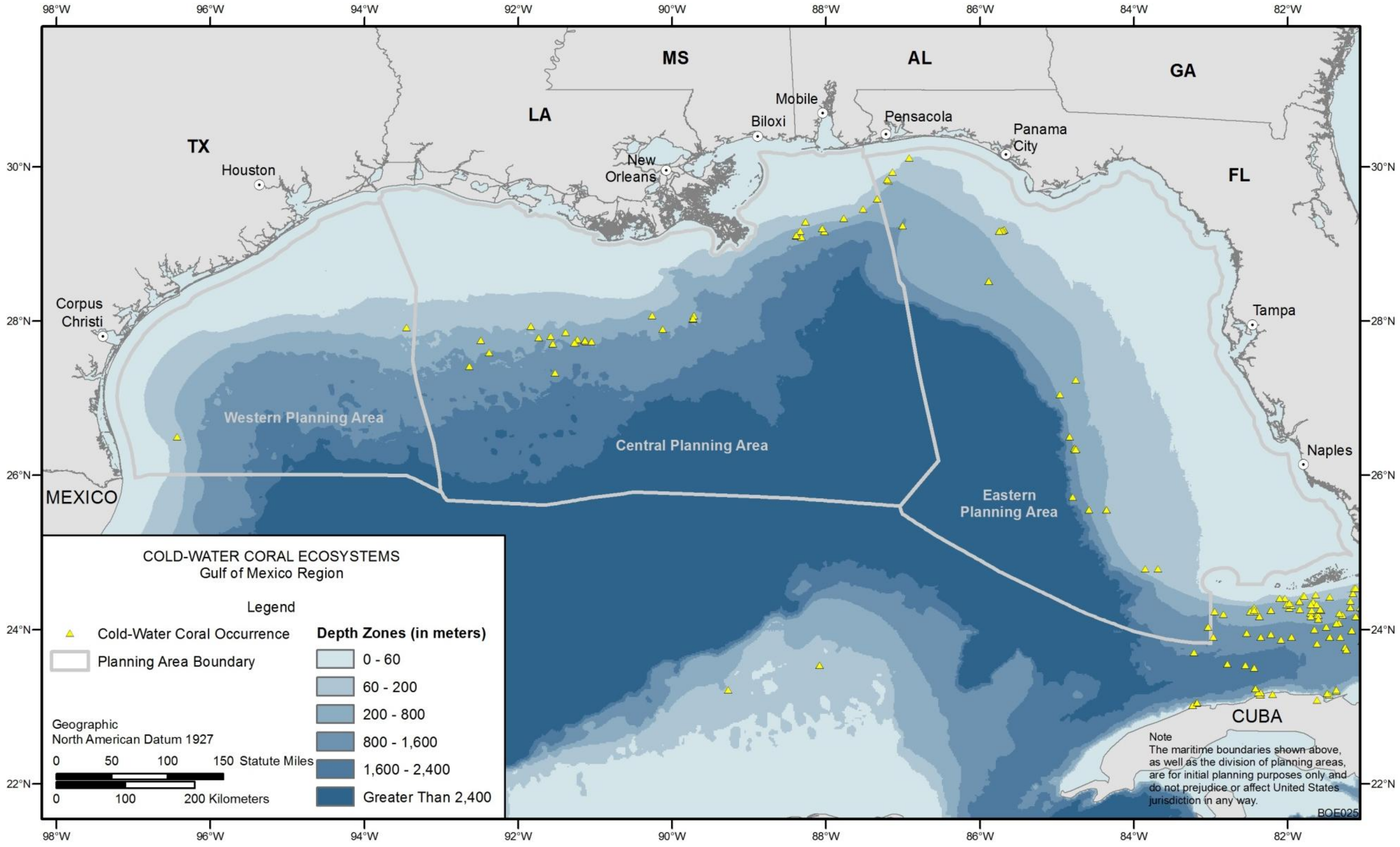


FIGURE 3.7.2-2 Location of Coldwater Coral System Features in the Western, Central, and Eastern Planning Areas

International, Inc. 2007). Predatory polychaetes and shrimp and crabs were also common. Overall, suspension feeders and predators were the dominant trophic guilds represented, but large scavengers were also present (CSA International, Inc. 2007). A study of the Viosca Knoll *Lophelia* communities found that fish communities differ according to depth, with communities found at 325 m (1,066 ft) being distinctly different than the deepwater fish species collected at 500 m (1,640 ft) (USGS 2008).

3.7.2.1.4 Hard Bottom. The term hard bottom (also referred to as live bottom) generally refers to exposed rock, but it can also refer to other substrata, such as coral and clay, or even artificial structures. Hard bottoms often support highly productive algal and animal communities. The sessile (nonmotile) biota typically growing on hard-bottom areas may include macroalgae, seagrasses, sponges, barnacles, hydroids, corals, cnidarians, bryozoans, and tunicates, which, in turn, provide shelter, food, and spawning sites for mobile fish and invertebrates. Within the Eastern and Western Gulf Neritic and the Mississippi Gulf Estuarine Ecoregions, major topographic features occur on the continental shelf and shelf edge across the west Florida shelf and in more restricted locations off Alabama, Mississippi, Louisiana, and Texas. The estimated areal extent of natural hard bottom in the GOM on the continental shelf is 4,772,600 ha (11,793,300 ac), with only 6% of this occurring in the Central and Western Planning Areas (GMFMC 1998). Authigenic carbonate exposed in deepwater areas below 300 m could total more than 200,000 ha (494,208 ac) as determined from 3D seismic remote sensing data (less than 1% of the total bottom area of the deep GOM).

Mississippi-Alabama Shelf. Within the Mississippi Estuarine Area, in inner-shelf and mid-shelf regions off Mobile Bay and the Alabama/Florida State line, there are small low-relief outcrops of rock, shell hash, and sandstone on areas with sand or shell bottom (Figure 3.7.2-1). This hard-bottom habitat, found in water depths of 18 to 40 m (59 to 131 ft), ranges from low-relief exposed rock in shallow depressions to rock outcrops with up to 5 m (16.4 ft) of vertical relief (Thomson et al. 1999). The dominant biota varies with location, but it can include barnacles, coralline algae, hydroids, sponges, octocorals, solitary hard corals, bryozoans, and ascidians (Schroeder et al. 1989; Thompson et al. 1999). These inner shelf outcrops also served as spawning grounds for a variety of fish, including the spot (*Leiostomus xanthurus*) and the Atlantic croaker (*Micropogonias undulates*).

Along the shelf edge between the Mississippi River and DeSoto Canyon, there are discontinuous carbonate reef structures called Pinnacle Trend regions; they fall primarily in two parallel bands along depth contours. BOEM (as MMS)-sponsored studies (Brooks and Giammona 1991; Continental Shelf Associates, Inc. 1992; Continental Shelf Associates, Inc., and Texas A&M University, Geochemical and Environmental Research Group 1999) have provided further information about these features, which consist of thousands of carbonate mounds ranging in size from less than a few meters to nearly a kilometer in diameter. The larger "pinnacle" features are found at depths of 74–82 m (243–269 ft) and 105–120 m (344–394 ft), and their vertical relief ranges from 2 to 20 m (6 to 66 ft), with the average being 9 m (30 ft). Linear ridges paralleling the isobaths were also mapped in the shallower depth zone. These ridges are typically about 20 to 250 m (66 to 820 ft) in width, are more than 1 km (0.6 mi) long, and have a relief of up to 8 m (26 ft). Shallow (generally less than 1 m, or 3 ft, deep) depressions, usually less than 15 m (49 ft) in diameter, were also found (Sager et al. 1992).

The pinnacle features provide a significant amount of hard substrate for colonization by suspension-feeding invertebrates, and they support relatively rich biological communities. Barnacles, worms, coralline algae, sponges, corals, and bryozoans are present at the tops of the shallowest features in water depths of less than about 70 m (230 ft) (GMFMC 2004). The diversity and abundance of the associated species appear to be related to the size and complexity of the features, with the low-relief rock outcrops (less than 1 m [3 ft] high) typically having low faunal densities, and the higher-relief features having the more diverse faunal communities. Although it is likely that little active reef building is occurring now, the Pinnacle Trend may serve as an important colonization site for hard-bottom species and allow cross-shelf gene flow between reef species in the western and eastern GOM (GMFMC 2004). In addition, pinnacles off Mobile Bay serve as aggregation sites and spawning grounds for fish and invertebrates during multiple life stages.

Louisiana-Texas Shelf Banks and South Texas Banks. Within the Mississippi Estuarine and Western Gulf Neritic Ecoregions, there are several low- to high-relief banks and ridges along the mid to outer Louisiana-Texas shelf in 22 to 200 m (72 to 656 ft) of water. Bank relief ranges from less than 1 to 150 m (3 to 492 ft) and can be as large as several hundred square meters in area. The major topographic features of the central and western GOM are shown in Figure 3.7.2-1. These features are elevated above the surrounding seafloor and are characterized as either mid-shelf bedrock banks or outer-shelf bedrock banks with carbonate caps (Rezak et al. 1983; Hickerson et al. 2008). Although these topographic features are small, the hard-bottom faunal assemblages associated with them often have high diversity, species richness, and biomass; they also provide habitat for important commercial and recreational fish species.

Benthic zones were described for the topographic features by Rezak et al. (1983). The zones were classified on the basis of their amount of reef-building activity and primary production (Rezak et al. 1983, 1985). The mid-shelf and shelf-edge banks along the Texas-Louisiana border contain a variety of zones, ranging from clear water high-productivity to low-productivity zones (Rezak et al. 1983). Several banks along the Louisiana-Texas mid shelf and shelf edge were near the storm track of Hurricane Rita in 2005. However, the long-term effects on these banks appear to have been minor (Robbart et al. 2009). Rezak et al. (1983) classifies the south Texas banks as low relief with turbidity-tolerant communities and little to no reef-building activity.

It appears that differences in the fish and invertebrate communities depend on the bank's structure, depth, and location. However, all areas have high fish and invertebrate densities and diversities, dominated by reef-associated species (Dennis and Bright 1988). Epibenthic biota that are colonizing the hard substrate include bryozoans, hard corals, octocorals, fire corals, sponges, sea whips, gastropods, hydroids, sea urchins, and spiny lobster (GMFMC 2004). Reef-associated fishes typical of the GOM congregate around these features, and many are of commercial and recreational importance (Section 3.8.4.1).

West Florida Shelf. Most of the hard-bottom habitat in the Northern GOM Shelf Marine Ecoregion is located on the west coast of Florida. Although not in the Western or Central Planning Areas, these areas could be affected by accidental oil spills and are therefore briefly described. The live-bottom communities on the west Florida shelf are tropical to temperate in nature, with the number of tropical species decreasing to the north. The communities are predominantly algal/sponge/coral assemblages, with the shallow-water octocorals and the hard corals significantly decreasing in abundance at depths deeper than about 40 m (161 ft). Most of the hard bottom on the west Florida shelf is low relief (less than 1 m [3 ft]), but it also includes ridges and pinnacles rising up to 30 m (98 ft) from the seafloor (Woodward-Clyde Consultants and Continental Shelf Associates, Inc. 1983; Continental Shelf Associates, Inc. 1987). Despite the relatively small amount of actual exposed rock outcrops across this shelf, dense sessile epifaunal assemblages are common. The primary topographic features on the west Florida shelf are the Florida Middle Ground (Figure 3.7.2-1), located about 160 km (99 mi) northwest of Tampa Bay, and Madison Swanson water, located south of Panama City at a depth of 60 to 100 m (197 to 328 ft). Steamboat Lumps, a low-relief area that measures 269 km^2 (104 mi^2) and is located west of Tarpon Springs, is another known spawning ground for reef fish. (Additional maps are available at http://oceanexplorer.noaa.gov/explorations/islands01/log/jun20/jun20.html).

Artificial hard-bottom sites, including sunken vessels, oil and gas platforms, and debris, represent only 1.3% of all hard-bottom sites in the GOM (GMFMC 1998); nevertheless, these structures support locally abundant fish populations in shelf waters of all GOM coast States (GMFMC 1998). Artificial reefs are placed in the GOM continental shelf to improve fishery production and recreational fishing opportunities.

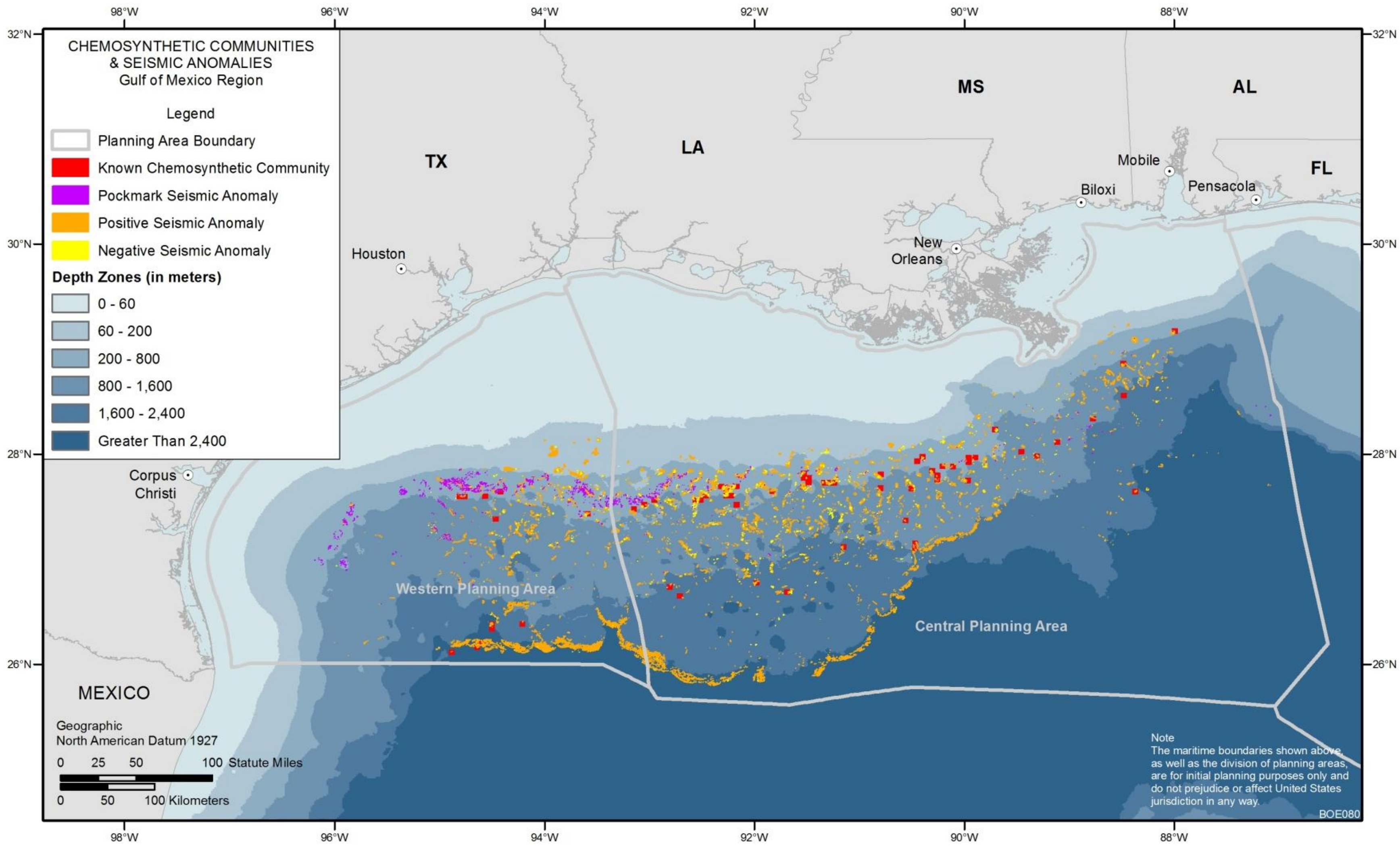
Oil platforms also serve as artificial reef habitats. There are 3,315 active oil platforms now present in GOM Federal waters (Boudreaux 2011). After oil platforms are decommissioned, they can be converted to artificial reefs by being toppled or partially removed. Oil platforms represent a novel habitat when compared with the surrounding soft sediments, and they provide attachment sites for sessile reef invertebrates such as corals, bryozoans, and sponges. In this way, they allow the range of fish and invertebrate species to expand. In addition, by serving as “islands” of hard substrate, the platforms can also promote gene flow between the eastern and western portion of the GOM (Sammarco et al. 2004).

Although the algae growing on oil platforms provide food for some platform biota, plankton is the primary food source supporting the platform community. The attached platform community in turn provides food for many but not all structure-oriented fish and invertebrates living on or near the platform. Single offshore platforms of average size have been found to provide habitat for an average of 10,000 to 30,000 fish within 50 m (164 ft) of the structure (Stanley and Wilson 2000). The high densities of fish near the platform decline to background levels within 10 to 50 m (33 to 164 ft) of the platform. Jacks, amberjack, red snapper, gray snapper, and triggerfish dominate the oil platform fish assemblage (Stanley and Wilson 2000).

Although platforms undoubtedly have higher amounts of organismal biomass than do the surrounding soft sediments, their role in enhancing fish production is controversial. Initially it was argued that reef fish are habitat-limited because of the scarcity of hard bottom on the Gulf continental shelf. Consequently, it was thought that artificial reefs provide needed habitat (Brickhill et al. 2005). Others argued that reef fish are not habitat-limited, and artificial reefs such as oil platforms simply attract fish away from natural hard bottom. 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). 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.

3.7.2.1.5 Chemosynthetic (Seep) Communities. In deepwater areas where oil and natural gas compounds seep up through the sediments, chemosynthetic bacteria inhabit specialized cells in clam, mussel, and worm hosts; they form symbiotic relationships in which methane and/or hydrogen sulfide are used to produce basic organic compounds. In the Northern GOM Slope Marine Ecoregion, chemosynthetic communities are associated with hydrocarbon seeps in water depths ranging from less than 300 m (984 ft) to more than 2,700 m (8,858 ft; Brooks et al. 2008). Figure 3.7.2-3 shows known chemosynthetic community locations. In addition, maps of acoustic seafloor anomalies in the GOM have been developed over the last 13 yr that can be used to predict the location of deepwater corals (Section 3.7.2.1.3-1) and chemosynthetic communities (Figure 3.7.2-3). The anomalies are present in the form of positive anomalies, negative anomalies, and pockmark features. The positive anomalies are indicative of hard-bottom authigenic carbonate deposits or solid hydrate formations with which deepwater coral or chemosynthetic communities are often associated. Positive anomalies do not guarantee the presence of deepwater communities because there may be a lack of exposed hard substrate for corals and the hydrocarbon seep could be inactive and not capable of supporting chemosynthetic communities. The negative anomalies are areas of rapid gas expulsion where it is generally not possible for significant communities to develop, although suitable hard substrate may be nearby. Pockmarks may be caused by large, short-term gas expulsion events and may or may not have associated hard substrate. BOEM has successfully used the presence of positive anomalies to predict the location of exposed hard-bottom, chemosynthetic, and/or deepwater coral communities, which has allowed these sensitive features to be avoided by oil and gas activities. Sassen et al. (1993b) showed that at locations for which data were available, most significant oil fields in the deepwater GOM had associated chemosynthetic communities. Since there is extensive natural oil and gas seepage in the GOM, an extensive amount of habitat is thought to be available for these types of communities, although the amounts are small in individual areal extent. In addition, chemosynthetic communities not associated with oil and gas seepage have been found at the base of the Florida Escarpment in water at a depth of about 3,200 m (10,499 ft) (Paull et al. 1984; Hecker 1985).

Evidence indicates that fauna associated with chemosynthetic communities can be extremely slow-growing. For example, tubeworms are estimated to grow less than 1 cm (0.4 in.) per year and to live longer than 200 yr (Fisher et al. 1997; MacDonald 2000). The seep mussels also exhibit slow growth rates, with adults surviving up to 40 yr (Nix et al. 1995; MacDonald 2000). Chemosynthetic communities on the upper continental slope (<1,000 m [3,281 ft]) and the mid to lower continental slope (>1,000 m [3,281 ft]) have been studied. Although general groups of epifauna, such as galatheid crabs, decapod shrimp, mussels, and tubeworms, were present at upper and lower slope sites, differences were strong at the species



Note
The maritime boundaries shown above as well as the division of planning areas, are for initial planning purposes only and do not prejudice or affect United States jurisdiction in any way.

FIGURE 3.7.2-3 Location of Chemosynthetic Communities in the Western and Central Planning Areas level (Brooks et al. 2008). There were differences in the invertebrate communities associated with mussel and tubeworm habitats although a single species of shrimp (*Alvinocaris muricola*) was typically numerically dominant at both habitat types. Depth, relative abundance of different mussel species in a bed, and the tubeworm size were important determinants of community composition (Cordes et al. 2010).

3.7.2.1.6 Climate Change Effects on GOM Marine Benthic Habitats. Climate change has the potential to profoundly affect marine benthic habitats and communities. One seafloor habitat likely to be affected is coral reefs. For example, as a stress response to warming water temperatures, coral reefs could suffer from an increased frequency of bleaching (Hoegh-Guldberg et al. 2007). Globally, bleaching appears to have increased in frequency and severity since the last quarter of the 20th century (Janetos et al. 2008), but on the basis of data from 1978 to 2006, there do not appear to be any long-term trends in the percentage of coral cover at the FGBNMS (Hickerson et al. 2008; Robbart et al. 2009). Recent surveys indicate that the FGBNMS appears to be healthy, with coral cover ranging from 50 to 70% on both banks and a low incidence of bleaching and other coral disease (Precht et al. 2008; Robbart et al. 2009). Much of this may be due to the distance of the coral reefs from land and the depth at which the reefs are located. However, the IPCC estimates that water temperatures could increase by 1.8 to 4.0°C by 2050 (IPCC 2007b), and with the rise in temperature, coral bleaching at the FGBNMS could increase.

In addition to coral bleaching, there are other challenges to coral reefs related to climate change. For example, there has been a rise in the occurrence of excessive algal growth on reefs and an increase in bacterial, fungal, and viral agents (Boesch et al. 2000; Twilley et al. 2001). There is also the potential for greater frequency of mechanical damage to corals from greater severity of tropical storms and hurricanes (Janetos et al. 2008).

In addition, the increase in atmospheric CO_2 has resulted in the formation of carbonic acid, at the expense of carbonates (aragonite and calcite), in seawater. The resulting 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). The projected decrease in pH varies depending on the model and model assumptions used; nevertheless, by 2050, the ocean's carbonate saturation might drop below levels necessary for coral reef accretion, and the pH of surface oceans might drop by as much as 0.5 pH by the end of this century (Royal Society 2005; Hoegh-Guldberg et al. 2007). Recent work also suggests ecosystem respiration is higher in the GOM because eutrophication has increased dissolved CO_2 and reduced oceanic pH by 0.11 to 0.16 (Cai et al. 2010). The trend is expected to continue, potentially leading to carbonate undersaturation (Cai et al. 2010).

As climate change has the potential to affect warm water corals, it could also affect coldwater *Lophelia* habitats. The saturation depth of aragonite (the primary carbonate form used by hard corals) appears to be a primary determinant of deep water 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).

In nearshore and mid-shelf benthic habitats, climate change may cause the temporal variability of key physical parameters — particularly dissolved oxygen, salinity, and temperature — to change or increase, which could significantly alter the existing structure of the benthic community (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. Habitats most likely to be affected include inner-shelf and mid-shelf hard-bottom and soft-sediment habitats, although the benthos of deepwater areas affected by the Mississippi River, such as Mississippi and DeSoto Canyons, may also be affected. 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). The increased freshwater inputs and surface water temperature may also promote water column stratification, which is also conducive to the development and expansion of the existing GOM Dead Zone. Hypoxic or anoxic conditions can reduce or eliminate the suitability of benthic habitat for marine organisms.

3.7.2.1.7 Effects of DWH Event on Marine Benthic Habitats. In response to the DWH event, extensive nearshore and offshore sediment sampling was conducted in order to map contamination levels (OSAT 2010). Of the sediment samples collected throughout the 2010 sampling period, less than 6% of deepwater (>200 m) samples and less than 1% of offshore and nearshore samples (out to 3 nautical miles and 200 m depth) exceeded the USEPA chronic aquatic life benchmark for PAHs and were chemically determined to be contaminated with oil from the DWH event (OSAT 2010). Dispersants were only detected in 1 of the 243 sediment samples, and no samples had dispersant concentrations that exceeded the USEPA's dispersant benchmarks (OSAT 2010). More data are needed before characterizing the implications of the DWH event on soft sediment habitat. In heavily oiled areas, the recovery time is unknown, but sediments in deeper waters may take longer to recover because colder temperatures could reduce microbial activity. However, studies of deepwater plumes following the DWH event suggest bacterial productivity rapidly responds to the presence of oil and microbial reduction in oil concentrations occurred more quickly than expected, given the low temperatures and high pressure (Hazen et al. 2010). Whether the same rapid breakdown would occur along the seafloor is unknown. Overall, natural physical and bioremedial processes will break down the oil, and it is likely that soft sediment habitat affected by the DWH event will recover.

There is some evidence that the DWH event affected more sensitive benthic habitats. In November 2010, a survey of deepwater corals along the predicted trajectory of the DWH event in 1,400 m (4,593 ft) of water revealed a 15 × 40-m (49 × 131-ft) area of dead and dying deepwater corals covered in brown flocculent (http://www.boemre.gov/ooc/press/2010/press1104a.htm). Follow-up studies indicated that the flocculent contained oil from the DWH event located approximately 11 km (7 mi) to the northeast and almost half of the corals at the site had been impacted by exposure to oil (White et al. 2012). Surveys of 11 other deepwater coral sites in the GOM did not suggest they had been impacted by the DWH event (White et al. 2012). Investigations are ongoing. It is not known how many deepwater coral communities were affected or whether the affected corals will recover. The DWH event occurred more than 320 km (200 mi) from the FGBNMS, and there were no reports of oil from the spill reaching the FGBNMS (http://flowergarden.noaa.gov/education/oilspill.html). The FGBNMS is monitored as part of a regular program, and any changes related to the spill should be detected.

3.7.2.2 Alaska – Cook Inlet

The Cook Inlet Planning Area is located within the Alaska Fjordland Shelf Ecoregion (Wilkinson et al. 2009). The physical characteristics of the benthic habitats of Kachemak Bay, Shelikof Strait, and lower Cook Inlet are critical in determining habitat function. Several distinct benthic habitats have been identified based on tidal inundation and substrate, which can consist of rock, sand, silt, and/or shell debris. Plant and animal communities in rocky habitats have strong patterns of zonation with marked variation in species composition, community structure, and productivity. In the rocky intertidal habitat, benthic assemblages are concentrated below the seaweed zone, probably due to battering by waves and kelp (MMS 1996b). The Shelikof Strait is relatively ice free even in winter (MMS 2003a). However, seasonal ice is an important influence on habitat function in Cook Inlet. The western side of Cook Inlet experiences seasonal ice scour and has biological and physical characteristics that are more similar to Arctic habitats compared to the eastern side, which does not experience ice scour (MMS 1996b, 2003a). The Cook Inlet lease sale 149 EIS (MMS 1996b) and 191 and 199 lease sale EIS (MMS 2003a) contain a comprehensive description of the habitats and biota found in Cook Inlet. See Section 3.8.4.2 and Section 3.8.5.2 for a further description of fish and benthic invertebrate communities in Cook Inlet.

The Gulf of Alaska is located outside of the Cook Inlet Planning Area and therefore would not be directly disturbed by oil and gas infrastructure. However, it could be affected by an oil spill associated with OCS activities in Cook Inlet and therefore will be briefly described. In the Gulf of Alaska, sediment deposition and sediment grain size are important determinants of benthic communities. In areas of the Gulf of Alaska where sediments are fine and sedimentation rates are high (particularly in the north-central region), nearshore infauna consists mostly of mobile deposit-feeding organisms. Greater numbers of sessile and suspension feeding infauna occur west of Prince William Sound as sediment changes to sand/gravel. A relatively low biomass of deposit feeders occurs in the eastern Gulf of Alaska, an environment characterized by strong tidal currents and sediment of low organic content (Semenov 1965).

Strong benthic-pelagic coupling is present in the Gulf of Alaska. Studies of Prince William Sound indicate sediment habitat receive the greatest springtime inputs of phytoplankton in years when phytoplankton blooms are of short duration and high biomass (Eslinger et al. 2001). Soft sediment habitat also contributes to water column productivity when sediments are resuspended by wind and wave action.

3.7.2.2.1 Climate Change Effects on Cook Inlet Marine Benthic Habitats.

Continuing trends in climate change are expected to result in chemical, physical, and hydrologic changes in Cook Inlet. For example, increased river discharge is expected to alter the salinity, temperature, and turbidity regimes in nearshore benthic habitat (Arctic Council 2005), potentially resulting in changes in the composition, abundance, and diversity of sessile benthic communities. See Sections 3.8.4.2 and 3.8.5.2 for a discussion of climate change and benthic fish and invertebrates. In addition to changes in hydrology, rising temperatures may reduce the extent and duration of landfast ice, resulting in a reduction in the scouring of intertidal and shallow subtidal habitats on the western side of Cook Inlet. A reduction in scour may allow more persistent and non-opportunistic invertebrate communities to develop. Warmer temperatures may also increase phytoplankton productivity, potentially resulting in greater food inputs to benthic habitats. Alternatively, the greater expected river discharge could increase stratification and reduce light and nutrients available for phytoplankton (Strom et al. 2010). Such a change could reduce organic matter inputs to the seafloor by decreasing phytoplankton productivity or shifting the phytoplankton community to smaller species, resulting in more of the primary productivity being consumed in the water column and less sinking to the seafloor.

3.7.2.3 Alaska – Arctic

The Beaufort and Chukchi Planning Areas include the Beaufort/Chukchian Shelf Marine Ecoregion and the Arctic Slope and Arctic Plains Marine Ecoregions. In both planning areas, oil and gas exploration and production activities will generally occur in water depths of less than 200 m (656 ft).

Most of the seafloor of the Beaufort/Chukchian Shelf Marine Ecoregion consists of a soft-bottom, featureless plain composed of silt, clay, and sand. Deposits of flocculated particles from plankton blooms, epontic organisms, and ice algae from ice retreat all contribute to the bottom sediments in these regions. Disturbance from sea ice scour is a dominant process affecting the seafloor of the Beaufort and Chukchi shelves. Deep keels of icebergs moving across the shelf scour sediments, causing chronic disturbance to benthic communities. Strudel (drainage of large volumes of freshwater through the ice at holes and cracks) scouring of the seafloor also occurs near the mouths of rivers during spring flood periods. Few species inhabit the seafloor in waters shallower than 2 m (6.6 ft) deep because of the bottom fast ice, which prohibits overwintering of most organisms. This nearshore benthic area is recolonized each summer, mainly by mobile, opportunistic, epifaunal crustaceans (amphipods, mysids, cumaceans, and isopods, which are fed on primarily by waterfowl and fishes). In slightly deeper water, the gouging of the seafloor by ice keels creates a habitat for opportunistic infauna (e.g., small clams and other invertebrates), which are fed on by seabirds, fishes, and walrus (Bluhm and Gradinger 2008). Surveys on the Chukchi Shelf revealed that tunicates, echinoderms, jellies, crabs, polychaetes, and sponges make up most of the benthic biomass (NPFMC 2009). Common fish on soft sediments included Arctic cod (*Boreogadus saida*), Pacific herring (*Clupea pallasii*), sculpins, and pollock (*Theragra chalcogramma*) (NPFMC 2009). See Sections 3.8.4.3 and 3.8.5.3 for descriptions of fish and invertebrate communities.

Food sources supporting soft-sediment habitat are highly seasonal and primarily derive from terrestrial sources and from water column primary and secondary production originating locally or advected from the Bering Sea. Data from the Northern Bering Sea and the Chukchi Sea suggests there is a strong coupling between phytoplankton biomass and benthic invertebrate biomass (also known as benthic-pelagic coupling), suggesting that communities on seafloor habitats rely strongly on organic matter originating from the water column. These benthic communities in turn support higher trophic levels such as benthic feeding birds and marine mammals (Dunton et al. 2005; Grebmeier et al. 2006). Thus, the fact that the biomass of benthic invertebrates in Chukchi Shelf sediments is higher than that in Beaufort Shelf sediments is thought to result from the higher phytoplankton and organic matter available on the former (Dunton et al. 2005). In contrast, benthic communities on the Beaufort Shelf do not appear to be related to phytoplankton biomass but rather to the availability of terrestrial organic matter from coastal erosion or riverine inputs (Dunton et al. 2006). Organic matter released from sea ice habitat is another food source that may be critical to benthic species in certain locations and seasons. For example, early life stages of benthic invertebrates are commonly found in the water column associated with sea ice (Gradinger and Bluhm 2005). In addition, much of the phytoplankton from ice-edge blooms associated with the spring sea ice melt is exported to the seafloor because of the low zooplankton density in the water column in the early spring (Bluhm and Gradinger 2008).

Hard-bottom seafloor habitat is also present, primarily in the form of cobble and boulders distributed sporadically along the inner Beaufort and Chukchi shelves and in the Barrow Canyon (MMS 2002a). Three such locations are in Stefansson Sound and western Camden Bay in the Beaufort Sea and in Peard Bay in the Chukchi Sea (MMS 2003b, Section III.B.1.b; BLM and MMS 2003b, Section III.A.2.c(3)). In addition, Peard Bay and the Stefansson Sound Boulder Patch have kelp communities, with the latter having the largest brown kelp (*Laminaria solidungula*) community in the Alaskan Arctic (Phillips et al. 1984; Dunton et al. 2004; Figure 3.7.2-4). The resident species are found at higher diversity, abundance, and biomass in boulder patches than in surrounding areas and are composed of a unique community of algae, bryozoans, hydroids, polychaetes, bivalves, crustaceans, and the soft coral associated with them (Iken 2009). Sediment inputs from rivers and ice scouring are primary controls on biological productivity in boulder habitat. Results of a recent study conducted under the BOEM Arctic Nearshore Impact Monitoring in the Development Area (ANIMIDA) Program demonstrated that suspended sediment can reduce the light available for kelp production during open-water periods of summer (Dunton et al. 2004) and that kelp productivity is significantly reduced in years where sediment loading is high (Aumack et al. 2007). The reduced photosynthesis can result from sediment coating kelp blades or reducing light penetration into the water column. Multiple studies have also demonstrated that boulder habitats are subject to frequent disturbance from the freezing and thawing of ice. If significantly scoured or overturned, communities associated with boulders are slow (2 or more years) to begin recovery, with full recovery taking a decade or more (Konar 2007 and references therein).

Although no drilling is proposed on the Beaufort or Chukchi slope, in recent investigations, “pock marks” were discovered on the Chukchi slope (MacDonald et al. 2005). These crater-like features are about 1 km (3,281 ft) in diameter and 40 m (131 ft) deep and are located between the 500-m and 1,000-m (1,640-ft and 3,280-ft) isobath. The abundance and

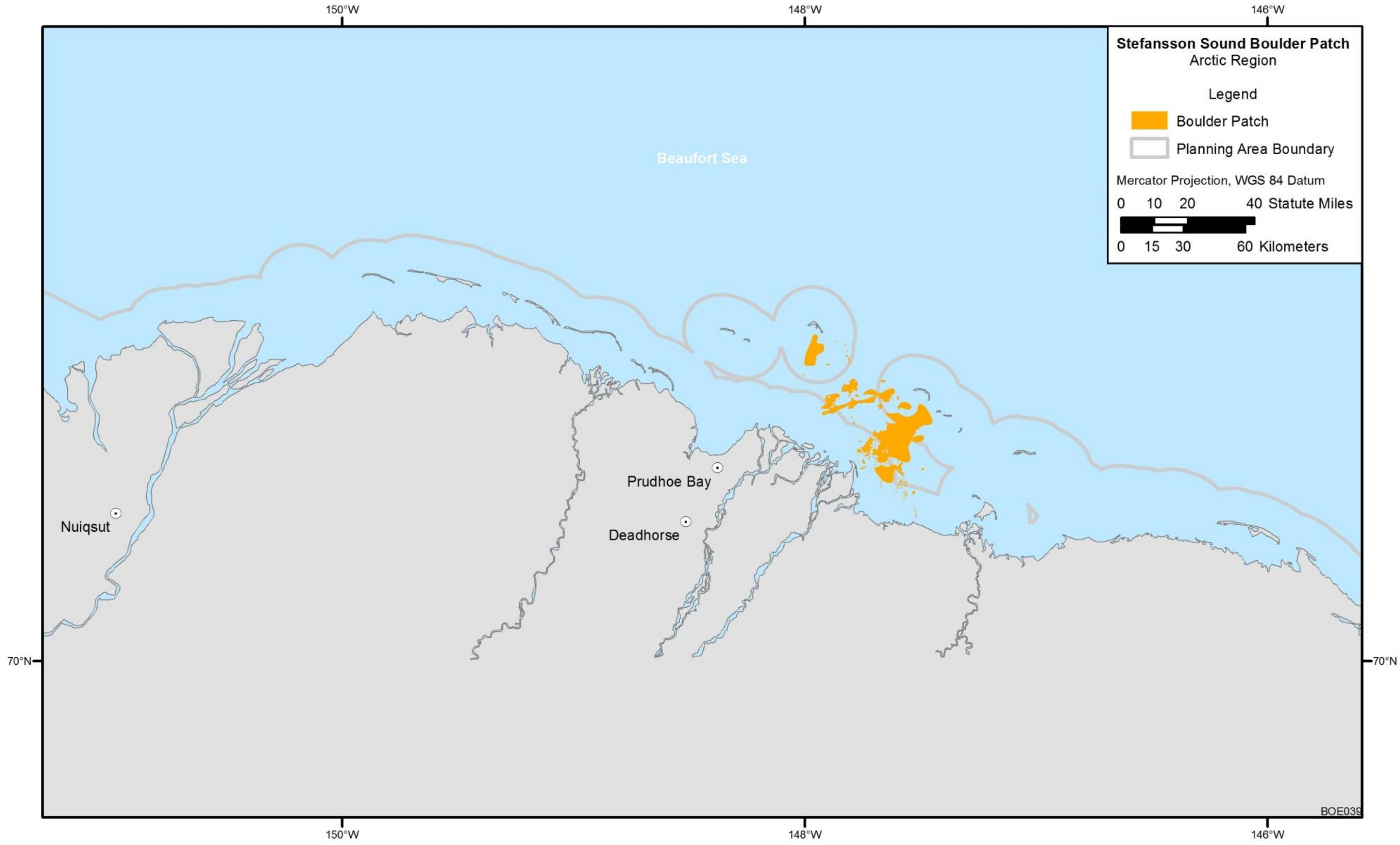


FIGURE 3.7.2-4 Location of the Stefansson Sound Boulder Patch in the Beaufort Sea Planning Area

diversity of invertebrates were higher in the pock marks than in the surrounding sediments. Brittle stars, various types of anemones, shrimps, eel pouts, stalked crinoids, benthic ctenophore, gooseneck barnacles, mysids, and holothurians were the most abundant epifauna. Polychaetes, foraminiferans, nemertineans, cnidarians, peanut worms, and clams were the most abundant infauna (MacDonald et al. 2005).

3.7.2.3.1 Climate Change Effects on Arctic Marine Benthic Habitats. Continuing trends in climate change are expected to result in chemical, physical, and hydrologic changes in the Alaska Fjordland Shelf and Beaufort/Chukchian Shelf Ecoregion. For example, increased river discharge is expected to alter the salinity, temperature, and turbidity regimes in nearshore benthic habitat (Arctic Council 2005; Hopcroft et al. 2008), potentially resulting in changes in the composition, abundance, and diversity of sessile benthic communities.

The predicted decrease in the extent and duration of sea ice also has implications for benthic habitat. The retreat of the summer sea-ice cover from the coastline during the last few decades (Arctic Council 2005) has created an unusually wide expanse of open water, which has led to the formation of large storm waves that cause shoreline erosion and consequent changes to the intertidal and shallow subtidal benthic habitats. A reduction in the extent of sea-ice cover may also reduce the intensity of benthic scouring. A decrease in the sea-ice cover will adversely affect sea-ice-dependent benthic biota and reduce the seasonally important pulse of sea-ice organic matter to the seafloor. Recent data also suggests that benthic-pelagic coupling could be weakened if the existing temperature increases and reductions in sea ice continue in the Arctic. A reduction in organic matter inputs to the benthos could reduce benthic productivity and shift the system from a benthic-dominated food web to a more pelagic-oriented system dominated by pelagic fishes (Grebmeier et al. 2006). Benthic feeding birds and marine mammals could suffer from the reduced benthic productivity (Grebmeier et al. 2006). Such changes are less likely to affect the Beaufort Sea than the Chukchi Sea which exhibits a high degree of benthic-pelagic coupling (Hopcroft et al. 2008). The loss of sea-ice organic-matter deposition may be made up for by higher open water phytoplankton productivity (Arrigo et al. 2008), some of which will settle to the seafloor. Alternatively, as Arctic waters warm, the flux of organic matter to the benthos may decrease if phytoplankton productivity decreases or shifts to smaller species due lower nutrient availability (Li et al. 2009) or if there is an increased consumption of phytoplankton by zooplankton (Arrigo et al. 2008).

Climate change also has several potential implications for hard-bottom habitat. The reduction in sea-ice cover may reduce the spatial and temporal extent of scouring, and it may also increase wave action, which could result in more frequent disturbance of slow-recovering Boulder Patch habitats. 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).

3.7.3 Marine Pelagic Habitats

Marine pelagic habitats exist in the water column rather than the seafloor, and include the water surface. The following sections focus on the water column as habitat for biota. See Section 3.4 for a discussion of water quality in the GOM, Cook Inlet Planning Area, and the Beaufort and Chukchi Sea Planning Areas.

3.7.3.1 Gulf of Mexico

3.7.3.1.1 Water Column. Pelagic habitats in the GOM include unique habitats such as drifting surface *Sargassum* and areas where dynamic ocean circulation processes result in high biological productivity. The Mississippi and Texas Estuarine Areas have high inputs of riverine nutrients, which promote phytoplankton productivity in the surface water; this, in turn, supports a high biomass of vertebrate and invertebrate consumers. Primary production is typically limited by nutrients whose concentrations are greatly reduced in the absence of riverine inputs. Therefore, primary production decreases to the west and east with distance from the Mississippi River, and it decreases from the Mississippi and Texas Estuarine Areas seaward to the neritic ecoregions, where the phytoplankton are dominated by small picophytoplankton, dinoflagellates, and cyanobacteria (Hulbert and Corwin 1972; Wawrik and Paul 2004). Oceanic waters beyond the continental shelf edge are similarly unproductive. Although most oceanic waters are relatively unproductive, there are areas of temporarily high productivity. For example, upwelling zones occur along the edge of the GOM shelf, where deepwater moves up the continental slope, bringing nutrients into the photic zone. The combination of high irradiance and high nutrient levels allows seasonally high primary and secondary production in upwelling zones. The DeSoto and Mississippi Canyons are important upwelling zones in the Central Planning Areas, and the south Texas shelf is an upwelling zone in the Western Planning Area (GMFMC 2004; Walker et al. 2005; Zavala-Hidalgo et al. 2006).

Most pelagic primary consumers are temporary or permanent zooplankton. Temporary zooplankton are larval stages of fish and invertebrates that mature in the marine environment or are transported into estuaries where they will reach their juvenile stage. Permanent zooplankton remain in a planktonic state for their entire life cycle. Zooplankton serve as critical food sources. They also play a key role in recycling nutrients within the water column and in transferring water column primary production to sediment consumers in the form of fecal pellets and carcasses.

Pelagic waters can be classified into zones on the basis of their depth (Bond 1996). Epipelagic habit is defined as the upper 200 m (656 ft) of the water column. Because of the high clarity of the water, light penetrates deeply enough to support limited primary production in water as deep as 200 m (656 ft). Below this euphotic zone, light levels and consequently primary production are limited or nonexistent. Below the epipelagic zone, the water column may be layered into the mesopelagic zone (200 to 1,000 m [656 to 3,281 ft]) and bathypelagic (>1,000 m [>3,281 ft]) zone. To overcome the low availability of food at depth, many mesopelagic fishes and megaplankton spend their days in depths of 200 to 1,000 m (656 to 3,281 ft) but migrate vertically at night into food-rich near-surface waters. Mesopelagic fish and zooplankton are important ecologically because they transfer significant amounts of energy between mesopelagic and epipelagic zones over each daily cycle. For example, the lanternfishes, which are abundant mid-water species in the GOM, are important prey for meso- and epipelagic predators like tuna (Hopkins et al. 1996).

The bathypelagic zone is an aphotic, food-poor habitat. Consequently, predators and scavengers dominate this zone. The base of the food web is relatively degraded particulate falling from the photic zone. This material can aggregate into larger particles called marine snow. Many organisms occupying the bathypelagic zone have evolved adaptations to the harsh physical and chemical conditions; these include a lowered metabolic rate and soft bodies with high water content to reduce the need for food and hypercephelization and large jaws to swallow a greater size range of prey (Miller 2004). Deeper-dwelling (bathypelagic) fishes are composed of strange, little-known species, such as snipe eels (family Nemichthyidae), slickheads (family Alepocephalidae), bigscales (family Melamphaidae), and whalefishes (family Cetomimidae) (McEachran and Fechhelm 1998). Most species are capable of producing and emitting light (bioluminescence) to aid communication in an environment devoid of sunlight.

The ecological effects of the DWH event are still being investigated. However, data collected from recent research cruises indicate that some tentative conclusions can be made about the effect of the spill on marine pelagic habitats. The spill released both oil and methane gas into the water column, some of which was entrained in bottom currents, forming a subsurface plume. Comprehensive sampling during and after the spill over a wide area and depth strata of the GOM reported less than 2% of water column samples taken from nearshore, offshore, and deepwater areas contained PAH concentrations exceeding USEPA toxicity benchmarks (OSAT 2010). Contamination related to oil from the DWH event was found within approximately 70 km (43 mi) of the wellhead in deep water. The toxicity of water samples decreased with distance from the wellhead (OSAT 2010). Surveys in late June 2010 indicated that there was a subsurface methane plume (as high as 180 m [591 ft]) in 800 to 1,200 m (2,625 to 3,937 ft) of water that extended from the DWH (Valentine et al. 2010; Kessler et al. 2011). However, the plume was not found in samples collected in August and September 2010, despite extensive areal sampling coverage (Kessler et al. 2011). Also in June 2010, clouds of oil trending southwest from the well were found at a depth of 1,100 m (3,609 ft); they extended 35 km (22 mi) from the wellhead (Camilli et al. 2010; Atlas and Hazen 2011). The dispersed oil was as thick as 200 m (656 ft) and up to 2 km (6,562 ft) in width (Camilli et al. 2010). Dispersants were also found in the subsurface oil clouds; their concentrations decreased significantly with time and distance from the well as a result of their dilution with seawater (Kujawinski et al. 2011). However, dispersant was still detectable at low, nontoxic levels up to 300 km (186 mi) away from the wellhead 64 days after the dispersant application ended, suggesting slow natural breakdown (Kujawinski et al. 2011).

The biological effects of the DWH event are still being investigated. Phytoplankton productivity has been found to increase, decrease, or remain unchanged following oil spills (Hu et al. 2011). PAH toxicity or lower solar irradiance could reduce phytoplankton productivity, while phytoplankton biomass could increase if zooplankton are suppressed. Jernelov and Linden (1981 cited in Hu et al. 2011) reported a phytoplankton bloom after the IXTOC-1 oil spill. Satellite imagery suggests that phytoplankton biomass increased in areas of the GOM following the DWH event, but there were not enough data to link the increase directly to the oil released by the DWH (Hu et al. 2011). The DWH event also changed pelagic microbial communities. The amount of menthanotropic and oil-eating bacteria increased greatly after the DWH event (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. In shallow coastal areas, the hydrocarbon appeared to be assimilated by bacteria and transferred up through the zooplankton food web (Graham et al. 2010). The carbon derived from the DWH event appeared to have been metabolized and assimilated into the food web within weeks (Graham et al. 2010; Atlas and Hazen 2011). These studies suggest the GOM has a tremendous natural capacity to assimilate accidental oil spills.

3.7.3.1.2 Pelagic *Sargassum* Habitat. Floating *Sargassum* mats are present in neritic and oceanic waters (Figure 3.7.3-1). *Sargassum* in the GOM consists of three species of brown algae: *Sargassum natans* (80%) *S. fluitans* (10%), and detached sessile *S. filapendula* (10%) (GMFMC 2004). Satellite maps indicate that *Sargassum* originates in the northwest GOM in the spring and is transported through the Florida Straits into the Atlantic Ocean via the Loop Current and Gulf Stream (Gower and King 2008). Its abundance is highest in the summer and decreases in the fall and winter (Figure 3.7.3-1). *Sargassum* is distributed over the entire GOM in shelf, basin, and slope waters.

As many as 54 fish species are closely associated with floating *Sargassum* at some point in their life cycle, but only two species spend their entire lives there: the *Sargassum* fish (*Histrio histrio*) and the *Sargassum* pipefish (*Syngnathus pelagicus*) (MMS 1999). Hydroids, anthozoans, flatworms, bryozoans, polychaetes, gastropods, nudibranchs, bivalves, cephalopods, pycnogonids, isopods, amphipods, copepods, decapod crustaceans, insects, and tunicates can all be found in the *Sargassum*-associated invertebrate community (GMFMC 2004). Most fish associated with *Sargassum* are temporary residents, such as juvenile stages of species that reside in shelf or coastal waters as adults (MMS 1999). *Sargassum* mats are also recognized as preferred habitat for hatchling sea turtles (Carr and Meylan 1980). These species subsist on the shrimp and crabs that dominate the invertebrate biomass within the *Sargassum* mat. Several large fish species of recreational or commercial importance — including dolphin fish, yellowfin tuna, blackfin tuna, skipjack tuna, Atlantic bonito, little tunny, and wahoo — feed on the small fishes and invertebrates attracted to *Sargassum* (Morgan et al. 1985; MMS 1999).

3.7.3.1.3 Climate Change Effects on GOM Marine Pelagic Habitats. See Water Quality, in Section 3.4.1, for a discussion of the potential effects of climate change on water quality in the GOM.

Climate change may affect water column productivity and ecosystem processes (Table 3.7.3-1). Surface water phytoplankton productivity in nearshore and mid-shelf areas is likely to increase during the spring because of the greater discharge of nutrient-rich river water into the GOM (Rabalais et al. 2010). The composition of the phytoplankton community may also change to reflect the new nutrient, salinity, and temperature regime, although the nature of the changes is unknown. Some have predicted that silica limitation in the face of greater nutrient

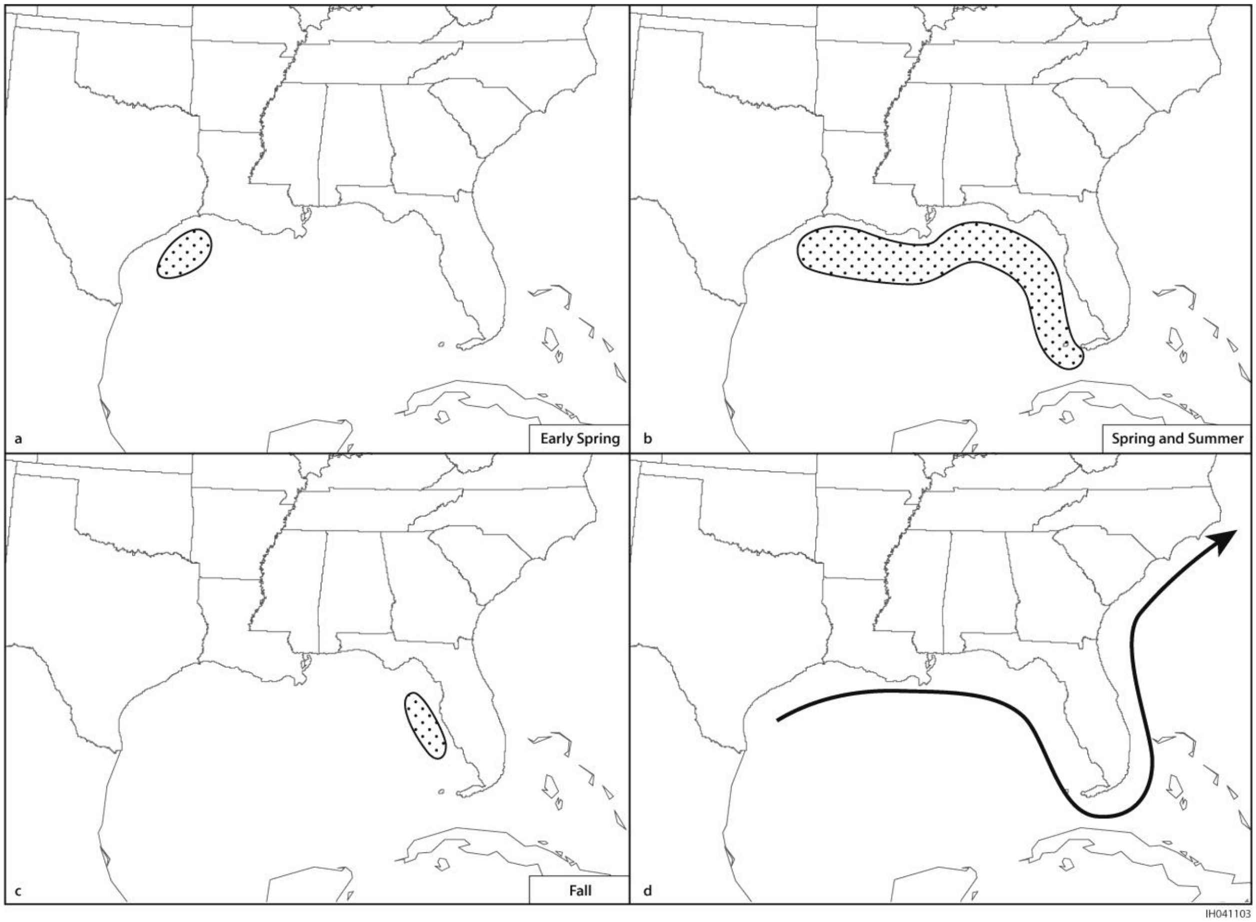


FIGURE 3.7.3-1 Areas of High Abundance of *Sargassum* in the GOM in (a) Early Spring, (b) Spring and Summer, and (c) Fall. General Trajectory of *Sargassum* Movement Is Shown in (d). (Map based on satellite data collected by Gower and King [2008].)

inputs may reduce the relative abundance of diatoms in favor of nuisance phytoplankton such as dinoflagellates (Turner 2001). If this were to occur, the traditional diatom-zooplankton food web could potentially shift to a microbial-based food web, resulting in a reduction in energy transfer to higher trophic levels. Along with increased primary production in the springtime, the greater freshwater inputs and surface water temperature may promote water column stratification; together, these could promote the development and expansion of the existing GOM Dead Zone (area of hypoxic or anoxic water that develops seasonally in the GOM). In the summer, the productivity of surface water phytoplankton may decrease because higher water temperatures may promote greater thermal stratification and reduce the transfer of nutrients to the upper water column. However, the expected increase in the frequency and severity of tropical storms may promote water column turnover and reduce the duration of hypoxic conditions (Rabalais et al. 2010).

The impact of increased atmospheric CO_2 on pelagic productivity is complicated and difficult to predict. Increased CO_2 could increase primary productivity by increasing the carbon available for photosynthesis. However, greater CO_2 has also resulted in the formation of

TABLE 3.7.3-1 Summary of Potential Changes in the Marine and Pelagic Habitats of the Northern GOM Marine Ecoregion That Could Result from Climate Change

Climate Change Impact Factor	Soft Sediment	Coral	Hard Bottom	Deepwater Coral	Chemosynthetic Communities	Pelagic Habitat
Sea level rise		Decrease in light availability				
Temperature increase	Changes in biogeochemical processes; changes in food inputs to the seafloor	Increase in coral bleaching	Changes in food inputs to the seafloor	Changes in food inputs to the seafloor		Greater water column stratification; changes in water column productivity
Ocean acidification		Decrease in growth and distribution	Decrease in coral growth	Decrease in growth and distribution	Decrease in growth of chemosynthetic mussels and clams	Changes in phytoplankton composition
Increased storm frequency	Increase in benthic disturbance	Physical damage to corals	Physical damage and scouring			Greater mixing of water column
Increased river discharge	Physiological stress on sessile organisms; changes in biogeochemical processes	Increased nutrients and turbidity may reduce light penetration	Physiological stress on sessile organisms	Could affect habitat in GOM canyons	Could affect habitat in GOM canyons	Greater water column stratification and variation in water chemistry; changes in water column productivity

carbonic acid at the expense of carbonates in seawater. Aside from affecting pelagic invertebrates (Section 3.8.5.1), ocean acidification could also negatively affect calcifying phytoplankton species such as the coccolithophores (Royal Society 2005), which are often a dominant primary producer found in low-nutrient waters over the outer continental shelf and slope. However, other research suggests coccolithophore productivity will increase with greater CO_2 concentrations (Royal Society 2005).

3.7.3.2 Alaska – Cook Inlet

See Section 3.4.2 for a discussion of water quality in Cook Inlet. Cook Inlet pelagic waters are influenced by riverine and marine inputs, resulting in salinity gradients and horizontal mixing near the inlet. In general, extensive areas of pack ice do not form in Cook Inlet because of the large tidal range and strong tidal currents. However, seasonal ice is observed during the winter (MMS 2003a). The Shelikof Strait is relatively ice free even in winter (MMS 2003a). Pelagic habitat in Cook Inlet is highly productive, with phytoplankton biomass peaking in the spring. The spring phytoplankton bloom begins as the water column stratifies and light levels increase. However, productivity remains high in summer because of the resuspension of nutrient-rich bottom sediments due to tidal flux and strong winds. There is spatial variation in productivity as well, with the west side of Cook Inlet having lower primary and secondary production due to greater sediment loading. Diatoms and microflagellates, many of them advected from the Gulf of Alaska, dominate the phytoplankton assemblage.

In Shelikof Strait, studies indicate that the densities of zooplankton and pollock eggs are higher than in the adjacent continental shelf, and interannual variation in both appears to be controlled primarily by physical factors such as currents, salinity, and temperature, which in turn influence biologically important variables such as phytoplankton production (Kendall et al. 1996; Napp et al. 1996; Incze et al. 1997; Bacheler et al. 2009). Zooplankton are dominated by copepods of estuarine, continental shelf, and marine origin (Incze et al. 1997; Speckman et al. 2005).

The fate of phytoplankton depends on the timing of the spring phytoplankton bloom. Zooplankton biomass in Cook Inlet tracks seasonal peaks in phytoplankton. Zooplankton can consume a high proportion of phytoplankton biomass in years with a prolonged lower density bloom (Eslinger et al. 2001). However, in years with a short high-density bloom, zooplankton consumption cannot keep up with phytoplankton production and much of the phytoplankton is exported to the seafloor.

3.7.3.2.1 Climate Change Effects on Cook Inlet Planning Area Pelagic Habitat. See Section 3.4.2 for a discussion of climate change and water resources in Cook Inlet. The effects of climate change on pelagic habitat in Cook Inlet are difficult to predict with certainty because of the complexity of the system. However, current and predicted trends suggest climate change will significantly alter the chemical, physical, and hydrologic properties of pelagic habitat, which will in turn alter biological communities. For example, the predicted increase in river discharge could change the salinity, temperature, and turbidity, and mixing regimes in nearshore areas and alter the composition of existing phytoplankton communities. 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 (Strom et al. 2010). In the future, given the complicated regulation of primary productivity and how each of these factors may be affected by climate change, annual phytoplankton productivity may increase or decrease (Strom et al. 2010). The timing and duration of phytoplankton blooms, as well as seasonal species composition, are also likely to be altered. Such changes in phytoplankton productivity may increase or decrease net export of organic matter to the benthos. For example, if climate change decreases nutrient availability, smaller species may come to dominate the phytoplankton assemblage, resulting in more of the primary productivity being consumed in the water column and less sinking to the seafloor.

Ocean acidification from increasing CO_2 inputs into the ocean is also predicted to continue in Alaskan waters and may reduce the availability of calcite and aragonite to calcifying marine organisms. In the Gulf of Alaska, carbonate undersaturated water from the outer shelf and slope periodically moves inshore, potentially reducing the abundance of calcifying invertebrate prey for commercially important species such as salmon and pollock (Fabry et al. 2009).

3.7.3.3 Alaska – Arctic

Water depths in the Beaufort and Chukchi Sea Planning Areas range up to 3,800 m (12,467 ft). Section 3.4.3 has a detailed description of the physical and chemical characteristics of the water column. In both planning areas, oil and gas exploration and production activities would generally occur in the inner shelf in water depths up to 200 m (656 ft).

The Beaufort Sea and Chukchi Sea are characterized by distinct hydrographic and productivity regimes. Both systems undergo extended seasonal periods of frigid and harsh environmental conditions, reduced light, seasonal darkness, prolonged low temperatures, and ice cover. The lack of sunlight and extensive ice cover in Arctic latitudes during winter months greatly reduces primary and secondary productivity (Craig 1989).

Pelagic habitat in the Beaufort/Chukchi Marine Ecoregion consists of ice-free open water and high-productivity areas of open water surrounded by sea ice (polynyas). Productivity in the water column is primarily controlled by temperature, nutrients, light, and the amount of sea ice in a given year. Phytoplankton productivity is highest in the summer when temperatures are highest (Hopcroft et al. 2008) and when nutrient and solar irradiance are most conducive to productivity. Phytoplankton productivity gradually decreases from the southwestern Chukchi Sea to the east to the Beaufort Sea (especially east of Point Barrow) and from inshore to offshore areas, although there are isolated mid-shelf upwelling regions where productivity is higher than it is in the surrounding water. The east-to-west trend is thought to be caused by the import of nutrients, phytoplankton, and organic matter-rich water into the Chukchi Sea from the adjacent Bering Sea (Dunton et al. 2005) as well as the cold nutrient-poor water flowing into the Beaufort Sea from the Atlantic. Sea ice is also a primary influence on primary productivity, and nutrients from upwelling off the Barrow and Herald Canyons can also be delivered to the continental shelf

(Pickart et al. 2009). Phytoplankton productivity is highest in warmer years with less sea ice because of the higher areal extent of surface water solar irradiance and the longer growing season (Wang et al. 2005).

There are multiple fates for water column productivity, and they depend highly on the timing of phytoplankton and zooplankton activity. In the early spring when waters are still cold, zooplankton (primarily protozoans and copepods) are not as active, and much of the productivity may be exported to the seafloor, where it is a critical subsidy for the benthic food web. In late spring and summer, however, during periods of active zooplankton growth, much of the productivity may be consumed in the water column (Hopcroft et al. 2008). In general, the Chukchi exhibits strong benthic-pelagic coupling, with high flux of phytoplankton and organic matter from open water areas (including polynyas) to the sediment. The production may also be advected to deep waters of the Canada Basin (Cooper et al. 2002; Bates et al. 2005).

Pelagic habitats of the Arctic contain classes of organisms similar to those found in subarctic and temperate waters, such as protozoan microzooplankton, copepods, euphausiids, shrimp, larvaceans, cnidarians, ctenophores, pteropods, and squid. The pelagic fish assemblage is dominated by Arctic cod, whitefish (*Coregonus*), capelin (*Mallotus villosus*), and herring. All of these resources are important forage for marine mammals and birds. See Sections 3.8.4.3 and 3.8.5.3 for a discussion of Arctic fish and invertebrates.

3.7.3.3.1 Sea Ice. Sea ice is an important habitat in the northern Beaufort and Chukchi Seas; it exists for variable periods in the colder months of the year near the coastline and perennially closer to the shelf edge and basin. Sea ice is more extensive and lasts longer in the Beaufort Sea than the Chukchi Sea. Algae growing on the underside of sea ice can be the primary source of productivity in northern areas of the shelf with permanent ice cover, and sea ice algal productivity and biomass can exceed the productivity of the water column during the spring (Gradinger 2009). One primary control over the growth of sea ice algae is the availability of light under the ice, which is a function of snow cover, ice thickness, and sediment loading; all of which are negatively related to productivity. In addition to the diatoms that dominate the algal assemblage, sea-ice communities contain a diverse mixture of bacteria, protozoans, and a rich meiofaunal and macroinvertebrate community dominated by amphipods, copepods, and nematodes. These organisms are, in turn, fed upon by higher trophic-level consumers, such as Arctic cod, seals, and birds. In addition, sea ice provides shelter and resting habitat for marine mammals and birds. Sea ice also supports the early life stages of fish (especially Arctic cod) and benthic invertebrates by providing temporary habitat (particularly nearshore sea ice) or by exporting seasonal pulses of organic matter to the seafloor (Gradinger and Bluhm 2005; Bluhm and Gradinger 2008). In addition, by trapping and transporting nutrients, sea ice can increase the spatial extent of nutrient availability to phytoplankton. Sea ice is responsible for strong ice-edge phytoplankton blooms, which occur as melting sea ice releases organic matter and fresh water, creating a stratified upper water column high in nutrients (Hopcroft et al. 2008; Mundy et al. 2009).

3.7.3.3.2 Climate Change. See Section 3.4.3 for a discussion of climate change and water resources in the Beaufort and Chukchi Seas. The effects of climate change on pelagic habitat in the Beaufort/Chukchi shelf are difficult to predict with certainty because of the complexity of the system. However, current trends suggest climate change will significantly alter the chemical, physical, and hydrologic properties of pelagic habitat, which will, in turn, affect biological communities. For example, increased river discharge is expected to alter the salinity, temperature, and turbidity regimes in nearshore areas (Hopcroft et al. 2008), which could change the distribution, abundance, and composition of existing phytoplankton and zooplankton communities (Section 3.8.5.3). Several rivers flow into the Beaufort shelf and this region may be more heavily affected than the western Chukchi shelf. The effects of increased river discharge on phytoplankton are difficult to predict because, although rivers deliver nutrients to coastal regions, the increase in sediment load could also reduce the availability of light.

Climate change in the Arctic is affecting the Arctic sea ice cover, which has retreated unusually far from the coastline during the last few decades (Arctic Council 2005). Climate change is expected to decrease the spatial extent and temporal duration of sea ice as well as make the ice thinner. Recent studies suggest the amount of ice formed in the winter is not sufficient to replace the amount of ice lost in the summer; consequently there has been a decrease in the ratio of thicker, multi-year ice to thinner, first-year sea ice (Kwok et al. 2009). Although thinner ice and less snow cover may promote the primary productivity beneath sea ice, increased river discharge (i.e., Mackenzie River) may trap more sediment within ice and reduce the availability of light (Gradinger and Bluhm 2005). In addition, a reduction in landfast ice will increase the sloughing of sediments from shoreline during storms, adding to the sediment loads and changing water chemistry in nearshore areas. In the winter, before the spring phytoplankton bloom, sea ice algae are the primary food source supporting pelagic biota (Lee et al. 2008). The loss of sea ice may therefore reduce seasonal food availability to sea ice dependent species. Spring ice melt occurs during a period when zooplankton are still inactive; therefore, much of the organic matter trapped in the sea ice is exported to the seafloor (Bluhm and Gradinger 2008). Recent data suggests that this strong benthic-pelagic coupling in the Chukchi Sea could be weakened if the existing temperature increases and reductions in sea ice continue (Grebmeier et al. 2006). The result could be a shift to a pelagic-based rather than a benthic-based food web as the flux of organic matter to the sediment is reduced and warmer temperatures promote increased phytoplankton grazing in the water column (Grebmeier et al. 2006; Hopcroft et al. 2008).

Overall phytoplankton productivity in the open water may increase as open water solar irradiance and wind-driven upwelling of nutrients increases with increasing temperature and ice retreat (Arctic Council 2005; Hopcroft et al. 2008; Arrigo et al. 2008). With the increase in phytoplankton productivity, the biomass of zooplankton may also increase if the phytoplankton blooms occur when zooplankton are active (Bluhm and Gradinger 2008). Alternatively, phytoplankton productivity may decrease or shift to picoplanktonic species if the upwelling of nutrients to the upper water column is reduced by stronger water column stratification from higher temperatures and ice melt (Li et al. 2009). In this case, there would be less energy available to larger zooplankton and ultimately pelagic fish, mammals, and birds.

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. Surface waters in the Arctic are currently supersaturated with aragonite (another form of carbonate), but it is predicted that they will be undersaturated by the century's end or earlier (reviewed in Fabry et al. 2009). Aside from affecting pelagic invertebrates, ocean acidification could also adversely affect calcifying phytoplankton species, such as the coccolithophores, which are often a dominant primary producer in low-nutrient waters over the outer continental shelf and slope. However, other research suggests that despite the potential adverse effects of reduced pH oncoccolithophore plate formation, their productivity could increase due to greater CO_2 concentrations which are used in photosynthesis. Clearly more research is needed as very few species have been tested, and many of these studies are laboratory based and may not be relevant to the far more complex oceanic environment (see Royal Society [2005] and Doney et al. [2009] for recent reviews).

3.7.4 Essential Fish Habitat

The National Marine Fisheries Service (NMFS) manages commercial and recreational fisheries within Federal waters under the Magnuson-Stevens Fishery Conservation and Management Act (FCMA) (16 USC 1801-1883). The 1996 amendments to this Act require regional fishery management councils (FMCs), with assistance from NMFS, to delineate essential fish habitat (EFH) in Fishery Management Plans (FMPs) or FMP amendments for all federally managed fisheries. EFH is defined as the water and substrate necessary for fish spawning, breeding, feeding, and growth to maturity (50 CFR Part 600). FMPs for fishery resources are submitted to the NMFS for approval and implementation. The FCMA mandates that any FMP shall: (1) describe and identify EFH for the fishery, (2) minimize to the extent practicable adverse effects on such habitat caused by fishing, and (3) identify other actions to encourage the conservation and enhancement of such habitat. The FCMA also requires Federal agencies to consult on activities that may adversely affect EFHs designated in the FMPs. Oil and gas development activities may have direct and indirect effects on an EFH that could be site-specific or habitat-wide.

In addition to designating EFH, the NMFS requires FMCs to identify habitat areas of particular concern (HAPCs) within FMPs (Figure 3.7.2.1.2-1). These HAPCs are discrete subsets of EFHs that the Councils may designate based on: (1) the importance of the ecological function provided by the habitat; (2) the extent to which the habitat is sensitive to human-induced environmental degradation; (3) whether, and to what extent, development activities are, or will be, stressing the habitat type; or (4) the rarity of the habitat type (GMFMC 2004). While the HAPC designation does not confer additional protection for or restrictions on an area, it can help prioritize conservation efforts.

3.7.4.1 Gulf of Mexico

Various State and Federal agencies are involved in the management of fish resources in the GOM. The GOM Fishery Management Council (GMFMC), which typically prepares FMPs for the GOM, has identified marine and estuarine EFHs within its management area for a variety of fish and invertebrates. These species are listed in Tables 3.7.4-1 and 3.7.4-2 (NMFS 2010a). See Section 3.8.4.1 for a general discussion of fish in the GOM, as well as the potential changes to fish communities resulting from climate change.

Estuarine and coastal EFH includes the following habitats: submerged aquatic vegetation, emergent intertidal wetlands (marshes and mangroves), soft-bottom (mud, sand, or clay), live hard-bottom, oyster reefs, and estuarine water column. See Section 3.7.1.1 for a description of these coastal habitats. Coral reefs, marine water column, marine sediment, live-/hard-bottom, the continental slope, chemosynthetic cold seeps, *Sargassum*, and man-made

TABLE 3.7.4-1 Species for Which Essential Fish Habitat Has Been Designated in the GOM Region by the GOM Fishery Management Council

Reef Fish Fishery
Snappers – Family Lutjanidae
Blackfin snapper (*Lutjanus buccanella*)
Cubera snapper (*Lutjanus cyanopterus*)
Gray snapper (*Lutjanus griseus*)
Lane snapper (*Lutjanus synagris*)
Mutton snapper (*Lutjanus analis*)
Queen snapper (*Etelis oculatus*)
Red snapper (*Lutjanus campechanus*)
Silk snapper (*Lutjanus vivanus*)
Vermillion snapper (*Rhomboplites aurorubens*)
Yellowtail snapper (*Ocyurus chrysurus*)
Wenchman (*Pristipomoides aquilonaris*)

Groupers – Family Serranidae
Black grouper (*Mycteroperca bonaci*)
Gag (*Mycteroperca microlepis*)
Red grouper (*Epinephelus morio*)
Scamp (*Mycteroperca phenax*)
Speckled hind (*Epinephelus drummondhayi*)
Snowy grouper (*Epinephelus niveatus*)
Yellowedge grouper (*Epinephelus favolimbatus*)
Yellowfin grouper (*Mycteroperca enenosa*)
Yellowmouth grouper (*Mycteroperca interstitialis*)

Jacks – Family Carangidae
Greater amberjack (*Seriola dumerili*)
Lesser amberjack (*Seriola fasciata*)
Almaco jack (*Seriola rivoliana*)
Banded rudderfish (*Seriola zonata*)

Triggerfishes – Family Balistidae
Gray triggerfish (*Balistes capriscus*)

Reef Fish Fishery (Cont.)
Tilefishes – Family Malacanthidae
Goldface tilefish (*Caulolatilus crysops*)
Blueline tilefish (*Caulolatilus microps*)
Tilefish (*Lopholatilus chamaeleonticeps*)

Wrasses – Family Labridae
Hogfish (*Lachnolaimus maximus*)

Red Drum Fishery
Red drum (*Sciaenops ocellatus*)

Coastal Migratory Pelagic Fishes
Cobia (*Rachycentron canadum*)
King mackerel (*Scomberomorus cavalla*)
Spanish mackerel (*Scomberomorus maculatus*)

Corals
Class Hydrozoa (stinging and hydrocorals)
Class Anthozoa (sea fans, whips, precious coral, sea pen, stony corals)

Shrimp Fishery
Brown shrimp (*Penaeus aztecus*)
Pink shrimp (*Penaeus duorarum*)
Royal red shrimp (*Hymenopenaeus robustus*)
White shrimp (*Penaeus setiferus*)

Lobster Fishery
Spiny lobsters (*Panulirus* spp.)

Source: NMFS 2010a; 50 CFR Part 622.

TABLE 3.7.4-2 Highly Migratory Species Designated in the GOM Region under Federally Implemented Fishery Management Plans

Coastal Sharks
Atlantic angel shark (*Squatina dumerili*)
Atlantic sharpnose (*Rhizoprionodon terraenovae*)
Basking shark (*Cetorhinus maximus*)
Bigeye sand tiger (*Odontaspis noronhai*)
Blacknose shark (*Carcharhinus acronotus*)
Bignose shark (*Carcharhinus altimus*)
Blacktip shark (*Carcharhinus limbatus*)
Bonnethead (*Sphyrna tiburo*)
Bull shark (*Carcharhinus leucas*)
Caribbean sharpnose shark (*Rhizoprionodon porosus*)
Caribbean reef shark (*Carcharhinus perezi*)
Dusky shark (*Carcharhinus obscurus*)
Finetooth shark (*Carcharhinus isodon*)
Galapagos shark (*Carcharhinus galapagensis*)
Great hammerhead (*Sphyrna mokarran*)
Lemon shark (*Negaprion brevirostris*)
Narrowtooth shark (*Carcharhinus Brachyurus*)
Night shark (*Carcharhinus signatus*)
Nurse shark (*Ginglymostoma cirratum*)
Sandbar shark (*Carcharhinus plumbeus*)
Scalloped hammerhead (*Sphyrna lewini*)
Silky shark (*Carcharhinus falciformis*)
Smooth hammerhead (*Sphyrna zygaena*)
Spinner shark (*Carcharhinus brevipinna*)
Tiger shark (*Galeocerdo cuvieri*)
White shark (*Carcharodon carcharias*)
Sand tiger shark (*Carcharias taurus*)
Whale shark (*Rhinocodon typus*)

Pelagic Sharks
Bigeye sixgill shark (*Hexanchus vitulus*)
Bigeye thresher shark (*Alopias superciliosus*)
Blue shark (*Prionace glauca*)
Common thresher shark (*Alopias vulpinus*)
Longfin mako shark (*Isurus paucus*)
Porbeagle shark (*Lamna nasus*)
Sevengill shark (*Heptranchias perlo*)
Sixgill shark (*Heptranchias griseus*)
Shortfin mako shark (*Isurus oxyrinchus*)
Oceanic whitetip shark (*Carcharhinus longimanu*)

Tuna
Albacore (*Thunnus alalunga*)
Atlantic bigeye (*Thunnus obesus*)
Atlantic bluefin (*Thunnus thynnus*)
Atlantic yellowfin (*Thunnus albacares*)
Skipjack (*Katsuwonus pelamis*)

Swordfish
Swordfish (*Xiphias gladius*)

Billfish
Blue marlin (*Makaira nigricans*)
Sailfish (*Istiophorus platypterus*)
White marlin (*Tetrapturus albidus*)
Longbill spearfish (*Tetrapturus pfluegeri*)

Source: NMFS 2010a.

structures are representative offshore and marine EFH. See Section 3.7.2.1 and Section 3.7.3.1 for descriptions of marine benthic and pelagic habitats in the GOM as well as the potential changes to these habitats resulting from climate change.

Within the Central and Western GOM Planning Areas, several individual reefs and banks located offshore of the Louisiana–Texas border have been designated HAPCs by the GMFMC (NMFS 2010a; Table 3.7.4-3; Figure 3.7.2-1). The HAPCs 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. Most of these HAPCs are important with respect to corals and coral reefs, and provide habitats for reef species such as snappers, groupers, and spiny lobster. In addition, NMFS has designated a HAPC for bluefin tuna located west of 86°W and seaward of

TABLE 3.7.4-3 The HAPCs Designated within the Central, Western, and Eastern GOM Planning Areas

Central and Western Planning Areas	
East Flower Garden Banks	Geyer Bank
West Flower Garden Banks	McGrail Bank
Stetson Bank	Jakkula Bank
29 Fathom Bank	Bouma Bank
MacNeil Bank	Sonnier Bank
Rezak Sidner Bank	Alderdice Bank
Rankin Bright Bank	
Eastern Planning Area	
Florida Middle Grounds	Madison-Swanson Marine Reserve
Tortugas North and South Ecological Reserves	Pulley Ridge

Source: NMFS 2010a.

the 100 m (328 ft) isobath, extending from the 100 m (328 ft) isobath to the Exclusive Economic Zone (EEZ), the limit of U.S. jurisdiction (Atlantic Bluefin Tuna Status Review Team 2011).

3.7.4.1.1 Effects of DWH Event on EFH and Managed Species. The DWH event has the potential to affect coastal and offshore EFH and managed species. Oil released as a result of the DWH event affected more than 1,046 km (650 mi) of the GOM coastal EFH, from the Mississippi River delta to the Florida panhandle (OSAT-2 2011; National Commission 2011b). More than 209 km (130 mi) of coastal habitat were moderately to heavily oiled, primarily in Louisiana (National Commission 2011b). EFH affected by oiling included beaches, coastal marshes, mudflats, mangroves, seagrass beds, and submerged aquatic vegetation (Section 3.7.1.1.5). Coastal EFH can also be affected by prevention and cleanup efforts such as excavation and removal of sand or mud (OSAT-2 2011). Studies of several oiled beaches in Florida, Alabama, Mississippi, and Louisiana indicated that 86–98% of the PAH fractions in the oil remaining in beach sands after cleanup were depleted, although the remaining PAH fractions had the potential to cause toxicological effects (OSAT-2 2011). Loss of marsh habitat along its edge as a result of oiling was observed. Of the over 5,000 water samples taken along the GOM, only 22 exceeded USEPA's aquatic life benchmarks for PAHs and could be attributed to oil from the DWH event. After August, none of the water samples that exceeded USEPA benchmarks contained oil that could be traced to the DWH event (OSAT 2010). A full understanding of the effects of the spill is expected to take a considerable period of time, likely years.

The DWH event affected offshore marine EFH as well. OSAT reported toxic PAH concentrations were present in less than 2% of sediment and water column samples taken from offshore and deepwater areas (OSAT 2010). However, some researchers have reported seeing what appeared to be thick deposits of an unidentified substance on the seafloor as well as dead and dying deepwater corals (BOEMRE 2010b). Follow-up studies indicated that the flocculent contained oil from the DWH event located approximately 11 km (7 mi) to the northeast and almost half of the corals at the site had been impacted by exposure to oil (White et al. 2012). Surveys of 11 other deepwater coral sites in the GOM did not suggest they had been impacted by the DWH event (White et al. 2012).

The DWH event occurred several hundred kilometers from hard-bottom topographic features considered HAPC. There were no reports of oil from the spill reaching the FGBNMS (http://flowergarden.noaa.gov/education/oilspill.html). The FGBNMS is monitored as part of a regular program, and any changes related to the spill should be detected.

The DWH event released oil and methane gas into marine water column EFH, forming both a surface slick and a subsurface plume containing oil mixed with dispersants (Section 3.7.3.1.1; Camilli et al. 2010; Kessler et al. 2011; Kujawinski et al. 2011). The methane plume appeared to be relatively short-lived, with most of the methane being consumed by bacteria within 120 days from the onset of release (Kessler et al. 2011; Hazen and Atlas 2011). Dispersant was detectable at low, nontoxic levels up to 300 km (186 mi) away from the wellhead 64 days after the dispersant application ended (Kujawinski et al. 2011).

There are many ongoing studies, but little data available on impacts to fisheries from the DWH event. The spill has the potential to cause population-level impacts on commercially harvested fish and invertebrate species, particularly species that have already-depressed populations or early life stages that rely heavily on marine and coastal habitats affected by the spill. The Atlantic Bluefin Tuna Status Review Team estimated that the DWH event, under a worst-case scenario, would reduce the 2010 bluefin tuna year class by 20%, which would result in up to a 4% reduction in spawning biomass (Atlantic Bluefin Tuna Status Review Team 2011). The few initial studies suggest that, despite occurring during the spawning period for many GOM fishes, the DWH event did not have an immediate negative impact on fish populations (including juvenile age classes, although there remains the potential for long-term population impacts from sublethal and chronic exposure (Fodrie and Heck 2011). Several years may be required to fully assess the impacts of the DWH event on fish populations, given the time lag between the spill and the eventual recruitment of immature year classes that may have been affected by the spill.

3.7.4.2 Alaska – Cook Inlet

See Section 3.8.4.2 for a general description of fish communities, their life history, and their ecological role in the Cook Inlet Planning Area as well as the potential changes to fish communities resulting from climate change. This section discusses managed species and EFH within Cook Inlet. Cook Inlet falls within the Gulf of Alaska (GOA) Fisheries Management Area of the North Pacific Fishery Management Council (NPFMC). As required under the FCMA, EFH is described for federally managed species in each FMP. The FMPs and the EFHs that occur in waters of Cook Inlet are described below. Regulatory measures to mitigate the effects of fishing on EFH include permanent and temporary closures for certain times or areas; restrictions on vessel sizes and trip limits; restrictions or limitations on gear types; restrictions on the spacing of nets; restrictions on the catch size and number; fishing practices that minimize bottom contact; limitations on boat sizes and speeds; bycatch limits; and license limitations

(NPFMC 2002). Supporting EFH documents can be found in NMFS (2005) and at http://www.fakr.noaa.gov/npfmc/index.html. Additional information concerning the biology, ecology, and behavior of fish species of Cook Inlet can be found in Section 3.8.4.2. The NMFS Alaska Fisheries Science Center also regularly publishes Stock Assessment and Fishery Evaluation Reports that describe stocks and other germane population information for valued fish resources (see http://www.afsc.noaa.gov).

FMPs applicable to Cook Inlet include the GOA Groundfish FMP, the Scallop FMP, and the Salmon FMP. The GOA Groundfish FMP (NPFMC 2010) applies to the U.S. EEZ waters south and east of the Aleutian Islands at longitude 170° W and Dixon Entrance at longitude 132°40' W and includes the western, central, and eastern regulatory areas. The Groundfish FMP covers all stocks of finfish except salmon (*Oncorhynchus* spp.), steelhead (*Oncorhynchus mykiss*), Pacific halibut (*Hippoglossus stenolepis*), Pacific herring, and tuna (*Scombridae*). Tuna are not found in Alaskan waters except during El Nino years. Species groups managed under the GOA Groundfish FMP are listed in Table 3.7.4-4. EFH has not been designated for all life stages of managed species. For example, there is insufficient information to specify EFH for early juvenile stages of all managed species. In addition, no EFH has been designated for any life stage of the following species: sharks, octopus, and forage fish. For species and life stages for which EFH has been designated, EFHs includes, taken together, the entire sediment and water column from lower Cook Inlet to the Gulf of Alaska Shelf (NPFMC 2010). The most diverse species group, the rockfish, is represented by 30 species (NMFS 2005). These fish use one or more aquatic habitats during different stages of their life cycles; the habitats include estuarine; bays; kelp forests; reefs; and nearshore, coastal, continental shelf, oceanic, and bathypelagic waters and/or substrates. Information on species-specific EFHs can be found in NPFMC (2010). The Alaska Seamount Habitat Protection Areas and Gulf of Alaska Coral Protection Areas are designated as HAPCs. No HAPC is designated within Cook Inlet. See individual sections on water quality, coastal habitat, and marine benthic and pelagic habitats in the Cook Inlet Planning Area for a description of these habitat types as well as potential changes to these habitats resulting from climate change.

The scallop FMP covers all Federal waters off the GOA. The fishery occurs in the GOA from the panhandle out to the Aleutian Islands and the Bering Sea. Portions of upper and lower Cook Inlet are closed to scallop fishing to reduce crab bycatch and protect crab habitat from dredging damage (NPFMC 2006). Closed areas are specified in regulations. Under existing State regulations, most areas closed to scallop dredging are also closed to bottom trawling. Scallops are found from intertidal waters to a depth of 300 m (984 ft). Their abundance tends to be greatest between 45 and 130 m (148 and 426 ft) on beds of mud, clay, sand, and gravel (Hennick 1973 cited in NPFMC 2006). Traditional knowledge and sampling data indicate that scallop distributions may contract and expand as the result of a variety of factors, including, but not limited to, temperature changes, current patterns, changes in population size, and changes in predator and prey distribution (NMFS 1998). EFH has been defined only for the late juvenile and adult life stages of weathervane scallops (*Patinopecten caurinus*; NPFMC 2006). The EFH for weathervane scallops was identified on the basis of historical information on their range and includes the lower Cook Inlet (NPFMC 2006). Weathervane scallops occur in discrete beds in areas 60 to 140 m (197 to 459 ft) deep over predominantly clayey silt and sandy bottoms, but

TABLE 3.7.4-4 Managed Species Designated under the Gulf of Alaska Groundfish Fisheries Management Plan and Life Stages for which EFH Has Been Designated

Management Group	Life Stage[a]	Management Group	Life Stage
Walleye pollock (*Theragra chalcogramma*)	E, L, LJ, A	Sculpins (various species)	LJ, A
Pacific cod (*Gadus macrocephalus*)	E, L, LJ, A	Atka mackerel (*Pleurogrammus monopterygius*)	L, A
Sole (*Pleuronectidae* spp., including dover, yellowfin, Alaska paice, rex, and flathead)	E, L, LJ, A	Squid	LJ, A
Northern rock sole (*Lepidopsetta polyxystra*)	L, LJ, A	Skates	A
Arrowtooth flounder (*Atheresthes stomias*)	L, LJ, A	Sharks	I
Sablefish (*Anoplopoma fimbria*)	E, L, LJ, A	Octopus	I
Pacific Ocean perch (*Sebastes alutus*)	L, LJ, A	Forage fish (eulachon, capelin, sand lance, myctophids and bathylagids, sand fish, euphausiids, and pholids and stichaeids).	I
Rockfish (*Sebastes* spp., including shortraker, rougheye, northern, dusky, yelloweye, and thornyhead)	Varies by species		

[a] E = egg; L = larvae; LJ = late juvenile; A = adults; I = insufficient information.

they are also found in areas with gravelly sand and silty sand. No HAPC has been designated within Cook Inlet for scallops.

Salmon fisheries are managed by the State of Alaska rather than the NPFMC. Even though the Council and NMFS are removed from routine management of salmon fisheries in the EEZ, the FMP asserts general NMFS and Council participation in and oversight of salmon management in the EEZ, and it asserts their express and specific authority in the State in the southeast commercial troll fishery and the EEZ sport fishery. At present, Council staff is comprehensively reviewing the Salmon FMP and may repeal or modify the current plan.

The Salmon FMP applies to the EEZ off the coast of Alaska and the salmon fisheries that occur there (NMFS 2005). Most fishing occurs in coastal waters or inlets, bays, and rivers where salmon are migrating, but fishing also occurs in offshore waters. The EFH has also been defined for the six salmon life stages: eggs and larvae, juveniles in freshwater, juveniles in estuaries, juveniles before their first winter in the marine environment, immature and maturing adults in the marine environment, and adults in fresh water. EFH for Pacific salmon includes waters and substrate necessary for spawning, breeding, feeding, or growth to maturity. The locations of many bodies of fresh water that are used by salmon (including several within Cook Inlet and associated tributaries and lakes) are described in documents organized and maintained by the Alaska Department of Fish and Game (ADFG) in the *Catalogue of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes* (http://www.adfg.alaska.gov/sf/SARR/AWC). Additional information on the biology, ecology, and EFH of Pacific salmon can be found at http://www.fakr.noaa.gov/habitat/efh/review/appx5.pdf.

Some fisheries that occur in Cook Inlet and the GOA are managed by authorities other than the NPFMC. Pacific halibut is managed by the International Halibut Commission, and there are a variety of State-managed fisheries for groundfishes, shellfish, salmon, and Pacific herring. The ADFG regularly publishes stock assessment information on State-managed fishes.

3.7.4.3 Alaska – Arctic

See Section 3.8.4.3 for a general description of fish communities, their life histories, and their ecological role in the Beaufort and Chukchi Sea Planning Areas as well as potential changes in Arctic fish communities resulting from climate change. This section discusses managed species and EFH within the Beaufort and Chukchi Sea Planning Areas. There are two fishery management plans that apply to the Chukchi and Beaufort Planning Areas: the FMP for the Arctic Management Area (Arctic FMP; NPFMC 2009) and the FMP for the salmon fisheries in the EEZ off the coast of Alaska (NPFMC and NMFS 1990). The Arctic FMP applies to all marine waters in the U.S. EEZ of the Chukchi and Beaufort Seas from 5.6 km (3.5 mi) (3 NM) offshore the coast of Alaska or its baseline to 370 km (230 mi) (200 NM) offshore, north of the Bering Strait (from Cape Prince of Wales to Cape Dezhneva), westward to the 1990 U.S./Russia maritime boundary line, and eastward to the U.S./Canada maritime boundary (NPFMC 2009). Complete FMPs can be found at http://www.fakr.noaa.gov/npfmc/fmp/fmp.htm.

The Arctic FMP governs commercial fishing for all stocks of finfish and shellfish in Federal waters, except for Pacific salmon and Pacific halibut, which are managed under the salmon FMP and the International Pacific Halibut Commission, respectively (NPFMC and NMFS 1990). The Arctic Management Area is closed to commercial fishing until such time in the future that sufficient information is available with which to initiate a planning process for commercial fishery development (NPFMC 2009). Although species managed under separate FMPs, such as salmon, groundfish, halibut, crabs, and scallops, are present in Arctic waters, their commercial harvest is not permitted in the Beaufort and Chukchi Sea Planning Areas (NPFMC 2009).

Under the Arctic FMP, EFH has been designated for three species (NPFMC 2009):

- *Arctic cod (*Boreogadus saida*).* Insufficient information is available to determine EFH for eggs, larvae, and early juveniles. However, this species has been reported to spawn under ice from during winter (Parker-Stetter et al. 2011). For late juveniles and adults, EFH includes pelagic and epipelagic Arctic waters from 0 to 200 m (0 to 656 ft) and upper slope waters from 200 to 500 m (656 to 1,640 ft).

- *Saffron cod (*Eleginus gracilis*).* Insufficient information is available to determine EFH for eggs, larvae, and early juveniles. For late juveniles and adults, EFH includes coastal pelagic and epipelagic Arctic waters from 0 to 50 m (0 to 164 ft) and wherever there are sand and gravel substrates.

- *Snow crab (*Chionoecetes opilio*).* Insufficient information is available to determine EFH for larvae and early juvenile life stages. EFH for eggs, late juveniles, and adult snow crabs consists of bottom habitats along the inner shelf from 0 to 50 m (0 to 164 ft) and middle shelf from 50 to 100 m (164 to 328 ft) in Arctic waters south of Cape Lisburne, wherever there are substrates consisting mainly of mud.

See individual sections on water quality, coastal habitat, and marine benthic and pelagic habitats in the Beaufort and Chukchi Seas for a description these habitat types as well as potential changes to these habitats resulting from climate change.

The salmon FMP designates EFH for the juvenile or adult marine life stages of chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), pink (*O. gorbuscha*), sockeye (*O. nerka*), and chum (*O. keta*) salmon as being all marine waters of the Chukchi Sea and Arctic Ocean from the mean higher tide line to the 370-km (200-NM) limit of the U.S. EEZ (NMFS 2005). There are no salmon HAPCs designated within the Beaufort Sea or Chukchi Sea Planning Area. No commercial fishing for salmon is allowed in the U.S. EEZ off Alaska except in designated areas, none of which are in the Beaufort or Chukchi Sea Planning Areas. Thus no commercial salmon fishery is present. In addition, all five managed salmon species decrease in abundance north of the Bering Strait (Craig and Haldorson 1986) and from west to east along the coast of the Beaufort and Chukchi Seas. Pink salmon and chum salmon are most common in Arctic waters (Augerot 2005; Stephenson 2005; Moss et al. 2009; Kondzela et al. 2009). Salmon are most abundant west of Point Barrow and appear to be rare in the Beaufort Sea and extremely rare in the eastern Beaufort Sea, although chum salmon are natal to the Mackenzie River and consistently found there in low numbers (Irvine et al. 2009). Chum and pink salmon may be natal to other rivers on the North Slope; that possibility has not been confirmed (Irvine et al. 2009).

3.8 MARINE AND COASTAL FAUNA

3.8.1 Mammals

All marine mammals are protected in U.S. waters under the Marine Mammal Protection Act of 1972 (MMPA; 16 USC 1631 *et seq*.). The MMPA organizes marine mammals into separate stocks for management purposes. By definition, a stock is a group of animals in common spatial arrangement that interbreed (NMFS 2011a). Some species receive additional protection under the Endangered Species Act (ESA; 16 USC 1531 *et seq*.). In the northern GOM and the Alaska OCS regions, the NMFS is the Federal agency responsible for conservation and management of whales, seals, dolphins, and porpoises. The USFWS manages manatees in the

GOM, and in Alaska waters, the USFWS manages sea otters, walruses, and polar bears. The MMPA also created the U.S. Marine Mammal Commission to provide an oversight role for the Federal agencies implementing the MMPA. Marine mammals are among the most important subsistence resources for coastal Alaskan Natives, and a large body of traditional and local knowledge exists about marine mammals (see Section 3.14.3). In recognition of both these factors, many marine mammal stocks are co-managed by the Federal Government (USFWS or NMFS) and Alaskan Native subsistence users under the authority of the MMPA. The take of other mammals (upland or terrestrial) is primarily regulated by the respective State.

3.8.1.1 Gulf of Mexico

3.8.1.1.1 Marine Mammals. The U.S. GOM marine mammal community is diverse and distributed throughout the northern GOM waters (Table 3.8.1-1). Twenty-one species of cetaceans regularly occur in the GOM (Jefferson et al. 2006; Davis et al. 2000) and are identified in the NMFS GOM Stock Assessment Reports (Waring et al. 2010) in addition to one species of Sirenian. The GOM's marine mammals are represented by members of the taxonomic order Cetacea, which is divided into the suborders Mysticeti (i.e., baleen whales) and Odontoceti (i.e., toothed whales), as well as the order Sirenia, which includes the manatee and dugong. Most GOM cetacean species have worldwide distributions; however, exceptions include the Gervais' beaked whale (*Mesoplodon europaeus*), Atlantic spotted dolphin (*Stenella frontalis*), and clymene dolphin (*Stenella clymene*). These species are found only in the Atlantic Ocean and its associated waters.

There are species that have been reported from GOM waters, either by sighting or stranding, that are not considered further in this document. These species include the blue whale (*Balaenoptera musculus*), the North Atlantic right whale (*Eubalaena glacialis*), and the Sowerby's beaked whale (*Mesolplodon bidens*), all considered extralimital in the GOM; along with the humpback whale (*Megaptera novaeangiliae*), the fin whale (*Balaenoptera physalus*), the sei whale (*Balaenoptera borealis*), and the minke whale (*Balaenoptera acutorostrata*), all considered rare occasional migrants in the GOM (Würsig et al. 2000; Mullin and Fulling 2004). Because these species are uncommon in the GOM (and by extension the WPA), they are not included in the most recent NMFS Stock Assessment Reports for the GOM (Waring et al. 2010).

Marine Mammals Listed under the Endangered Species Act. Five baleen whales including the North Atlantic right whale (*Eubalaena glacialis*), blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), sei whale (*Balaenoptera borealis*), and humpback whale (*Megaptera novaeangliae*); one toothed whale, the sperm whale (*Physeter macrocephalus*); and one sirenian, the West Indian manatee (*Trichechus manatus*) occur in the northern GOM; and are all listed as federally endangered under the ESA. The sperm whale is common in oceanic waters of the northern GOM and may be a resident species, while the baleen whales are rare or extralimital in the northern GOM (Würsig et al. 2000). The West Indian manatee typically inhabits only coastal marine, brackish, and freshwater areas.

TABLE 3.8.1-1 Marine Mammals in the GOM[a]

		General Occurrence[b]			Typical Habitat		
Family/Species	Status[c]	Western GOM[d]	Central GOM[e]	Eastern GOM[f]	Coastal	Shelf	Slope/ Deep
Order Cetacea							
Suborder Mysticeti (Baleen whales)							
Family Balaenidae							
North Atlantic right whale (*Eubalaena glacialis*)	E/D	EX	EX	EX	–	X	X
Family Balaenopteridae							
Bryde’s whale (*Balaenoptera edeni*)		O	O	O	–	X	X
Fin whale (*Balaenoptera physalus*)	E/D	EX	EX	EX	–	X	X
Humpback whale (*Megaptera novaeangliae*)	E/D	EX	EX	EX	–	X	X
Minke whale (*Balaenoptera acutorostrata*)		EX	EX	EX	–	X	X
Sei whale (*Balaenoptera borealis*)	E/D	EX	EX	EX	–	X	X
Blue whale (*Balaenoptera musculus*)	E/D	EX	EX	EX	–	X	X
Suborder Odontoceti (Toothed whales and dolphins)							
Delphinidae							
Atlantic spotted dolphin (*Stenella frontalis*)		C	C	C	–	X	X
Bottlenose dolphin (*Tursiops truncatus*)		C	C	C	X	X	X
Clymene’s dolphin (*Stenella clymene*)		C	C	C	–	–	X
False killer whale (*Pseudorca crassidens*)		O	O	O	–	–	X
Fraser’s dolphin (*Lagenodelphis hosei*)		O	O	O	–	–	X
Killer whale (*Orcinus orca*)		O	O	O	–	–	X
Melon-headed whale (*Peponocephala electra*)		UC	UC	O	–	–	X
Pantropical spotted dolphin (*Stenella attenuata*)		C	C	C	–	–	X

TABLE 3.8.1-1 (Cont.)

		General Occurrence[b]			Typical Habitat		
Family/Species	Status[c]	Western GOM[d]	Central GOM[e]	Eastern GOM[f]	Coastal	Shelf	Slope/ Deep
Delphinidae (Cont.)							
Pygmy killer whale (*Feresa attenuata*)		O	O	O	–	–	X
Risso's dolphin (*Grampus griseus*)		UC	UC	UC	–	–	X
Rough-toothed dolphin (*Steno bredanensis*)		UC	UC	UC	–	–	X
Short-finned pilot whale (*Globicephala macrorhynchus*)		UC	UC	O	–	–	X
Spinner dolphin (*Stenella longirostris*)		O	O	O	–	–	X
Striped dolphin (*Stenella coeruleoalba*)		UC	UC	UC	–	–	X
Kogiidae							
Dwarf sperm whale (*Kogia sima*)		O	O	O	–	–	X
Pygmy sperm whale (*Kogia breviceps*)		O	O	O	–	–	X
Physeteridae							
Sperm whale (*Physeter macrocephalus*)	E/D	C	C	C	–	–	X
Ziphidae							
Blainville's beaked whale (*Mesoplodon densirostris*)		O	O	O	–	–	X
Cuvier's beaked whale (*Ziphius cavirostris*)		O	O	O	–	–	X
Gervais' beaked whale (*Mesoplodon europaeus*)		O	O	O	–	–	X
Sowerby's beaked whale (*Mesoplodon bidens*)		EX	EX	EX	–	–	X
Order Sirenia							
Sirenidae							
West Indian manatee, Florida subspecies (*Trichechus manatus latrostris*)	E	O	O	UC	X	–	–

Footnotes on next page.

TABLE 3.8.1-1 (Cont.)

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[a] C = Common — regularly observed throughout the year; EX = Extralimital — known only on the basis of a few records that probably resulted from unusual wanderings of animals into the region; O = Occasional — relatively few observations throughout the year, but some species may be more frequently observed in some locations or during certain times (e.g., during migration); and UC = Uncommon — infrequently observed throughout the year, but some species may be more common in some locations or during certain times of the year (e.g., during migration or when on summer calving grounds or wintering grounds). – = Absent — not recorded from the area; X = Present.

[b] The indicated occurrence does not reflect the distribution and occurrence of individual stocks of marine mammals within localized geographic areas, but rather the broad distribution of the species within the larger categories of OCS waters.

[c] E = Endangered under the Endangered Species Act; D = Depleted under the Marine Mammal Protection Act.

[d] Western GOM includes OCS waters from the Texas-Mexico border to the Texas-Louisiana border.

[e] Central GOM includes OCS waters from the Texas-Louisiana border to the Alabama-Florida border.

[f] Eastern GOM includes OCS waters of the west coast of Florida.

Source: Waring et al. 2010.

Cetaceans: Mysticetes. The occurrences of the North Atlantic right whale in the northern GOM represent distributional anomalies, normal wanderings of occasional animals, or a more extensive historic range beyond the sole known calving and wintering ground in the waters of the southeastern United States (Waring et al. 2010), and are therefore considered extralimital. The North Atlantic right whale inhabits primarily temperate and subpolar waters (Jefferson et al. 2006). It ranges from wintering and calving grounds in coastal waters of the southeastern United States to summer feeding, nursery, and mating grounds in New England waters and northward to the Bay of Fundy, the Scotian Shelf, and the Gulf of St. Lawrence (Waring et al. 2010). In the North Atlantic, it primarily inhabits the area between 20° and 60°N (NMFS 2011a). The North Atlantic right whale forages on or near the surface on copepods and other zooplankton (e.g., krill) (Jefferson et al. 2006). Six major congregation areas identified for the western North Atlantic right whale are the coastal waters of the southeastern United States, Great South Channel, Georges Bank/Gulf of Maine, Cape Cod and Massachusetts Bays, Bay of Fundy, and Scotian Shelf (Waring et al. 2010). The minimum stock size in western North Atlantic, estimated in 2005, is 361 individuals (Waring et al. 2010). The few confirmed records of the North Atlantic right whale in the northern GOM have been in the Northern GOM Slope and the GOM Basin Level II Ecoregions (see Figure 3.2.2-1).[9]

The blue whale is the largest marine mammal. Blue whales are extralimital in the northern GOM (Würsig et al. 2000) with the only records consisting of two strandings, one each on the Louisiana and Texas coasts, with the identifications for both strandings being questionable (Davis and Schmidly 1997). It occurs in all major oceans of the world (Jefferson et al. 2006; Waring et al. 2010). They migrate to feeding grounds in subarctic waters during spring and

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[9] Descriptions of the marine ecoregions in the northern GOM are provided in Section 3.2.3.

summer, after wintering in subtropical and tropical waters (Würsig et al. 2000). Most blue whale sightings in the North Atlantic are from the Gulf of St. Lawrence, where they may be present throughout most of the year (NMFS 2011a). Blue whales tend to occur in the open ocean; however, in some areas they come close to shore to feed and possibly breed (Jefferson et al. 2006). Blue whales tend to occur alone or in pairs, but aggregations of 12 or more may develop in prime feeding grounds (Jefferson et al. 2006). They feed almost exclusively on krill (euphausids) (Pauly et al. 1995; Jefferson et al. 2006; NMFS 2011a). The minimum blue whale population estimate for the western North Atlantic, based on counts made in the Gulf of St. Lawrence, is 440 (Waring et al. 2010).

The fin whale is an oceanic species that occurs worldwide. There are few reliable reports of fin whales in the northern GOM, indicating that fin whales are not abundant there (Jefferson and Schiro 1997) and they are therefore considered extralimital. Most fin whale sightings occur where deep water approaches the coast (Jefferson et al. 2006), and it mostly occurs in temperate to polar waters and less commonly in tropical waters (NMFS 2011a). Fin whales tend to be more common north of 30°N (NMFS 2010b). In the North Atlantic, fin whales occur in groups of two to seven (NMFS 2011a). The fin whale makes seasonal migrations between tropical and subtropical waters (where it mates and calves in winter) and the north-temperate polar feeding grounds that it occupies during the summer months (Jefferson et al. 2006). New England waters are a major feeding ground for fin whales (Waring et al. 2010), where they feed on concentrations of zooplankton (e.g., krill), fishes, and cephalopods (Pauly et al. 1995; Jefferson et al. 2006). The best estimate for the western North Atlantic fin whale stock is 3,985 with a minimum estimate of 3,269 (Waring et al. 2010).

The sei whale is rare in the northern GOM (Würsig et al. 2000), based on records of a single stranding in the Florida Panhandle and three strandings in eastern Louisiana (Jefferson and Schiro 1997) and they are therefore considered extalimital. It is an oceanic species that occurs in tropical to polar waters, being more common in the mid-latitude temperate zones. It seldom occurs close to shore (Jefferson et al. 2006). Groups of two to five individuals are commonly observed, but loose aggregations of 30 to 50 occasionally occur (Jefferson et al. 2006; NMFS 2011a). The sei whale feeds on concentrations of zooplankton (e.g., krill and copepods), fishes, and cephalopods (Pauly et al. 1995). The best estimate for the Nova Scotia sei whale stock is 386 with a minimum estimate of 208 (Waring et al. 2010).

Humpback whales are rare in the northern GOM (Würsig et al. 2000), based on a few confirmed sightings and one stranding event, and are therefore considered extralimital. The humpback whale occurs in all oceans, feeding in higher latitudes during spring, summer, and autumn, and migrating to a winter range over shallow tropical and subtropical banks, where they calve and presumably breed (Jefferson et al. 2006). They normally occur in coastal and shelf waters but frequently travel across deep water during migration (Clapham and Mead 1999). Humpback whales usually occur alone or in groups of two or three, although larger aggregations occur in breeding and feeding areas (Jefferson et al. 2006). Humpback whales feed on concentrations of zooplankton (e.g., krill) and fishes (Pauly et al. 1995; Jefferson et al. 2006). The best estimate of the Gulf of Maine humpback whale stock is 11,570 individuals (NMFS 2011a).

Cetaceans: Odontocetes. The sperm whale occurs worldwide in deep waters from the tropics to the pack-ice edges, although generally only large males venture to the extreme northern and southern portions of the species' range (Jefferson et al. 2006). It is the only great whale considered common in the northern GOM (Mullin et al. 1991; Davis and Fargion 1996; Jefferson and Schiro 1997). Consistent sightings and satellite tracking results indicate that sperm whales occupy the northern GOM throughout the year (Mullin et al. 1991; Davis and Fargion 1996; Jefferson and Schiro 1997; Davis et al. 2000; Jochens et al. 2008), where it is widely distributed in the Northern GOM Slope, Mississippi Fan, and GOM Basin Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). Sperm whales tend to inhabit areas with water depths of 600 m (1,970 ft) or more and are uncommon at depths shallower than 300 m (984 ft) (NMFS 2011a). However, they do come close to shore where submarine canyons or other geophysical features bring deep water near the coast (Jefferson et al. 2006). Aggregations of sperm whales commonly occur in waters over the shelf edge in the vicinity of the Mississippi River Delta in waters that are 500 to 2,000 m (1,641 to 6,562 ft) in depth (Mullin et al. 1991; Davis and Fargion 1996; Davis et al. 2000). Sperm whales often concentrate along the continental slope in or near cyclones and zones of confluence between cyclones and anticyclones (Davis et al. 2000). They commonly occur in medium to large groups of up to fifty individuals (Jefferson et al. 2006). Dive depths observed in the GOM range from 544 to 644 m (1,784 to 2,113 ft) and average 45.5 minutes in length (Watwood et al. 2006). Sperm whales prey on cephalopods, fishes, and benthic invertebrates (Pauly et al. 1995; Jefferson et al. 2006). For management purposes, sperm whales in the GOM are considered a separate stock from those in the Atlantic Ocean (Jochens et al. 2008). The best estimate of the abundance of sperm whales in the northern GOM is 1,665 individuals with a minimum population estimate of 1,409 (Waring et al. 2010).

Sirenians. The West Indian manatee occurs in tropical and subtropical coastal marine, brackish, and fresh waters of the southeastern United States, GOM, Caribbean Sea, and Atlantic coast of northeastern South America (Jefferson et al. 2006). There are two subspecies of the West Indian manatee: the Florida manatee (*T. m. latirostris*), which ranges from the northern GOM to Virginia, and the Antillean manatee (*T. m. manatus*), which ranges from northern Mexico to eastern Brazil, including the islands of the Caribbean Sea (Jefferson et al. 2006). The Florida manatee inhabits marine, estuarine, and freshwater habitats (coastal tidal rivers and streams, mangrove swamps, salt marshes, freshwater springs, and vegetated bottoms). In the northern GOM, most Florida manatee sightings are from the Western Florida Estuarine Area and Eastern Gulf Neritic Level III Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). The Florida manatee makes use of specific areas for foraging (especially shallow grass beds with ready access to deep water), drinking (springs and freshwater runoff sites), resting (secluded canals, creeks, embayments, and lagoons), and for travel corridors (open waterways and channels) (USFWS 2007a). While Florida manatees can occur at depths greater than 4 m (12 ft), most occur in relatively shallow water (Haubold et al. 2006). The West Indian manatee mostly occurs alone or in groups of up to six individuals. However, larger groups may occur, especially in winter at sources of warm water (e.g., power plant outfalls) (Jefferson et al. 2006). The Florida manatee feeds on submerged, floating, and emergent vegetation, and requires freshwater for drinking (USFWS 2012h). In some cases (e.g., at docks), they actively consume invertebrates (Courbis and Worthy 2003).

The Florida manatee is intolerant of cold waters, seeking warm-water sites when temperatures drop below 20°C (68°F). It is unable to tolerate prolonged exposures to temperatures colder than 16°C (61°F) (Haubold et al. 2006). To avoid cold water, the Florida manatee seeks refuge in natural warmwater sites (e.g., springs, deep water areas, and areas thermally influenced by the Gulf Stream) and industrial plant thermal discharges (Laist and Reynolds 2005). Nearly two thirds of Florida manatees winter in industrial plant discharges, most of which are power plants (USFWS 2007a). In winter, the GOM subpopulations move southward to warmer waters. The winter range is restricted to waters at the southern tip of Florida and to waters near localized warm-water sources, such as power plant outfalls and natural springs in west-central Florida. Crystal River in Citrus County is typically the northern limit of the manatee's winter range on the GOM coast. In the spring, they leave warm-water sites and often travel large distances along the GOM and Atlantic coastlines. During warmer months, manatees are common along the GOM coast of Florida from Everglades National Park northward to the Suwannee River in northwestern Florida and less common farther westward, infrequently occurring as far west as Texas (Powell and Rathbun 1984; Rathbun et al. 1990; Davis and Schmidly 1997).

Florida manatees have been divided into four distinct regional management units: the Atlantic Coast Unit that occupies the east coast of Florida, including the Florida Keys and the lower St. Johns River north of Palatka, Florida; the Southwest Unit that occurs from Pasco County, Florida, south to Whitewater Bay in Monroe County, Florida; the Upper St. Johns River Unit that occurs in the river south of Palatka, Florida; and the Northwest Unit that occupies the Florida Panhandle south to Hernando County, Florida (USFWS 2012h). Manatees from the Northwest Unit are more likely to be seen in the northern GOM, and can be found as far west as Texas; however, most sightings are in the eastern GOM. Based on a survey of warm water refuges made in 2009, the best available count of the Florida manatee is 3,802 individuals (Waring et al. 2010). This includes manatees that occur within the GOM and along the Atlantic coast.

Marine Mammals Not Listed under the Endangered Species Act. Twenty-two species of cetaceans, not listed under the ESA, occur in the GOM. The mysticetes (baleen whales) account for two of these species while the other 20 species are odontocetes (toothed whales and dolphins).

Cetaceans: Mysticetes. The Bryde's whale (*Balaenoptera edeni*) occurs in tropical and subtropical waters throughout the world, both offshore and near the coast (Jefferson et al. 2006). Individuals tend to occur alone or in pairs, but may aggregate in groups of 10 to 20 on feeding grounds. The Bryde's whale feeds on fishes, shrimp, pelagic red crabs, and large zooplankton such as krill and copepods (Pauly et al. 1995; Jefferson et al. 2006; NMFS 2011a). Dives last 5 to 15 minutes and can reach a depth of 300 m (1,000 ft) (NMFS 2011a). In the northern GOM, most sightings of Bryde's whales have been made in the DeSoto Canyon region and off western Florida, although some sightings have been made in the west-central portion of the northeastern GOM (i.e., in the Northern GOM Slope Level II Ecoregion south of the Florida Panhandle; see Figure 3.2.2-1) (Waring et al. 2010; Read et al. 2011; Wilkinson et al. 2009). The best estimate of Bryde's whale abundance for the northern GOM is 15 individuals with the minimum population estimate of 5 individuals (Waring et al. 2010).

The minke whale *(Balaenoptera acutorostrata*) occurs worldwide. It prefers temperate to boreal waters, but also occurs in subtropical to tropical waters (NMFS 2011a). Most records from the GOM have come from the Florida Keys, although strandings in western and northern Florida, Louisiana, and Texas have been reported (Jefferson and Schiro 1997) and they are therefore considered extralimital. The minke whale occurs more often in coastal and inshore areas compared to offshore areas (Jefferson et al. 2006). Similar to other baleen whales, minke whales generally occupy the continental shelf rather than the continental shelf edges (Waring et al. 2010). It usually occurs alone or in groups of only two to three whales, although loose aggregations of up to 400 can occur in feeding areas in higher latitudes (NMFS 2011a). The minke whale preys on a variety of large zooplankton (e.g., krill and copepods) and small schooling fishes (Pauly et al. 1995; Jefferson et al. 2006). Minke whales are rare in the GOM with the only confirmed records coming from stranding information (Würsig et al. 2000), and are therefore considered extralimital. The best estimate for the Canadian East Coast population, which includes the minke whales that occur off the eastern coast of the United States to the GOM, is 8,987 individuals. The minimum population estimate is 6,909 (Waring et al. 2010).

Cetaceans: Odontocetes (Family Kogiidae). The pygmy sperm whale (*Kogia breviceps*) has a worldwide distribution in deep waters from temperate to tropical waters. It is especially common over and near the continental slope (Jefferson et al. 2006). The pygmy sperm whale usually occurs alone or in groups up to seven individuals (NMFS 2011a). In some areas, including the GOM, it is among the most frequently stranded small whale species (Jefferson et al. 2006; Waring et al. 2010). Pygmy sperm whales can dive at least 300 m (1,000 ft) (NMFS 2011a). They feed mainly on squid, but will also eat crab, shrimp, and fishes (Pauly et al. 1995; Jefferson et al. 2006). In the GOM, they occur primarily along the continental shelf edge and in deeper waters off the continental shelf (Mullin et al. 1991).

The dwarf sperm whale *(Kogia sima*) has a worldwide distribution in temperate to tropical waters, mostly over the continental shelf and slope (Jefferson et al. 2006; Culik 2010). In the northern GOM, most sightings occur in oceanic waters (Waring et al. 2010). The dwarf sperm whale mostly occurs in groups of less than five individuals, although groups of up to 10 do occur (Jefferson et al. 2006). It is capable of diving to a depth of at least 300 m (1,000 ft) (NMFS 2011a). The dwarf sperm whale feeds on squid, fishes, and crustaceans (Pauly et al. 1995; Jefferson et al. 2006).

At sea, it is difficult to differentiate the pygmy sperm whale from the dwarf sperm whale. Most sightings of these two species have been in the Northern GOM Slope and GOM Basin Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). The best estimate of abundance for dwarf and pygmy sperm whales combined in the northern GOM is 453 individuals with a minimum population estimate of 340 (Waring et al. 2010).

Cetaceans: Odontocetes (Family Ziphiidae). Due to the difficulty of at-sea identification of beaked whales, most observations in the GOM are identified as Cuvier's beaked whales (*Ziphius cavirorostris*), *Mesoplodon* spp., or unidentified *Ziphiidae* (Waring et al. 2010). In the northern GOM, beaked whales are broadly distributed in waters greater than 1,000 m (3,280 ft) in depth over lower slope and abyssal landscapes (Davis et al. 1998, 2000) in the

Northern GOM Slope, Mississippi Fan, and GOM Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009).

The Blainville's beaked whale (*Mesoplodon densirostris*) occurs in warm-temperate to tropical waters worldwide, mostly in offshore deep waters (Jefferson et al. 2006). It is often associated with steep underwater geologic structures such as banks, submarine canyons, seamounts, and continental slopes (NMFS 2011a). The Blainville's beaked whale most commonly occurs singly or in pairs, but groups of up to 7 to 12 individuals are reported (Jefferson et al. 2006; NMFS 2011a). Commonly, dives occur to depths of 500 to 1,000 m (1,600 to 3,300 ft) and last 20 to 45 minutes (NMFS 2011a). Blainville's beaked whales feed on squid and some fishes (Pauly et al. 1995; Jefferson et al. 2006). There have been four documented strandings and two sightings of the Blainville's beaked whale in the northern GOM (Waring et al. 2010).

The Gervais' beaked whale (*Mesoplodon europaeus*) is widely, but sparsely, distributed in temperate to tropical oceanic waters of the central and north Atlantic Ocean (Waring et al. 2010; NMFS 2011a). It usually occurs alone or in small social groups (NMFS 2011a). The species feeds on squid, mysid shrimp, and fish (Pauly et al. 1995; Jefferson et al. 2006; NMFS 2011a). Stranding records suggest that the Gervais' beaked whale is probably one of the most common *Mesoplodon* species in the northern GOM (Jefferson and Schiro 1997).

The best abundance estimate for the Gervais' and Blainville's beaked whales combined in the northern GOM is 57 individuals with a minimum population estimate of 24 (Waring et al. 2010).

The Cuvier's beaked whale (*Ziphius cavirorostris*) occurs worldwide in offshore deep waters, except for polar waters (Jefferson et al. 2006; Waring et al. 2010). It prefers waters of the continental slope and edge and steep underwater geologic features such as banks, seamounts, and submarine canyons where depths are greater than 1,000 m (3,000 ft) (NMFS 2011a). The Cuvier's beaked whale mostly occurs alone or in small groups up to 12 individuals, although groups up to 25 whales have been reported (NMFS 2011a). It can dive to depths of at least 1,000 m (3,000 ft) that last 20 to 40 minutes (NMFS 2011a). Its diet consists of squid, fishes, and crustaceans (Pauly et al. 1995; Jefferson et al. 2006). The Cuvier's beaked whale is probably one of the most common beaked whale species in the northern GOM (Jefferson and Schiro 1997; Davis et al. 1998, 2000). The best estimate of abundance for Cuvier's beaked whale in the northern GOM is 65 individuals with a minimum population estimate of 39 (Waring et al. 2010).

The Sowerby's beaked whale (*Mesoplodon bidens*) generally occurs in cold temperate to subarctic waters of the North Atlantic. It usually occurs alone or in small groups of 3 to 10 individuals. Dives, lasting 10 to 15 minutes, can reach depths of 1,500 m (4,920 ft) (NMFS 2011a). It feeds on squid and small fishes (Pauly et al. 1995; Jefferson et al. 2006). There are no abundance estimates for the Sowerby's beaked whale in the GOM. The Sowerby's beaked whale does not regularly inhabit the GOM (MacLeod et al. 2006). The one stranding report from the GOM represents an extralimital occurrence (Jefferson and Schiro 1997; Waring et al. 2010).

Cetaceans: Odontocetes (Family Delphinidae). The Atlantic spotted dolphin (*Stenella frontalis*) is endemic to the Atlantic Ocean in tropical to temperate waters from about 50°N to 25°S (Culik 2010). It mostly occurs in coastal or continental shelf waters that are 20 to 250 m (65 to 820 ft) deep, but also inhabits continental slope waters up to 2,000 m (6,562 ft) deep (Culik 2010; Jefferson et al. 2006; NMFS 2011a). The Atlantic spotted dolphin may seasonally enter shallow water in pursuit of migratory prey (Perrin 2002). In the northern GOM, the Atlantic spotted dolphin is usually observed from the continental shelf waters 10 to 200 m (33 to 656 ft) deep to slope waters less than 500 m (<1,640 ft) deep throughout the Northern GOM Shelf and the more shoreward portions of the Northern GOM Slope Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). The Atlantic spotted dolphin generally occurs in groups smaller than 50 individuals, with coastal groups usually consisting of 5 to 15 individuals (Jefferson et al. 2006); however, groups as large as 200 do occur (NMFS 2011a). They sometimes associate with other cetaceans such as bottlenose dolphins (*Tursiops truncatus*) (NMFS 2011a). Atlantic spotted dolphins usually dive about 10 m (30 ft) but can reach depths up to 60 m (200 ft) (NMFS 2011a). They feed on fishes and cephalopods (Pauly et al. 1995; Jefferson et al. 2006). Current population size for the Atlantic spotted dolphin in the northern GOM is unknown because survey data is more than 8 yr old. Estimated abundance, based on outer continental shelf observations made from fall 2000 and 2001 surveys, is 37,611 individuals (Waring et al. 2010).

The bottlenose dolphin inhabits tropical and temperate waters worldwide primarily between 45°N to 45°S (NMFS 2011a). For management purposes, in the northern GOM, bottlenose dolphins are divided into six stock groups: (1) western coastal stock (Mississippi River Delta to the Texas-Mexico border); (2) northern coastal stock (Mississippi River Delta to 84°W); (3) eastern coastal stock (84°W to Key West); (4) continental shelf stock; (5) oceanic stock; and (6) 32 bay, sound, and estuarine stocks (Waring et al. 2010). The seaward boundary for the three bottlenose dolphin coastal stocks is the 20-m (66-ft) isobath, which ranges 4 to 90 km (2.5 to 56 mi) from shore (Waring et al. 2010). The northern GOM continental shelf stock occurs in waters from 20 to 200 m (66 to 656 ft) deep, while the oceanic stock inhabits waters greater than 200 m (656 ft) deep (Waring et al. 2010). The continental shelf stock; coastal stocks; and bay, sound, and estuarine stocks occur throughout the Northern GOM Shelf Level II Ecoregion, while the oceanic stock occurs primarily within the Northern GOM Slope Level II Ecoregion (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009).

Bottlenose dolphins usually occur in groups of less than 20 individuals, but offshore herds of several hundred individuals occur. It commonly associates with other cetaceans (Jefferson et al. 2006). Bottlenose dolphins are opportunistic feeders, taking a wide variety of fishes, cephalopods, and shrimp (Pauly et al. 1995; Jefferson et al. 2006). Coastal bottlenose dolphins consume benthic invertebrates and fish, while offshore individuals feed on pelagic fish and squid (NMFS 2011a).

The population sizes for the continental shelf stock; the western coastal stock; and most of the bay, sound, and estuarine stocks have been not been estimated in over 8 yr. Therefore, their current population estimates are unknown (Waring et al. 2010). The best current estimate of abundance for the eastern coastal stock is 7,702 with a minimum population estimate of

6,551 bottlenose dolphins, while the best current estimate of abundance for the northern coastal stock is 2,437 with a minimum population estimate of 2,004. The best current estimate of abundance for the oceanic stock is 3,708 individuals with a minimum population estimate of 2,641 dolphins (Waring et al. 2010).

The Clymene dolphin (*Stenella clymen*e) is endemic to tropical and sub-tropical waters of the Atlantic Ocean including the Caribbean Sea and GOM. It is a deepwater oceanic species not often observed near shore (Jefferson et al. 2006), generally occurring in waters 250 to 5,000 m (820 to 16,400 ft) deep (NMFS 2011a). There is an atypical report of a Clymene dolphin off southern Texas waters with a bottom depth of 44 m (144 ft) (Fertl et al. 2003). In the northern GOM, most Clymene dolphin sightings are in the Northern GOM Slope, Mississippi Fan, and GOM Basin Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). Herds, often segregated by age and sex, are normally less than 200 individuals and are often less than 50 individuals. Clymene dolphins occur with other dolphin species (Jefferson et al. 2006; Jefferson and Curry 2003). They occur in the GOM throughout the year (Jefferson et al. 1995; Jefferson and Curry 2003). The Clymene dolphin is an active bowrider and will approach ships from many miles away (Jefferson and Curry 2003). It feeds on fishes and cephalopods (Pauly et al. 1995; Jefferson et al. 2006). The best estimate for the abundance of the Clymene dolphin in the northern GOM is 6,575 individuals with a minimum population estimate of 4,901 (Waring et al. 2010).

The false killer whale (*Pseudorca crassidens*) occurs worldwide in tropical and temperate oceanic waters (generally between 50°N and 50°S) that are deeper than 1,000 m (3,300 ft) (Culik 2010; Jefferson et al. 2006; NMFS 2011a). However, inshore movements occasionally occur that are associated with either food resources or shoreward flooding of warm oceanic currents (Stacey et al. 1994). In the GOM, most sightings occur in the Northern GOM Slope, Mississippi Fan, and GOM Basin Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). The false killer whale normally occurs in groups of 10 to 60, but groups of up to 300 or more do occur (Culik 2010). The false killer whale is one of the most common cetacean species involved in mass strandings; one observed mass stranding near Mar del Plata, Argentina, included 835 individuals (Baird 2009b). It associates with at least 10 other species of cetaceans, especially the bottlenose dolphin (Stacey et al. 1994). False killer whales primarily eat fish and cephalopods, but they will attack small cetaceans (Pauly et al. 1995; Jefferson et al. 2006). To increase their potential to find prey, a group may travel in a broad band several kilometers wide (NMFS 2011a). The best estimate for the abundance of the false killer whale in the northern GOM is 777 individuals with a minimum population estimate of 501 (Waring et al. 2010).

The Fraser’s dolphin (*Lagenodelphis hosei*) has a worldwide distribution in tropical to warm temperate waters between 30°N and 30°S (NMFS 2011a). It normally occurs in oceanic waters deeper than 1,000 m (3,300 ft) but will occur near shore where deep water approaches the coast (Jefferson et al. 2006; NMFS 2011a). Fraser’s dolphins are often associated with areas of upwelling (NMFS 2011a). In the GOM, they occur in deeper waters off the continental shelf (Waring et al. 2010), mostly in the Northern GOM Slope and at the boundary between the Northern GOM Slope and the GOM Basin Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). Some Fraser’s dolphins inhabit the northern GOM throughout the year (Waring et al. 2010). The Fraser's dolphin usually occurs in herds of 10 to 100 individuals, but occasionally occurs in herds consisting of hundreds to thousands of individuals (Jefferson et al. 2006; NMFS 2011a). It often occurs with other cetaceans, particularly the melon-headed whale (*Peponocephala electra*) (Jefferson et al. 2006). Fraser's dolphins can dive to nearly 600 m (2,000 ft) (NMFS 2011a), where they feed on fishes, cephalopods, and crustaceans (Pauly et al. 1995; Jefferson et al. 2006). Based on observations made from 1996 to 2001, 726 Fraser's dolphins occurred in the northern GOM.

The killer whale (*Orcinus orca*) has a worldwide distribution from tropical to polar waters. They are more common in nearshore cold temperate to subpolar waters (Jefferson et al. 2006). In the GOM, killer whales occur primarily in the deeper oceanic waters off the continental shelf at depths ranging from 256 to 2,652 m (840 to 8,700 ft) (Davis and Fargion 1996; Waring et al. 2010). Sightings in the northern GOM occur from the Northern GOM, Mississippi Fan, and GOM Basin Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). Killer whale pods contain 1 to 55 individuals with resident pods tending to be larger than transient pods (Jefferson et al. 2006). Killer whales are top-level predators that feed on marine mammals, marine birds, sea turtles, fishes, and cephalopods (Pauly et al. 1995; Jefferson et al. 2006). The best estimate of the abundance of killer whales in the northern GOM is 49 individuals with a minimum population estimate of 28 (Waring et al. 2010).

The melon-headed whale has a worldwide distribution in subtropical to tropical oceanic waters (Jefferson et al. 2006). In the GOM, sightings of melon-headed whales are mostly in the Northern GOM Slope Level II Ecoregion, with some sightings in the GOM Basin Level II Ecoregion (see Figure 3.2.2-1) (Mullin et al. 1994; Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). The melon-headed whale occurs in most areas of its range throughout the year (Jefferson and Barros 1997). Worldwide, it usually occurs in pods of 100 to 500 individuals with a known maximum of 2,000 individuals (Jefferson et al. 2006). Average herd size in the GOM is 130 to 310 individuals (Jefferson and Barros 1997). The melon-headed whale has strong social bonds, evidenced by mass strandings including up to several hundred individuals observed for mass strandings in Brazil and Australia (Jefferson and Barros 1997). Strandings of individual melon-headed whales have occurred in the GOM (Waring et al. 2010). In the GOM, melon-headed whales often occur with other species such as Fraser's dolphin or the rough-toothed dolphin (*Steno bredanensis*) (Jefferson and Barros 1997; Jefferson et al. 2006). Melon-headed whales will occasionally ride the bow waves of passing ships (Jefferson and Barros 1997). They feed on cephalopods, fishes, and some crustaceans (Pauly et al. 1995; Jefferson et al. 2006; NMFS 2011a). The best estimate of the abundance of the melon-headed whale in the northern GOM is 2,283 individuals with a minimum population estimate of 1,293 (Waring et al. 2010).

The pantropical spotted dolphin (*Stenella attenuata*) occurs in tropical to warm temperate oceanic waters worldwide roughly from 40°N to 40°S (Culik 2010). In the GOM, sightings of the pantropical spotted dolphin occur in the Northern GOM Slope, Mississippi Fan, and the GOM Basin Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). During the day, they typically occur in waters between 90 and 300 m (300 and 1,000 ft) deep and will dive into deeper waters at night in search of prey

(NMFS 2011a). The pantropical spotted dolphin is the most common cetacean in the oceanic northern GOM (Mullin et al. 1991). School sizes may range from several to thousands of individuals (Perrin 2001). It often schools with other dolphins such as spinner dolphins (*Stenella longirostris*) (NMFS 2011a). The pantropical spotted dolphin primarily feeds on epipelagic fishes and cephalopods (Pauly et al. 1995; Jefferson et al. 2006). The best estimate of the abundance of the pantropical spotted dolphin in the northern GOM is 34,067 individuals with a minimum population estimate of 29,311 (Waring et al. 2010).

The pygmy killer whale (*Feresa attenuata*) occurs worldwide in deeper tropical and subtropical waters, generally between 40°N and 35°S (Jefferson et al. 2006; Culik 2010). Generally, the pygmy killer whale occurs in groups of 50 individuals or less, although some herds of several hundred occur (Jefferson et al. 2006). Its diet includes cephalopods and fishes, though reports of feeding on other dolphins are reported (Pauly et al. 1995; Jefferson et al. 2006). In the northern GOM, the pygmy killer whale occurs primarily in deeper oceanic waters off the continental shelf (Waring et al. 2010). It inhabits the Northern GOM Slope, Mississippi Fan, and GOM Basin Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). The best estimate of the abundance of the pygmy killer whale in the northern GOM is 323 individuals and the minimum population estimate is 203 (Waring et al. 2010).

The Risso's dolphin (*Grampus griseus*) occurs worldwide in tropical to temperate waters, generally between 60°N and 60°S, where it inhabits deep oceanic waters (e.g., depths greater than 1,000 m [3,300 ft]) seaward of the continental shelf and slopes) (Culik 2010; Jefferson et al. 2006; NMFS 2011a). In the northern GOM, they are widely distributed throughout the Northern GOM Slope, Mississippi Fan, and GOM Basin Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). Their core area of occurrence is between the 350- and 975-m (1,150- and 3,200-ft) isobaths with seafloor slopes greater than 22 m/km (116 ft/mi) (Baumgartner 1997). Groups of 4,000 can occur, but herds tend to average 10 to 30 in number (Jefferson et al. 2006; NMFS 2011a). Risso's dolphins associate with other cetaceans and hybridization with bottlenose dolphins is recorded (Jefferson et al. 2006). It can dive to at least 300 m (1,000 ft) and remain underwater for up to 30 minutes (NMFS 2011a). The Risso's dolphin feeds primarily on squid and secondarily on fishes and crustaceans (Pauly et al. 1995; Jefferson et al. 2006). The best estimate of the abundance of the Risso's dolphin in the northern GOM is 1,589 individuals with a minimum population estimate of 1,271 (Waring et al. 2010).

The rough-toothed dolphin occurs in tropical to warm-temperate oceanic and continental shelf waters worldwide (Jefferson et al. 2006; Waring et al. 2010). In the northern GOM, sightings are scattered throughout most Level II ecoregions, with most sightings in the Northern GOM Slope (see Figure 3.2.2-1) (Mullin and Fulling 2004; Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). It most commonly occurs in groups of 10 to 20, but herds of more than 100 do occur (Jefferson et al. 2006; NMFS 2011a). The rough-toothed dolphin often associates with other dolphins including the short-finned pilot whale (*Globicephala macrorhynchus*), bottlenose dolphin, pantropical spotted dolphin, and spinner dolphin (NMFS 2011a). It feeds on benthic invertebrates, cephalopods, and fishes (Pauly et al. 1995; Jefferson et al. 2006). The abundance of the rough-toothed dolphin in the northern GOM, based on a combined abundance estimate for the oceanic and OCS portions of the GOM based on surveys conducted between 2000 and 2004, was 2,653 (Waring et al. 2010).

The short-finned pilot whale occurs worldwide in tropical to temperate waters, generally in deep offshore areas (Jefferson et al. 2006). In the GOM, most sightings occur in the Northern GOM Slope with a few sightings in the Mississippi Fan and GOM Basin Level II Ecoregions (see Figure 3.2.2-1) (Waring et al. 2010; Wilkinson et al. 2009). Pods often consist of 25 to 50 animals; however, a pod can consist of up to several hundred individuals (Jefferson et al. 2006; NMFS 2011a). While swimming or looking for food, a pod may spread out over 1 km (0.6 mi) (NMFS 2011a). The short-finned pilot whale feeds at depths of 305 m (1,000 ft) or more (NMFS 2011a) predominately on squid, with fishes being consumed occasionally (Pauly et al. 1995; Jefferson et al. 2006). It is among the cetacean species that most frequently mass-strand (Jefferson et al. 2006). The best estimate of the abundance of the short-finned pilot whale in the northern GOM is 716 individuals with a minimum population estimate of 542 (Waring et al. 2010).

The spinner dolphin occurs worldwide in tropical, subtropical, and some warm-temperate waters normally in deep oceanic waters between 40°N and 40°S (Culik 2010; NMFS 2011a). In the northern GOM, most sightings are within the Northern GOM Slope Level II Ecoregion (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). Herd size ranges from under 50 to several thousand (Jefferson et al. 2006), and the spinner dolphin often schools with other dolphins, such as the pantropical spotted dolphin (Perrin 1998). It feeds on mesopelagic fishes, squid, and shrimp (Culik 2010; Pauly et al. 1995; Jefferson et al. 2006). The best estimate of the abundance of the spinner dolphin in the northern GOM is 1,989 individuals with a minimum population estimate of 1,356 (Waring et al. 2010).

The striped dolphin (*Stenella coeruleoalba*) occurs in tropical to temperate waters. In the northern GOM, sightings occur in oceanic waters (Waring et al. 2010). Its presence is often associated with areas of upwelling and convergence zones (NMFS 2011a). The striped dolphin only occurs close to shore in areas where deep water approaches the coast (Jefferson et al. 2006). In the northern GOM, sightings are mostly in the Northern GOM Slope, Mississippi Fan, and GOM Basin Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). Mass strandings of the striped dolphin are rare because of its offshore distribution (Archer and Perrin 1999). Individual strandings in the GOM are reported (Waring et al. 2010). School size throughout its range generally ranges from about 25 to 100 individuals, although schools of hundreds to thousands of individuals do occur (NMFS 2011a). The striped dolphin can dive to depths of 700 m (2,300 ft) or more (NMFS 2011a). They feed primarily on small, mid-water squid and fishes, especially lanternfish (Pauly et al. 1995; Jefferson et al. 2006). The best estimate of the abundance of the striped dolphin in the northern GOM is 3,325 individuals with a minimum population estimate of 2,266 (Waring et al. 2010).

Factors Influencing Marine Mammal Distribution and Abundance. Various mesoscale oceanographic circulation patterns strongly influence the distribution and abundance of cetaceans within the northern GOM. These patterns are primarily driven by river discharge (primarily the Mississippi/Atchafalaya Rivers), wind stress, and the Loop Current and its derived circulation phenomena. Circulation on the continental shelf is largely wind-driven, with localized effects from freshwater (i.e., river) discharge, while mesoscale circulation beyond the shelf is largely driven by the Loop Current in the eastern GOM. Approximately once or twice a year, the Loop Current sheds anticyclonic eddies (also called warm-core rings). Anticyclones are long-lived, dynamic features that generally migrate westward and transport large quantities of high-salinity, nutrient-poor water across the near-surface waters of the northern GOM. These anticyclones, in turn, spawn cyclonic eddies (also called cold-core rings) during interaction with one another and upon contact with topographic features of the continental slope and shelf edge. These cyclones contain and maintain high concentrations of nutrients and stimulate localized production (Davis et al. 2000).

In the north-central GOM, the relatively narrow continental shelf south of the Mississippi River Delta may be an additional factor affecting cetacean distribution (Davis et al. 2000). Outflow from the Mississippi River mouth transports large volumes of low salinity, nutrient-rich water southward across the continental shelf and over the slope. River outflow also may be entrained within the confluence of a cyclone-anticyclone eddy pair and be transported beyond the continental slope. In either case, this nutrient-rich input of water leads to a localized deepwater environment with enhanced productivity, and may explain the persistent presence of aggregations of sperm whales within 50 km (31 mi) of the Mississippi River Delta in the vicinity of the Mississippi Canyon. Other marine predators, such as the bottlenose dolphin, also focus their foraging efforts on these abundant prey locations to improve overall efficiency and reduce energy costs (Bailey and Thompson 2010).

Climate Change. Marine mammal populations throughout the GOM may be affected by climate change and to a lesser extent by hurricane events. As previously discussed (Section 4.8.1.1), 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 marine mammal habitats and the abundance of marine mammal forage or prey resources. The construction of sea walls or other structures to protect coastal habitats against rising sea levels could potentially impact coastal marine species and possibly interfere with the movement of species such as the West Indian manatee (Learmonth et al. 2006). It is not possible at this time to identify the likelihood, direction, or magnitude of climate change on the marine mammals of the GOM. However, the current state of climate change and its impacts on marine mammals would need to be considered in any subsequent environmental reviews for lease sales or other OCS-related activities.

Unusual Mortality Event for Cetaceans in the Gulf of Mexico. On December 13, 2010, NMFS declared an unusual mortality event (UME) for cetaceans (whales and dolphins) in the GOM. A UME is defined under the MMPA as a "stranding that is unexpected, involves a significant die-off of any marine mammal population, and demands immediate response." Evidence of the UME was first noted by NMFS as early as February 2010. As of April 1, 2012, a total of 714 cetaceans (5% stranded alive and 95% stranded dead) have stranded since the start of the UME (NMFS 2012a). The vast majority of these strandings involve premature, stillborn, or neonatal bottlenose dolphins between Franklin County, Florida, and the Louisiana/Texas border (NMFS 2011f). Table 3.8.1-2 provides information on the cetacean strandings during

TABLE 3.8.1-2 Unusual Mortality Event Cetacean Data for the Northern Gulf of Mexico

Cetaceans Stranded	Phase of Deepwater Horizon Oil-Spill Response	Dates
114 cetaceans stranded	Prior to the response phase for the oil spill	February 1, 2010–April 29, 2010
122 cetaceans stranded or were reported dead offshore	During the initial response phase to the oil spill	April 30, 2010–November 2, 2010
478 cetaceans stranded[a]	After the initial response phase ended	November 3, 2010–April 1, 2012[b]

[a] This number includes 6 dolphins that were killed incidental to fish-related scientific data collection and 1 dolphin killed incidental to trawl relocation for a dredging project.

[b] The initial response phase ended for all four States on November 2, 2010. Response re-opened for eastern and central Louisiana on December 3, 2010 and closed again on May 25, 2011.

Source: NMFS 2012a.

pre-response, initial-response, and post-response phases for the DWH event. The 714 animals include 6 dolphins killed during a fish-related scientific study and 1 dolphin killed incidental to a dredging operation (NMFS 2012a).

It is unclear at this time whether the increase in strandings is related partially, wholly, or not at all to the DWH event (NMFS 2011f). The NMFS has also documented an additional 15 UMEs since 1991 that have been previously declared in the GOM; 11 of these involved cetaceans and the other 4 UMEs involved manatees (NMFS 2011g). However, the current data in Table 3.8.1-2 also shows a marked increase in strandings during the DWH event response and afterward. NMFS (2011f) considers the investigation into the cause of the UME and the potential role of the DWH event to be “ongoing and no definitive cause has yet been identified for the increase in cetacean strandings in the northern Gulf in 2010 and 2011.” It is therefore unclear whether increases in stranded cetaceans during and after the DWH event response period are or are not related to impacts from the DWH event; this will likely remain unclear until NMFS completes its UME and NRDA evaluation processes. However, investigations are ongoing to determine what role *Brucella* (a genus of bacteria) may be having on the UME. The adverse effects of *Brucella* include abortion, meningoencephalitis (brain infection), pneumonia, skin infection (e.g., blubber abscesses), and bone infection (NMFS 2012a). All marine mammals collected either alive or dead were found east of the Louisiana/Texas border through Franklin County, Florida. The highest concentration of strandings has occurred off eastern Louisiana, Mississippi, Alabama, and the panhandle of Florida, with a lesser number off western Louisiana (NMFS 2012a).

Deepwater Horizon Event. The DWH event in Mississippi Canyon Block 252 and the resulting oil spill and related spill-response activities (including use of dispersants) have affected marine mammals that have come into contact with oil and remediation efforts. Within the designated DWH spill area, 171 marine mammals (89% of which were deceased) were reported. This includes 155 bottlenose dolphins, 2 *Kogia* spp., 2 melon-headed whales, 6 spinner dolphins, 2 sperm whales, and 4 unknown species (NMFS 2011h). There have not been any manatees reported within the areas affected by the DWH event. All marine mammals collected either alive or dead were found east of the Louisiana/Texas border through Apalachicola, Florida. The highest concentration of strandings occurred off eastern Louisiana, Mississippi, and Alabama with a significantly lesser number off western Louisiana and western Florida (NMFS 2012a). Due to known low detection rates of carcasses (e.g., on average only 2% of cetacean deaths), it is possible that the number of deaths of marine mammals is underestimated (Williams et al. 2011). It is also important to note that evaluations have not yet confirmed the cause of death, and it is possible that many, some, or no carcasses were related to the DWH oil spill (NMFS 2011f).

3.8.1.1.2 Terrestrial Mammals Listed under the Endangered Species Act. This section focuses on federally endangered terrestrial mammals likely to be present in coastal habitats of the northern GOM, although numerous terrestrial mammal species not listed under the ESA may be present in coastal habitats at any given time. Four federally endangered GOM coast "beach mice" subspecies occupy restricted habitats within mature coastal dune habitats of northwestern Florida and Alabama: (1) the Alabama beach mouse (*Peromyscus polionotus ammobates*), (2) Choctawhatchee beach mouse (*Peromyscus polionotus allophrys*), (3) Perdido Key beach mouse (*Peromyscus polionotus trissyllepsis*), and (4) St. Andrew beach mouse (*Peromyscus polionotus peninsularis*). They are recognized subspecies of the old-field mouse (*Peromyscus polionotus*) (Bowen 1968; USFWS 1987). Additionally, the federally endangered Florida salt marsh vole (*Microtus pennsylvanicus dukecampbelli*), a subspecies of the meadow vole (*Microtus pennsylvanicus*), occurs in limited salt marsh areas in the Big Bend area of Florida (NatureServe 2010a). Figure 3.8.1-1 shows the GOM coast distributions of the four beach mouse subspecies and the Florida salt marsh vole.

Beach mouse habitat is restricted to mature coastal barrier sand dunes. The primary and secondary (frontal) dunes are generally characterized by thick growths of sea oats (*Uniola paniculata*) and other species such as blue stem (*Schizachyrium scoparium*), beach grass (*Panicum amarum*), and beach goldenrod (*Chrysoma pauciflosculosa*) (USFWS 2006a). The scrub dunes provide refugia for beach mice during and after tropical storm events (USFWS 2007b). The scrub dunes tend to be dominated by large patches of scrub live oak (*Quercus geminata*) with gopher apple (*Licania michauxii*) and green briar (*Smilax* spp.) ground cover (USFWS 2006a). The inland extent of the scrub dune habitat ends where the maritime forest begins (USFWS 2006a). Beach mice dig burrows mainly on the lee side of the primary dunes and in other secondary and interior dunes where the vegetation provides suitable cover. The beach mice may also use ghost crab (*Ocypoda quadratus*) burrows. The dynamic hurricane-dune regeneration cycle maintains the dune habitat structure preferred by beach mice (Bird et al. 2009).

Beach mice typically feed nocturnally in the dunes and remain in burrows during the day. Their diets vary seasonally but consist mainly of seeds, fruits, and insects (Bird et al. 2009).

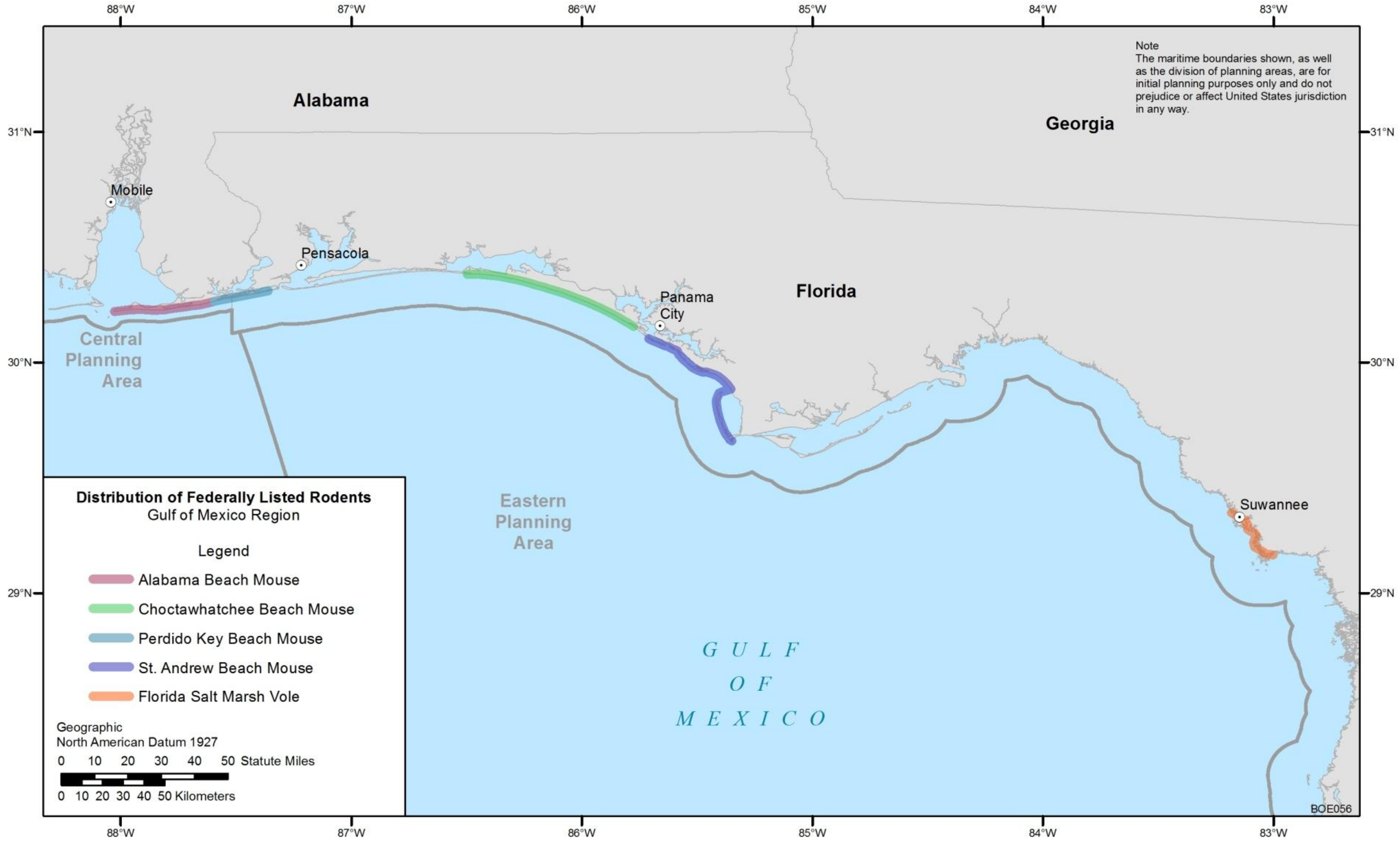

FIGURE 3.8.1-1 Coastal Distribution of the Endangered Beach Mouse Subspecies and the Florida Salt Marsh Vole in the GOM

Most foraging occurs in the sand dunes. Beach mice inhabit a single home range during their lifetime that averages about 5,000 m^2 (53,820 ft^2). Individual home ranges normally overlap. An individual may have 20 or more burrows within its home range (Bird et al. 2009). Beach mice use the highly vegetated areas of swales when moving between the primary and secondary dunes (Bird et al. 2009). The densities of beach mice are cyclic and can have large fluctuations on a seasonal and annual basis resulting from changes in reproductive rates, food availability, habitat quality and quantity, catastrophic events, disease, and predation (USFWS 2007b). Beach mice breed year-round with up to 13 generations per year. Peak breeding occurs in fall and winter, declines in spring, and occurs at low levels in summer. Average life span is about 9 months (USFWS 2007b).

The endangered status of beach mouse subspecies results from the loss and degradation of coastal dune habitats due to coastal development and natural processes. The combination of habitat loss and fragmentation resulting from beachfront development, the subsequent isolation of remaining habitat fragments and beach mouse populations, and destruction of these remaining habitats by hurricanes has increased the threat of extinction of the beach mouse subspecies (USFWS 1987; Oli et al. 2001).

The following provides additional information on the four beach mouse subspecies and the Florida salt marsh vole.

The Alabama beach mouse is known or believed to occur in Baldwin County, Alabama (USFWS 2012c). It occurs in Alabama within disjunctive private coastline holdings and a coastal strand habitat in the Bon Secour National Wildlife Refuge (Baldwin County). It appears to be the dominant small mammal in the dune and scrub habitats on the Fort Morgan Peninsula. Surveys and habitat analyses (Swilling et al. 1998; USFWS 2007b) provide overwhelming evidence that beach mice also forage and burrow in areas beyond the frontal dunes, including the escarpment and interior scrub. The Alabama beach mouse originally occurred along 53.9 km (33.5 mi) of coastline in Baldwin County, Alabama. As of May 2008, the Alabama beach mouse occurred within 991 ha (2,450 ac) of primary, secondary, and tertiary dunes and interior scrub habitat along an estimated 21 km (13 mi) of Alabama coastline (USFWS 2009a) (Figure 3.8.1-1). The revised critical habitat for the Alabama beach mouse encompasses about 490 ha (1,211 ac) of coastal dune and scrub habitat in Baldwin County, Alabama (USFWS 2007b). The critical habitat includes five units: (1) Fort Morgan — 180 ha (446 ac); (2) Little Point Clear — 108 ha (268 ac); (3) Gulf Highland — 111 ha (275 ac); (4) Pine Beach — 12 ha (30 ac); and (5) Gulf State Park — 78 ha (192 ac). The USFWS (2007b) describes and provides maps for these critical habitat units.

The Choctawhatchee beach mouse is known or believed to occur in Bay, Okaloosa, and Walton Counties, Florida (USFWS 2012d). It was once present along the coastal dunes between Choctawhatchee Bay and St. Andrew Bay, Florida. Since Hurricane Ivan, trapping sessions have indicated healthy populations at Topsail Hill Preserve State Park. The viability of populations elsewhere appear to be in decline and/or are at very low densities (USFWS 2007b). Habitat for the Choctawhatchee beach mouse is primary, secondary, and occasionally tertiary sand dunes with a moderate cover of grasses and forbs (FNAI 2001). About 1,010 ha (2,500 ac) of Choctawhatchee beach mouse habitat exists (USFWS 2007b). The revised critical habitat for the

Choctawhatchee beach mouse encompasses about 973 ha (2,404 ac) of coastal dune and scrub habitat in Okaloosa, Walton, and Bay Counties, Florida (USFWS 2006a). The critical habitat includes five units: (1) Henderson Beach — 39 ha (96 ac); (2) Topsail Hill — 125 ha (309 ac); (3) Grayton Beach — 73 ha (179 ac); (4) Deer Lake — 20 ha (49 ac); and (5) West Crooked Island/Shell Island — 716 ha (1,771 ac). The USFWS (2006a) provides maps for and describes these critical habitat units.

The Perdido Key beach mouse is known or believed to occur in Baldwin County, Alabama, and Escambia County, Florida (USFWS 2012e). Historically, the Perdido Key beach mouse occurred in coastal dune habitat between Perdido Bay, Alabama, and Pensacola Bay, Florida (Bowen 1968). The effects of Hurricane Frederic (in 1979) combined with increased habitat fragmentation due to human development led to the extirpation of all but one population of Perdido Key beach mouse. The remaining population at Gulf State Park (at the westernmost end of Perdido Key) contained 30 individuals. Some of the individuals from this site were used to reestablish the subspecies at Gulf Islands National Seashore (GINS) during 1986–1988 (Holler et al. 1989). In 2000, five pairs were relocated from the GINS-Perdido Key area to Perdido Key State Park. In February of 2001, this relocation was supplemented with an additional 16 pairs that were released on both north and south sides of Highway 292 in suitable habitat. After 2 yr of quarterly survey trapping, indications were that the relocations to Perdido Key State Park successfully established a population at that location. Individuals were also trapped on private lands between GINS and Perdido Key State Park in 2004, increasing documentation of current occurrences of the Perdido Key beach mouse. Currently, the Perdido Key beach mouse exists on lands in areas along 13.5 km (8.4 mi) of coastline from Perdido Key at GINS to Perdido Key State Park (Figure 3.8.1-1). The revised critical habitat for the Perdido Key beach mouse encompasses about 525 ha (1,300 ac) of coastal dune and scrub habitat in Baldwin and Escambia Counties, Florida (USFWS 2006a). The critical habitat includes five units: (1) Gulf State Park — 96 ha (238 ac); (2) West Perdido Key — 59 ha (147 ac); (3) Perdido Key State Park — 111 ha (275 ac); (4) Gulf Beach — 66 ha (162 ac); and (5) Gulf Islands National Seashore — 258 ha (638 ac). The USFWS (2006a) describes and provides maps for these critical habitat units.

The St. Andrew beach mouse is known or believed to occur in Bay and Gulf Counties, Florida (USFWS 2012f). It is the easternmost of the four GOM coastal subspecies (Figure 3.8.1-1) and currently consists of two disjunctive populations: East Crooked Island in Bay County, Florida, and St. Joseph Peninsula in Gulf County, Florida (USFWS 2010a). The current population at East Crooked Island is a result of translocations of beach mice from St. Joseph State Park to Crooked Island (1997–1998). The St. Andrew beach mouse also occurs on private lands to the west of Mexico Beach, Florida (USFWS 2009b). Population estimates reported in 2008 were 3,000 mice at East Crooked Island and 1,775 mice in the front dunes at St. Joseph State Park (USFWS 2009b). Optimal habitat is an undisturbed, intact, and functioning system of unconsolidated marine substrate, beach sand, primary natural sand dunes, and secondary and scrub dunes (USFWS 2009b). Of the estimated 83.3 km (51.8 mi) of current suitable habitat within the historic range of the St. Andrew beach mouse, the beach mouse occupies 44.5 km (27.7 mi) (USFWS 2010a). The critical habitat for the St. Andrew beach mouse encompasses about 1,008 ha (2,490 ac) of coastal dune and scrub habitat in Bay and Gulf Counties, Florida (USFWS 2006a). The critical habitat includes three units: (1) East Crooked

Island — 335 ha (826 ac); (2) Palm Point — 65 ha (162 ac); and (3) St. Joseph Peninsula — 608 ha (1,502 ac). The USFWS (2006a) describes and provides maps for these critical habitat units.

The Florida salt marsh vole is known or believed to occur in Levy County, Florida (USFWS 2012g). Originally the only known occurrence of the Florida salt marsh vole was Waccasassa Bay in Levy County, Florida, where it existed in low numbers. In 2004, several individuals were discovered on the Lower Suwannee National Wildlife Refuge located in southeastern Dixie/northwestern Levy Counties, Florida (Raabe and Gauron 2005). The two locations are only about 8 km (5 mi) apart (USFWS 2008a), resulting in the currently known approximate range shown in Figure 3.8.1-1. The Florida salt marsh vole appears to be most common in areas vegetated by saltgrass (*Distichlis spicata*). Its salt marsh habitat is vulnerable to flooding by hurricanes and extremely high tides (NatureServe 2010a). It probably survives high tides and storm flooding by swimming and climbing vegetation. Due to the very restricted range of the Florida salt marsh vole, catastrophic events could result in its extinction (NatureServe 2010a). Due to its rarity, life history and reproductive behavior of the subspecies are not well studied. However, some aspects are assumed to be similar to the meadow vole — feeding on a variety of plant matter, high reproductive rates with breeding throughout the year, and a lifespan of about 6 months (USFWS 1997). Critical habitat is not designated for the Florida salt marsh vole, primarily because publishing critical habitat maps could increase the chance of illegal collecting or attracting trespass on the lands where it occurs (USFWS 1991a).

Climate Change. GOM coastal habitats will be affected by climate change. Factors associated with climate change that can effect beach mice and the Florida salt marsh vole include alteration in stream flow and river discharges, wetland loss, sea level rise, changes in storm frequency and strength, sediment yield, mass movement frequencies and coastal erosion, and subsidence. The small tidal range of the GOM coast increases the vulnerability of coastal habitats to the effects of climate change. Rising sea levels and changes in the frequency, intensity, timing, and distribution of tropical storms and hurricanes are expected to have substantial impacts on coastal wetland and shoreline patterns and processes (Michener et al. 1997; Scavia et al. 2002). Increases in sea level rise and storm frequency and severity may increase inundation and erosion of beach mice and Florida salt marsh vole habitats. The construction of sea walls or other protective measures to protect coastal habitats from increasing sea levels could potentially impact alternative sites suitable for these species.

Deepwater Horizon Event. The DWH event in Mississippi Canyon Block 252 and the resulting oil spill and related spill-response activities (including use of dispersants) had the potential to affect the federally endangered terrestrial mammals and their habitats present in the coastal habitats of the northern GOM. OSAT-2 (2011) prepared a summary report on the fate and effects of residual oil from the DWH event in the beach environment. PAHs associated with the residual oil have the potential to impact terrestrial mammals (OSAT-2 2011). The report focused on four case study beach areas, one of which (Bonn Secour, Alabama) coincided with habitat for the Alabama beach mouse. Bon Secour generally received more oiling than the average of surrounding beaches (or the beaches where other endangered beach mice occur) and served as an example of a worst-case scenario (OSAT-2 2011). At Bon Secour, submerged oil mats consisted of 10.7% oil and 89.3% sand, small surface residue balls consisted of 7.4% oil and 92.6% sand, and supratidal buried oil consisted of 6.5% oil and 93.5% sand. Only 3% of trenches dug as part of the shoreline cleanup assessment were considered to have moderate-to-heavy oiling in the supratidal buried oil (OSAT-2 2011).

Only manual removal of oil was permitted in the Bon Secour National Wildlife Refuge (OSAT-2 2011). However, complete avoidance of beach mouse habitat is not always feasible when an oil response emergency occurs, and some beach mouse habitat has been damaged as a result of response activities to the DWH event (e.g., from sand removal, alteration, or compaction and by vegetation disturbance or destruction) (Frater 2011). Key findings by OSAT-2 (2011) of relative importance to beach mice are (1) in most locations, PAH concentrations in supratidal buried oil will decrease to 20% of current levels within 5 years, but there are isolated conditions where PAH concentrations are predicted to persist substantially longer; and (2) wildlife resources would likely experience a greater threat from further cleanup activities than from the oil that still remains on the beaches. OSAT-2 (2011) concluded that the inherent oil toxicity to beach mice was considered medium but the likelihood that beach mice would be exposed to supratidal buried oil, submerged oil mat, or small surface residue balls was low. Overall, impacts on beach mice would be possible (lowest impact-level determination in the report). Estimated daily doses of PAHs calculated for the Alabama beach mouse (the subspecies mostly likely to be exposed to oil at the highest concentrations) were below toxicity reference values, suggesting a low risk from incidental exposure to oil. It was also concluded that beach mice would likely avoid burrowing in areas with high levels of residual oil (OSAT-2 2011). Further cleanup would result in a low impact for submerged oil mats, a medium impact for small surface residue ball cleanup, and a high impact (most severe impact-level determination) for supratidal buried oil. Impacts could occur from additional alteration or damage to habitat from cleanup activities and from increased human traffic (OSAT-2 2011).

The long-term consequences of the DWH event are still being determined. It is uncertain how much oil impacted GOM beaches, how much continues to impact the beaches, how the physical and chemical characteristics of the oil are changing with time, and the magnitude and duration of future redepositional events. Long-term studies will be needed to determine if future changes in the beach ecosystem will be benign or serious (Hayworth et al. 2011). Ecological impact studies and restoration efforts related to the DWH event are ongoing. On April 18, 2012, the Deepwater Horizon Natural Resource Damage Assessment (NRDA) Trustees Council announced that they finalized the “Deepwater Horizon Phase I Early Restoration Plan & Environmental Assessment” that addresses eight restoration projects that will be implemented to restore ecological resources (Deepwater Horizon Natural Resource Trustees 2012). These include coastal dune habitat improvements that could benefit one or more of the endangered beach mouse species.

3.8.1.2 Alaska – Cook Inlet

3.8.1.2.1 Marine Mammals. The following information describes the life history attributes, distributions, and seasonal movements of 17 marine mammal species that occur in Cook Inlet (Cook Inlet Level III Coastal Ecoregion) or nearby waters of the Gulf of Alaska (Gulf of Alaska Level III Coastal Ecoregion) that could be affected by activities related to lease sales in Cook Inlet (Table 3.8.1-3).[10] (The Level III Ecoregions are described in Section 3.2.4 and are shown in Figure 3.2.2-2.) Nine of these species are threatened or endangered under the ESA.

Marine Mammals Listed under the Endangered Species Act.

Cetaceans: Mysticetes. In Alaska, the endangered blue whale (*Balaenoptera musculus*) primarily occurs south of the Aleutian Islands and the Bering Sea (Berzin and Rovnin 1966; NMFS 2011a). It also occurs north of 50°N extending from southeastern Kodiak Island across the Gulf of Alaska and from southeast Alaska to Vancouver Island (Berzin and Rovnin 1966). Individuals from the eastern North Pacific and western North Pacific blue whale stocks can occur in the Gulf of Alaska during spring and summer after wintering in subtropical and tropical waters (Carretta et al. 2011). The eastern North Pacific blue whale stock occurs in the eastern North Pacific, ranging from the northern Gulf of Alaska to the eastern tropical Pacific. Most winter in the highly productive waters of Baja California, Gulf of California, and on the Costa Rica Dome (Carretta et al. 2011). Blue whales from the central North Pacific stock feed in summer southwest of Kamchatka, south of the Aleutian Islands, and in the Gulf of Alaska. This stock winters in lower latitudes in the western Pacific and less frequently in central Pacific including offshore waters north of Hawaii (Carretta et al. 2011). While the blue whale occurs in south central Alaska, it is not expected to occur within Cook Inlet. Blue whales tend to occur alone or in pairs, but aggregations of 12 or more may develop in prime feeding grounds (Jefferson et al. 2006). Blue whales feed year-round (Carretta et al. 2011). They feed almost exclusively on krill (euphausids) (Pauly et al. 1995; Jefferson et al. 2006; NMFS 2011a). Mating and calving occur in the late fall and winter (Zimmerman and Rehberg 2008). The best estimate of the abundance of the eastern North Pacific blue whale stock is 2,497 with a minimum abundance of 2,046; no abundance estimates are available for the central North Pacific blue whale stock (Carretta et al. 2011).

The endangered fin whale (*Balaenoptera physalus*) ranges worldwide from subtropical to Arctic waters, and most sightings occur where deep water approaches the coast (Jefferson et al. 2006). Most fin whales migrate seasonally from relatively low-latitude wintering habitats where breeding and calving occur to high-latitude summer feeding areas (Perry et al. 1999). Northward migration begins in spring with migrating whales entering the Gulf of Alaska from early April through June (MMS 1996b). Their summer distribution extends from central California into the Bering and Chukchi Seas, while their winter range is restricted to the waters off the coast of California. Some fin whales feed in the Gulf of Alaska, including near the entrance to Cook Inlet (NMFS 2003). During the months of July and August, fin whales concentrate in the Bering Sea-eastern Aleutian Island area. In September to October, most fin whales are in the Bering Sea, Gulf of Alaska, and along the U.S. coast as far south as Baja, California (Mizroch et al. 1984; Brueggman et al. 1984). The fin whale feeds on concentrations of zooplankton (e.g., krill), fishes, and cephalopods (Pauly et al. 1995; Jefferson et al. 2006). A provisional estimate for the fin whale population west of the Kenai Peninsula is 5,700 animals (Allen and Angliss 2011).

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[10] A solitary Pacific walrus inhabited the Cook Inlet from the 1980s until its death in 2001 (Little 2001); however, as the occurrence of the Pacific walrus in the Cook Inlet is atypical, the species is not addressed in this section.

TABLE 3.8.1-3 Cook Inlet Marine Mammals

Species	Status[a]
ORDER CETACEA	
Suborder Mysticeti (baleen whales)	
Eubalaena japonica (North Pacific right whale)	E/D
Balaenoptera acutorostrata (minke whale)	–
Balaenoptera borealis (sei whale)	E/D
Balaenoptera musculus (blue whale)	E/D
Balaenoptera physalus (fin whale)	E/D
Eschrichtius robustus (gray whale)	DL/D
Megaptera novaeangliae (humpback whale)	E/D
Suborder Odontoceti (toothed whales and dolphins)	
Physeter macrocephalus (sperm whale)	E/D
Delphinapterus leucas (beluga whale)	E/D
Orcinus orca (killer whale)	D
Lagenorhychus obliquidens (Pacific white-sided dolphin)	–
Ziphius cavirostris (Cuvier’s beaked whale)	–
Phocoenoides dalli (Dall’s porpoise)	–
Phocoena phocoena (harbor porpoise)	–
ORDER CARNIVORA	
Suborder Pinnipedia (seals, sea lions, and walrus)	
Eumetopias jubatus (Steller sea lion)	E/D, T/D[b]
Phoca vitulina richardsi (harbor seal)	–
Suborder Fissipedia (sea otters)	
Enhydra lutris (sea otter)	T

[a] Status: E = endangered under the ESA; T = threatened under the ESA; C = candidate for listing under the ESA; DL = delisted under the ESA; D = depleted under the MMPA (for the killer whale, it only applies to the AT1 group of eastern North Pacific transient killer whales); – = not listed.

[b] The western U.S. stock of Steller sea lion encompasses the range of the Western District Population Segment of the Steller sea lion, which is listed as endangered under the ESA, and the eastern U.S. stock encompasses the range of the Eastern District Population Segment, which is listed as threatened under the ESA.

The endangered humpback whale (*Megaptera novaeanglia*) occurs worldwide in all ocean basins, feeding in higher latitudes during spring, summer, and autumn, and migrating to a winter range over shallow tropical and subtropical banks, where they calve and presumably breed (Jefferson et al. 2006). Members of the Western North Pacific and Central North Pacific stocks occur in Alaskan waters. They migrate from winter breeding grounds near Japan, Hawaii, or Mexico to summer feeding grounds from Washington to as far north as the Chukchi Sea (Zimmerman and Karpovich 2008). In the Gulf of Alaska, areas with concentrations of humpback whales include the Portlock and Albatross Banks and west to the eastern Aleutian Islands, Prince William Sound, and the inland waters of southeastern Alaska (Berzin and

Rovnin 1966). Humpback whales have also been routinely observed in lower Cook Inlet (Rugh et al. 2005, 2007). The Kodiak Island area supports a feeding aggregation of humpback whales (Waite et al. 1999). Current data demonstrate that the Bering Sea remains an important feeding area. Humpback whales usually occur alone or in groups of two or three, although larger aggregations occur in breeding and feeding areas (Jefferson et al. 2006). Humpback whales feed on concentrations of zooplankton (e.g., krill) and fishes using a variety of techniques that concentrate prey for easier feeding (Pauly et al. 1995; Jefferson et al. 2006). Feeding rarely occurs while migrating or during winter while in tropical waters (Zimmerman and Karpovich 2008). The best population estimate for the Western North Pacific stock is 938 whales with a minimum population estimate of 732 individuals; the best population estimate for the Central North Pacific stock is 7,469 whales with a minimum population estimate of 5,833 individuals (Allen and Angliss 2011).

The endangered North Pacific right whale (*Eubalaena japonica*) historically ranged across the entire North Pacific north of 35°N and occasionally as far south as 20°N before commercial whaling reduced their numbers. Today, distribution and migratory patterns of the North Pacific stock are largely unknown. The whales in the North Pacific population summer in their high-latitude calanoid copepod and euphausid crustacean feeding grounds, and migrate to more temperate, possibly offshore, waters during the winter (Braham and Rice 1984; Scarff 1986; Allen and Angliss 2011). North Atlantic and Southern Hemisphere right whales calve in coastal waters during the winter, but locations of calving grounds in the eastern North Pacific are not known (Scarff 1986). Right whales remain in the southeastern Bering Sea from May through December (Allen and Angliss 2011).

There is evidence of North Pacific right whale occurrence in the Gulf of Alaska and Bering Sea (Wade et al. 2011). Recent sightings have been concentrated in the western outer Bristol Bay area, midway on a line between Unimak Island and Kuskokwim Bay, and this area may be an important feeding area for the few remaining North Pacific right whales (Shelden et al. 2005). More recent sightings of North Pacific right whales in the eastern Bering Sea during the summer are the first reliable observations in decades (Moore et al. 2000b; Tynan et al. 2001; Wade et al. 2011). These sightings include the first few calves documented in the eastern North Pacific in over a century (LeDuc et al. 2001; Brownell et al. 2001; Wade et al. 2011). These sightings suggest that the abundance in the eastern North Pacific is possibly in the tens of animals. North Pacific right whales remain the most highly endangered marine mammal in the world. Little is known regarding the migratory behavior, life history characteristics, and habitat requirements of this species. The basic life history parameters and census data (including population abundance, growth rate, age structure, breeding ages, gender ratios, and distribution) remain undetermined. Given that the population is extremely small and little current information is available, recovery is not anticipated in the foreseeable future (e.g., several decades or longer).

Based on available evidence, the NMFS revised the species' critical habitat on July 6, 2006 (71 FR 38277) to include one area in the Gulf of Alaska and one in the Bering Sea. For more information on North Pacific right whales, see NMFS (2006), which reported the largest number of eastern North Pacific right whales identified in the Bering Sea to be 23 individuals. The minimum estimate of abundance is 17 individuals (Allen and Angliss 2011).

The endangered sei whale (*Balaenoptera borealis*) is an oceanic species that occurs in tropical to polar waters, being more common in the mid-latitude temperate zones. It seldom occurs close to shore (Jefferson et al. 2006). They inhabit deepwater areas of the open ocean, most commonly over the continental slope (Carretta et al. 2011; Reeves et al. 1998). Sei whales migrate to lower latitudes for breeding and calving in the winter and to higher latitudes in summer for feeding, including the Gulf of Alaska and along the Aleutian Islands and the southern Bering Sea (Reeves et al. 1998). Sei whales begin their southward migration in August or September. Groups of 2 to 5 individuals are commonly observed, but loose aggregations of 30 to 50 occasionally do occur (Jefferson et al. 2006; NMFS 2011a). Sei whales feed on concentrations of zooplankton (e.g., krill and copepods), fishes, and cephalopods (Pauly et al. 1995). Sei whales observed in Alaska are members of either the Eastern North Pacific stock and/or the Hawaiian stock. The abundance of the Eastern North Pacific stock is estimated at 126 individuals with a minimum estimate of 83 whales; while abundance estimates for the Hawaiian stock are 77 with a minimum abundance of 37 (Caretta et al. 2011).

Cetaceans: Odontocetes. The NMFS recognizes five stocks of beluga whales (*Delphinapterus leucas*) in U.S. waters: (1) Cook Inlet, (2) Bristol Bay, (3) eastern Bering Sea, (4) eastern Chukchi Sea, and (5) Beaufort Sea (Allen and Angliss 2011). There are no physical barriers among these stocks, but genetic data indicates that the stocks do not interbreed (Citta and Lowry 2008). Most of the Cook Inlet stock was listed as an endangered distinct population segment (DPS) under the ESA in 2008 (NMFS 2008a). The beluga whales that inhabit Yakutat Bay (fewer than 20 individuals) are included as part of the Cook Inlet stock but are not considered part of the Cook Inlet DPS (Allen and Angliss 2011).

The beluga whale occurs throughout seasonally ice-covered Arctic and subarctic waters of the Northern Hemisphere (Stewart and Stewart 1989) and is closely associated with open leads and polynyas in ice-covered regions (Allen and Angliss 2011). Depending on season and region, beluga whales may occur in both offshore and coastal waters. Ice cover, tidal conditions, access to prey, temperature, and human interaction affect seasonal distribution (Allen and Angliss 2011). During the winter, beluga whales generally occur in offshore waters associated with ice packs, and in the spring, many migrate to warmer coastal estuaries, bays, and rivers for molting and calving (Sergeant and Brodie 1969). Breeding occurs in March or April, with calves born the following May through July, usually when herds are at or near summer concentration areas (Citta and Lowry 2008). Beluga whales shed their skin (molt) yearly in July in shallow water, often where there is coarse gravel to rub against (Citta and Lowry 2008).

The Cook Inlet DPS occurs near river mouths in the northern Cook Inlet during the spring and summer months and in mid-Inlet waters in the winter; evidence indicates that the stock remains in Cook Inlet throughout the year (Allen and Angliss 2011; NMFS 2008a). Based on surveys conducted in the Gulf of Alaska between 1936 and 2000, a few belugas occur in the Gulf of Alaska outside of Cook Inlet. Those belugas are considered part of the Cook Inlet stock (Laidre et al. 2000).

The NMFS (2011b) designated 7,800 km^2 (3,013 mi^2) of critical habitat for the Cook Inlet DPS of beluga whales on April 11, 2011 (Figure 3.8.1-2). Critical Habitat Area 1 and Critical Habitat Area 2 are respectively equivalent to the Type 1 and 2 habitats identified in the

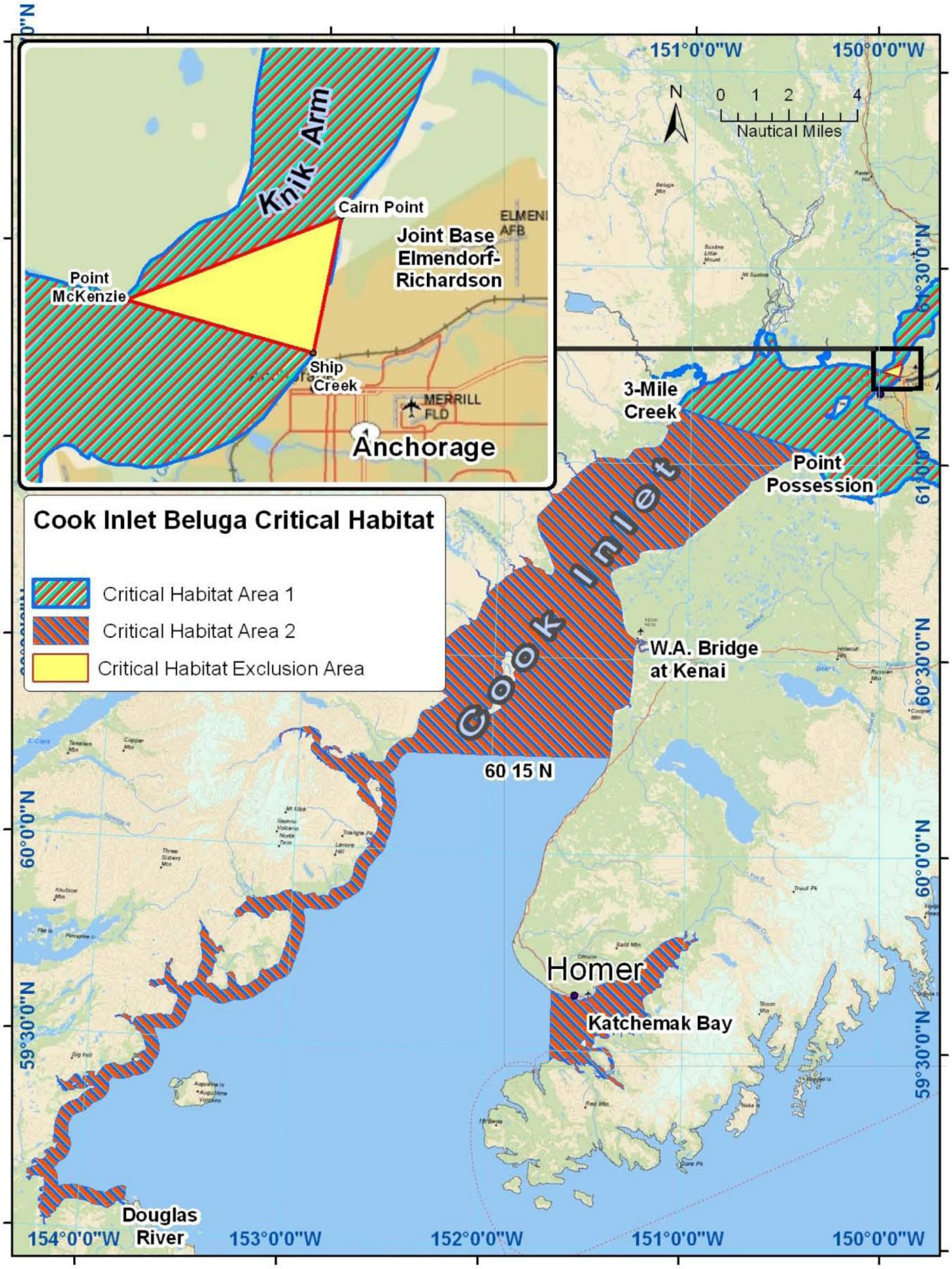

FIGURE 3.8.1-2 Critical Habitat for the Cook Inlet Beluga Whale DPS

conservation plan for the Cook Inlet beluga whale (NMFS 2008b). Critical Habitat Area 1, encompassing1,909 km^2 (738 mi^2), occurs in the upper portion of Cook Inlet that contains a number of shallow tidal flats, river mouths, and estuarine areas that are important for foraging, calving, molting, and escaping predators. This area, considered the most valuable habitat type for Cook Inlet belugas, contains the highest concentrations of belugas from spring through fall (NMFS 2008b, 2011b). Critical Habitat Area 2, encompassing 5,891 km^2 (2,275 mi^2), is used less during spring and fall, but is known to be used in fall and winter. Dispersed fall and winter feeding and transit areas occur in this critical habitat area, which includes near and offshore areas of the mid- and upper Inlet and nearshore areas of the lower Inlet (Figure 3.8.1-2). The deeper dives made by Cook Inlet beluga whales in this area of critical habitat suggest that the area is an important fall and winter feeding area that may be important to the winter survival and recovery of Cook Inlet beluga whales (NMFS 2008b, 2011b).

Two fish species especially fed upon by Cook Inlet beluga whales are king (Chinook) salmon and Pacific eulachon. Other items prominent in their diet are Pacific salmon, cod, walleye pollock, yellowfin sole, and other fishes and invertebrates (NMFS 2011b). In spring, the belugas feed on eulachon, gadids (cod and pollock), anadromous steelhead trout, and freshwater fishes. During summer, belugas prey on the Pacific salmon species that spawn in the rivers throughout Cook Inlet. In the fall, they feed on the various fish species that occur in nearshore bays and estuaries. Stomach samples for Cook Inlet belugas during winter are not available, but the belugas probably prey on deeper water prey such as flatfish, sculpin, and pollock (NMFS 2008b).

During 1978 to 1979, 95% of the Cook Inlet beluga whale range occupied 7,226 km^2 (2,790 mi^2) of Cook Inlet (Rugh et al. 2010). The Cook Inlet beluga whale stock (which includes the Cook Inlet DPS) was estimated at 1,300 animals in 1979 (NMFS 2008a). By 1994, the stock numbered 653 whales and declined to 347 whales by 1998. Subsistence hunting and interactions with fishing gear appear to be the major factors leading to abundance declines (Laidre et al. 2000). The Cook Inlet stock has continued to decline by 1.45% per year from 1999 to 2008 (Allen and Angliss 2011). Between 1998 and 2008, 95% of the beluga whale range in Cook Inlet was 2,806 km^2 (1,083 mi^2). Most areas occupied are in the upper portions of Cook Inlet (Rugh et al. 2010). The current best population estimate for the Cook Inlet DPS is 284 as of June 2011 (Hobbs et al. 2011). A healthy population level for the Cook Inlet beluga whale stock should be at least 780 individuals (NMFS 2008b).

The endangered sperm whale (*Physeter macrocephalus*) occurs worldwide in deep waters from the tropics to the pack-ice edges, although generally only large males venture to the extreme northern and southern portions of the species' range (Jefferson et al. 2006). Sperm whales tend to inhabit areas with water depths of 600 m (1,970 ft) or more and are uncommon at depths shallower than 300 m (984 ft) (NMFS 2011a). However, they do come close to shore where submarine canyons or other geophysical features bring deep water near the coast (Jefferson et al. 2006). In Alaska, their northernmost boundary extends from Cape Navarin (62°N) to the Pribilof Islands, with whales more commonly found in the Gulf of Alaska and along the Aleutian Islands. The shallow continental shelf may prevent their movement into the northeastern Bering Sea and Arctic Ocean (Allen and Angliss 2011). Females and young sperm whales usually remain in tropical and temperate waters year-round, while males move north to feed in the Gulf of Alaska, Bering Sea, and waters around the Aleutian Islands (Gosho et al. 1984; Allen and Angliss 2011). Seasonal movement of sperm whales in the North Pacific is not well-defined, but they typically occur south of 40°N during the winter (Gosho et al. 1984). Males move north in the spring and summer to feed in the Gulf of Alaska, Bering Sea, and waters around the Aleutian Islands (Berzin and Rovnin 1966). Fall migrations begin in September and most whales have left Alaskan waters by December (MMS 1996b), returning to temperate and tropical portions of their range, typically south of 40°N, in the fall (Gosho et al. 1984; Allen and Angliss 2011). Breeding occurs during the spring and early summer (April through August). Sperm whales are present year-round in the Gulf of Alaska, but are apparently more abundant in summer than in winter (Allen and Angliss 2011). Sperm whales commonly occur in medium to large groups of up to 50 individuals (Jefferson et al. 2006). Sperm whales prey on cephalopods, fishes, and benthic invertebrates (Pauly et al. 1995; Jefferson et al. 2006). The number of sperm whales occurring in Alaska waters is unknown. More than 100,000 sperm whales were estimated to occur in the western North Pacific in the late 1990s (Allen and Angliss 2011).

Pinnipeds. The Steller sea lion (*Eumetopias jubatus*) in Alaska is comprised of an eastern U.S. stock, which includes animals east of Cape Suckling, Alaska (144°W), and a western U.S. stock, including animals at and west of Cape Suckling (Allen and Angliss 2011). The eastern stock encompasses the range of the Eastern Distinct Population Segment of the Steller sea lion that is listed as threatened under the ESA, while the western stock encompasses the range of the Western Distinct Population Segment that is listed as endangered under the ESA (NOAA 2011a). The centers of abundance and distribution of the Steller sea lion are located in the Gulf of Alaska and the Aleutian Islands. Individuals from only the western stock inhabit areas of south central Alaska could be affected by oil and gas activities in the Cook Inlet Planning Area. The Steller sea lion is not known to migrate, but individuals disperse widely outside of the breeding season (late May to early July). At sea, Steller sea lions commonly occur near the 200-m (660-ft) depth contour, but individuals occur from nearshore to well beyond the continental shelf. Some individuals may enter rivers in pursuit of prey (NMFS 2008c). Steller sea lions eat a variety of fishes and cephalopods and occasionally birds and seals (Zimmerman and Rehberg 2008). Older juveniles can dive to depths of 500 m (1,500 ft) and can stay underwater for more than 16 minutes (Zimmerman and Rehberg 2008). However, dive depths of juveniles generally do not exceed 20 m (66 ft), while adults will dive to depths greater than 250 m (820 ft) (NMFS 1993).

Thirty-eight Steller sea lion rookeries and hundreds of haulouts occur within the range of the western stock of the Steller sea lion (Allen and Angliss 2011; NMFS 2008c). The locations of the rookeries and haulouts change little from year to year (NMFS 1993). Major rookeries in and near Cook Inlet include Outer Island, Sugarloaf Island, Marmot Island, Chirikof Island, and Chowiet Island. There are several major haulouts in and near 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. Breeding and pupping occur on rookeries; rookeries normally occur on relatively remote islands, rocks, reefs, and beaches, where access by terrestrial predators is limited. Rookeries are normally occupied from late May through early July (NMFS 1993). Haulouts are areas used for rest and refuge by all sea lions during the non-breeding season and by non-breeding adults and subadults during the breeding season. Some rookeries are used as haulouts after the breeding season is over. In addition to rocks, reefs, and beaches normally used as haulouts, sea lions may also use sea ice and man-made structures such as breakwaters, navigational aids, and floating docks (NMFS 1993). Sea lion critical habitat includes a 32 nautical km (20 nautical mi) buffer around all major haulouts and rookeries, as well as associated terrestrial, air, and aquatic zones. Special foraging areas in Alaska have also been designated critical habitat for Steller sea lions including the Shelikof Strait area of the Gulf of Alaska, the Bogoslof area in the Bering Sea shelf, and the Seguam Pass area in the central Aleutian Islands (NMFS 1993). Figure 3.8.1-3 shows the Steller sea lion critical habitat in the area of Cook Inlet Planning Area. The minimum population estimate for the Steller sea lion western stock is 42,366 (Allen and Angliss 2011). The abundance of the western stock is stable or slightly decreasing (NMFS 2008c).

Fissipeds. The sea otter (*Enhydra lutris*) inhabits shallow water areas along the shores of the North Pacific. Three stocks of the sea otter occur in Alaskan waters: (1) Southwest Alaska, extending from the Kodiak Archipelago southwest through the Alaska Peninsula to the Aleutian Islands; (2) south central Alaska, between Cape Yukataga and the east coast of Cook Inlet and including the eastern side of Cook Inlet; and (3) Southeast Alaska, extending from the U.S./Canadian border to Cape Yukataga (Gorbics and Bodkin 2001). Individuals from both the south central and southwest Alaska stocks occur in south central Alaska where they could be affected by oil and gas activities in the Cook Inlet Planning Area. The Southwest Alaska stock has declined dramatically over the past several decades, probably due to predation by killer whales (Schneider and Ballachey 2008), causing the USFWS to list that stock as a threatened DPS under the ESA (USFWS 2006b).

Five units totaling 15,164 km^2 (5,855 mi^2) are designated as critical habitat for the Southwest Alaska DPS (USFWS 2009c). Unit 5 (Kodiak, Kamishak, Alaska Peninsula), containing 6,755 km^2 (2,607 mi^2) of critical habitat (USFWS 2009c), is the most likely of the sea otter critical habitat units to be affected by activities related to lease sales in Cook Inlet. This unit ranges from Castle Cape in the west to Tuxedni Bay in the east, and includes the Kodiak Archipelago (USFWS 2009c). The unit includes the nearshore marine environment ranging from the mean high tide to the 20-m (66-ft) depth contour as well as waters occurring within 100 m (330 ft) of the mean high tide line (USFWS 2009c). The lower western half of Cook Inlet to Redoubt Point is included in Unit 5 of the critical habitat (USFWS 2009c).

The sea otter inhabits coastal waters less than 90 m (295 ft) deep, with the highest densities usually found within the 40-m (130-ft) isobath where young animals and females with pups forage. Preferred habitat includes rocky reefs, offshore rocks, and kelp beds. Sea otters in Alaska are not migratory and, while capable of movements over 100 km (60 mi), generally do not disperse over long distances (Allen and Angliss 2011). They will sometimes rest in groups of fewer than 10 to more than 1,000 individuals. Sea otters seldom come onshore, and when they do, they are seldom more than a few meters from water (Schneider and Ballachey 2008).

Sea otters prey on a great variety of mostly benthic food sources including sea urchins, clams, mussels, snails, abalone, crabs, scallops, chitons, limpets, octopus, and fin fish (Estes et al. 1978; Garshelis et al. 1986; Riedman and Estes 1990; Green and Brueggeman 1991; Kvitek et al. 1993). They dive to depths of 1.5 to 76 m (5 to 250 ft). A dive usually lasts 1 to 1.5 minutes, but can last 5 minutes or more (Schneider and Ballachey 2008). The recovery and

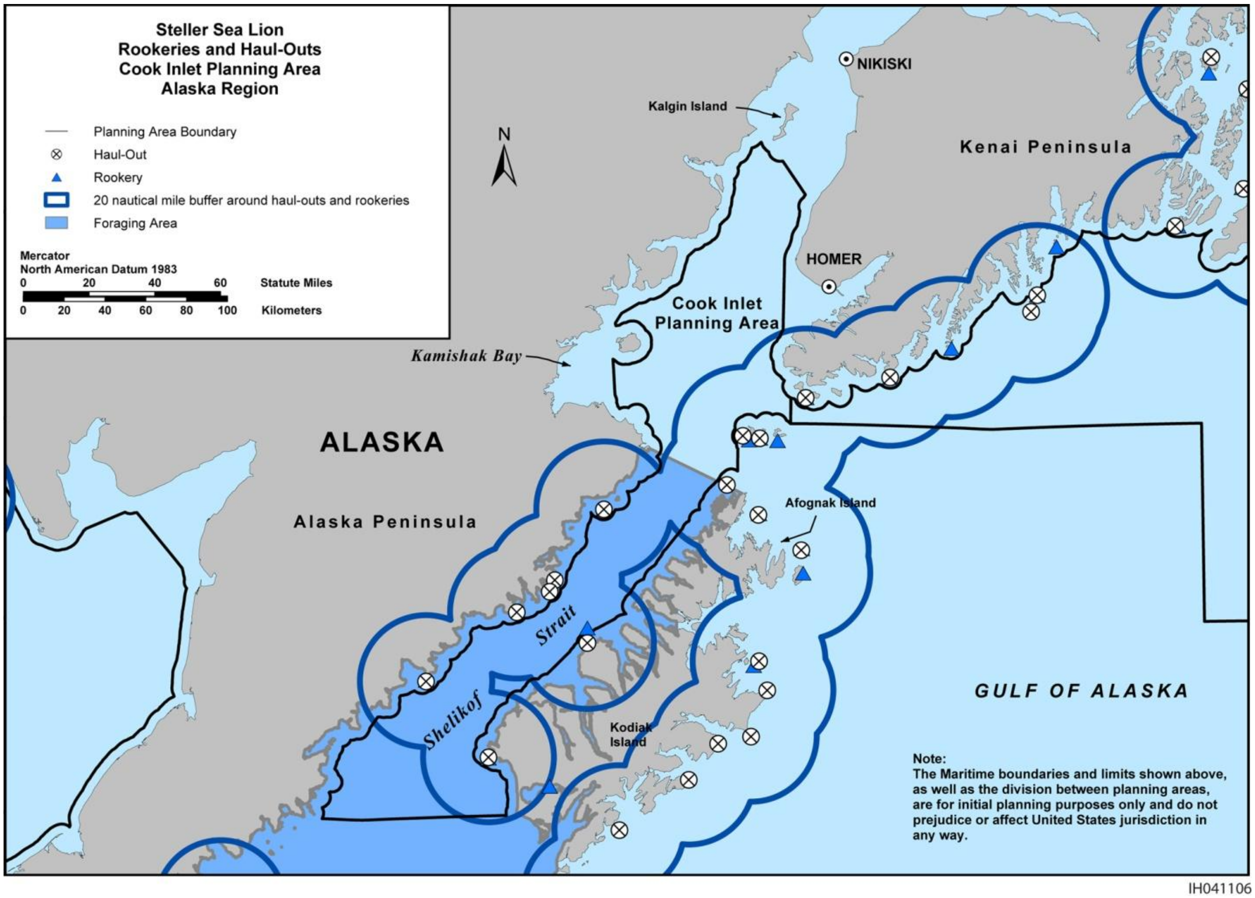

FIGURE 3.8.1-3 Steller Sea Lion Critical Habitat in the Area of the Cook Inlet Planning Area (note: the figure is in the process of being prepared/modified)

expansion of the sea otter populations in Prince William Sound and in Southeast Alaska, coupled with the otter's preference for crab and clam species that are of commercial interest (such as Dungeness crab and butter clam) (Garshelis et al. 1986; Kvitek et al. 1993), has resulted in competition and conflict with commercial-fishing interests (Garshelis and Garshelis 1984; USFWS 1994a).

Among marine mammals, sea otters probably have one of the higher reproductive rates and a potential for fairly rapid population recovery (such as 17–20% per year [Riedman et al. 1994]) after substantial losses due to natural or man-made causes (such as overharvest or an oil spill). Female sea otters can reach sexual maturity at 2 yr of age (30%), with all females mature at 5 yr of age (Bodkin et al. 1993). With a gestation period of about 6 months and a pup dependency of 6 months, most sexually mature female sea otters (85–90%) are able to pup in a given year (Jameson and Johnson 1993). Post-weaning survival can range from 18 to 86%, and survival of sea otters more than 2 yr of age can approach or exceed 90%. Females can live up to 22 yr and males up to 15 yr (USFWS 2010c).

The current estimate for the Southwest Alaska stock is 47,676 sea otters, with a minimum population estimate of 38,703, while the current estimate for the south central Alaska stock is 15,090 sea otters, with a minimum population estimate of 13,955. Of these, 2,673 sea otters occur in Cook Inlet/Kenai Fiords (Allen and Angliss 2011). The south central Alaska stock population trend is stable, while the Southwest Alaska stock is declining (Allen and Angliss 2011). The cause of the population decline is not known for sure, but weight of evidence indicates that increased predation by killer whales as the most likely cause. The most important threats to recovery of the population are predation and oil spills; other threats to recovery include subsistence harvest, illegal take, and infectious disease (USFWS 2010c).

Marine Mammals Not Listed under the Endangered Species Act.

Cetaceans: Mysticetes. The Eastern North Pacific population of the gray whale (*Eschrichtius robustus*) was delisted from the ESA in 1994 (USFWS and NMFS 1994). The Eastern North Pacific stock (which encompasses this population) winters primarily along the west coast of Baja California where calving occurs from January to mid-February (Allen and Angliss 2011). The northward migration, which occurs in nearshore waters, begins in mid-February and continues through May (Allen and Angliss 2011). Gray whales arrive for their feeding season in the Gulf of Alaska in late March and April (at which time some individuals may occur close to Cook Inlet), the northern Bering Sea (Cherikov Basin located west and north of the Norton Basin) in May or June, and the Chukchi and Beaufort Seas in July or August (Rice and Wolman 1971). Some gray whales have been observed feeding year-round in the waters southeast of Kodiak Island (Moore et al. 2007). They begin their southward migration in mid-October, passing through Unimak Pass from late October to early January (Frost and Karpovich 2008). Breeding occurs during their southward migration to the Gulf of California and Baja. In recent years, gray whales have begun to delay their southbound migration, are expanding their feeding range along the migration route and northward to Arctic waters, and some even remain in polar waters over winter (Moore 2008).

Gray whales usually live in small groups of about three whales, although groups up to 18 whales occur (Frost and Karpovich 2008). Gray whales feed primarily on benthic amphipods in the northern Bering, Chukchi, and western Beaufort Seas. Shallow coastal areas and offshore shoals in the Chukchi and western Beaufort Seas also provide rich feeding habitat (Rugh et al. 1999). Gray whales seldom feed while migrating or during winters in tropical waters (Frost and Karpovich 2008). In summer, gray whales select coastal/shoal waters and open waters, while in autumn they select coastal and shoal/trough habitats in light ice and open water (Moore et al. 2000a). They generally occur closer to shore than other large whale species (Berzin and Rovnin 1966). The abundance estimate for the Eastern North Pacific gray whale stock is 19,126 with a minimum estimate of 18,017 individuals. The population of this stock has been increasing over the past several decades (Allen and Angliss 2011).

The minke whale (*Balaenoptera acutorostrata*) occurs from the Bering and Chukchi Seas south to near the equator with apparent concentrations of whales near Kodiak Island (Allen and Angliss 2011). Zerbini et al. (2006) observed concentrations of minke whales in the area of the eastern Aleutian Islands with scattered observations along the Alaska Peninsula and Kodiak Island. In spring, most minke whales are found over the continental shelf and prefer shallow coastal waters. In Alaska, minke whales are most abundant in the Gulf of Alaska during summer for feeding but become scarce in the fall, with most whales leaving by October (Consiglieri et al. 1982). Only a few whales have been reported in the northeastern Gulf of Alaska (offshore the Icy Bay area) and in southeastern Alaska (Sitka area) during winter. Breeding occurs year-round in the Pacific. The minke whale usually occurs alone or in groups of only two to three whales, although loose aggregations of up to 400 can occur in feeding areas at higher latitudes (NMFS 2011a). The minke whale preys on a variety of large zooplankton (e.g., krill and copepods) and small schooling fishes (Pauly et al. 1995; Jefferson et al. 2006). No estimates are available for the number of minke whales in the entire North Pacific. The provisional estimate for the number of minke whales in central-eastern and southeastern Bering Sea is 810 and 1,003, respectively (Allen and Angliss 2011). There are no data on the trends of minke whale abundance in Alaska (Allen and Angliss 2011).

Cetaceans: Odontocetes. The Cuvier's beaked whale (*Ziphius cavirostris*) is the most widespread of the beaked whales, occurring in all oceans and most seas except in the high polar waters (Moore 1963). Its distribution in the northeastern Pacific ranges from Baja California to the northern Gulf of Alaska, Aleutian Islands, and Commander Islands (Allen and Angliss 2011). Although the Cuvier's beaked whale occurs in south central Alaska, individuals do not apparently enter Cook Inlet (Allen and Angliss 2011). The Cuvier's beaked whale prefers waters of the continental slope and edge and steep underwater geologic features such as banks, seamounts, and submarine canyons where depths are greater than 1,000 m (3,000 ft) (NMFS 2011a). Within its range, the Cuvier's beaked whale mostly occurs alone or in small groups up to 12 individuals, although groups up to 25 have been reported (NMFS 2011a). It dives to depths of at least 1,000 m (3,000 ft) that last 20 to 40 minutes (NMFS 2011a). Its diet consists of squid, fishes, and crustaceans (Pauly et al. 1995; Jefferson et al. 2006). Cuvier's beaked whale strandings indicate that it is the most widespread beaked whale and not as rare as originally thought (Moore 1963; Moore 1963; Culik 2010; Allen and Angliss 2011). Information on population abundance or trends for the Alaska stock of the Cuvier's beaked whale is not available (Allen and Angliss 2011).

The Dall's porpoise (*Phocoenoides dalli*) is present year-round throughout its entire range in the northeast Pacific, from Baja California, Mexico, to the Bering Sea in Alaska. However, within this range, the Dall's porpoise does not occur in the upper Cook Inlet or in the shallow eastern flats of the Bering Sea (Allen and Angliss 2011). Dall's porpoise generally occurs over the continental shelf adjacent to the slope and over oceanic waters greater than 2,500 m (8,200 ft) deep (Allen and Angliss 2011). It also occurs closer to shore in narrow channels and fjords that have clear, relatively deep water (Culik 2010). The Dall's porpoise usually travels in groups of 2 to 20 animals, but occasionally occurs in loosely associated groups of hundreds to thousands of animals (NMFS 2011a). They also occasionally occur with other marine mammals, especially the Pacific white-sided dolphin (*Lagenorhychus olbiquidens*) (Jefferson 1988). Dall's porpoises routinely feed at depths of 500 m (1,640 ft) or more, primarily on squid and small schooling fishes (Culik 2010; Jefferson 1988). Based on survey data over 8 yr old,[11] the best estimate of the abundance of the Alaska stock is 83,400 individuals with a minimum population estimate of 76,874 (Allen and Angliss 2011).

The harbor porpoise (*Phocoena phocoena*), in the Eastern North Pacific Ocean, ranges from Point Barrow, along the Alaska coast, and down the west coast of North America to Point Conception, California (Allen and Angliss 2011). They generally occur in harbors, bays, and river mouths but may also be concentrated in and along turbid river water plumes such as the Copper River and Icy Bay areas. In the Gulf of Alaska and southeast Alaska, the harbor porpoise frequents waters less than 100 m (330 ft) in depth, with high densities of animals occurring in Glacier Bay, Yakutat Bay, Copper River Delta, and Sitkalidak Strait (Dahlheim et al. 2000). Activities associated with lease sales in Cook Inlet could potentially affect harbor porpoise individuals in the Gulf of Alaska stock. This stock includes individuals occurring from Cape Suckling to Unimak Pass (Allen and Angliss 2011). Harbor porpoises usually occur in groups smaller than 8 individuals, although they will aggregate into groups of 50 to several hundred during feeding or migration (Culik 2010). Harbor porpoises consume a wide variety of fishes and cephalopods, apparently preferring non-spiny schooling fish such as herring, mackerel, and pollock (Leatherwood and Reeves 1987). Based on survey data over 11 yr old, the population estimate for the Gulf of Alaska harbor porpoise stock is 31,046 with a minimum estimate of 25,987 (Allen and Angliss 2011).

The killer whale (*Orcinus orca*) occurs along the entire Alaskan coast within the Beaufort Sea, Chukchi Sea, Bering Sea, Aleutian Islands, Gulf of Alaska, Prince William Sound, Kenai Fjords, and southeastern Alaska. Killer whales are relatively common in lower Cook Inlet, but are somewhat infrequent in the upper Cook Inlet (Shelden et al. 2003). NMFS recognizes several stocks of killer whales in Alaskan waters: (1) the Eastern North Pacific Northern Resident stock, occurring from British Columbia through part of southeastern Alaska; (2) the Eastern North Pacific Alaska Resident stock, occurring from southeastern Alaska to the Aleutian Islands and the Bering Sea; (3) the Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock, occurring mainly from Prince William Sound through the Aleutian Islands and the Bering Sea; (4) the AT1 Transient stock, occurring in Alaska from Prince William Sound through the Kenai Fjords; (5) the West Coast Transient stock, occurring from California through southeastern Alaska; and (6) the Eastern North Pacific Offshore stock, occurring from California through Alaska (Allen and Angliss 2011). Oil and gas activities in the Cook Inlet Planning Area could potentially affect killer whales from the Eastern North Pacific Alaska Resident stock and the Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock.

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[11] The NMFS has a policy to use data less than 8 years old for the purposes of calculating the potential biological removal, which is defined by the MMPA as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. The potential biological removal level is the product of the following factors:

- The minimum population estimate of the stock;
- One-half the maximum theoretical or estimated net productivity rate of the stock at a small population size; and
- A recovery factor of between 0.1 and 1.0.

Killer whales are top-level predators that feed on marine mammals, marine birds, sea turtles, fishes, and cephalopods (Pauly et al. 1995; Jefferson et al. 2006). The resident stocks mainly feed on salmonids, whereas the transient stocks tend to feed on marine mammals (NMFS 2011a). Killer whales occur along the entire coast of Alaska (Allen and Angliss). In summer, they concentrate in Prince William Sound, the Kodiak Island area, and the nearshore waters of southeastern Alaska. The movement of killer whales to nearshore waters may be in response to migration of their prey (Heimlich-Boran 1988; Culik 2010). In fall and winter, killer whales are numerous around Kodiak Island and adjacent shelf waters but not elsewhere in the Gulf of Alaska (Consiglieri et al. 1982). The peak breeding period of killer whales is May through July (Consiglieri et al. 1982).

Killer whale group or pod size varies from 1 to 100 (Braham and Dahlheim 1982). Most pods in Alaska have fewer than 40 individuals (Zimmerman and Small 2008). Transient killer whale pods move over broader ranges of territory than do resident pods and prefer to feed on other marine mammals, such as seals, porpoises, and baleen whales (Heimlich-Boran 1988; Ford et al. 2005; Jefferson et al. 1991). The minimum size of the Eastern North Pacific Alaska Resident stock is 2,084 individuals, while the minimum size of the Gulf of Alaska, Aleutian Island, and Bering Sea Transient stock is 552 individuals (Allen and Angliss 2011). As mentioned previously, individuals from these stocks could potentially be affected by oil and gas activity in the Cook Inlet Planning Area.

The Pacific white-sided dolphin occurs in the Eastern North Pacific from the southern Gulf of California, north to the Gulf of Alaska and west to Amchitka in the Aleutian Islands. They rarely occur in the southern Bering Sea (Allen and Angliss 2011). This dolphin species generally occurs offshore over the continental slope in waters from 200 to 2,000 m (660 to 6,600 ft) deep (Stacey and Baird 1991; Consiglieri et al. 1982). Individuals do enter the inshore passes of Alaska (Stacey and Baird 1991; Consiglieri et al. 1982; Ferrero and Walker 1996). In the Gulf of Alaska, occurrences of the Pacific white-sided dolphins vary seasonally, in that they are rarely present in winter, become increasingly abundant in spring, and are most abundant in the summer when fish abundance is highest (Consiglieri et al. 1982). They commonly occur in groups of several hundred individuals, and groups of more than 1,000 individuals have been sighted (Leatherwood and Reeves 1987). Pacific white-sided dolphins feed on squid and fish (Pauly et al. 1995). There are no reliable population estimates for the North Pacific stock of the Pacific white-sided dolphin because abundance estimates are over 8 yr old. The estimated minimum population abundance in the early 1990s was 26,880 individuals (Allen and Angliss 2011).

Carnivores: Pinnipeds. The harbor seal (*Phoca vitulinea richardsi*) is distributed along the southeast Alaska coastline west through the Gulf of Alaska and Aleutian Islands, and into the Bering Sea north to Cape Newenham and the Pribilof Islands (Allen and Angliss 2011). Among the three stocks of harbor seals that occur in Alaska, the Gulf of Alaska stock could be affected by oil and gas activities in the Cook Inlet Planning Area. The Gulf of Alaska stock occurs from Cape Suckling to Unimak Pass, including animals that occur throughout the Aleutian Islands (Allen and Angliss 2011). Harbor seals are nonmigratory with local movements associated with tides, weather, season, food availability, and reproduction (Allen and Angliss 2011). Harbor seals occupy a wide variety of habitats in fresh and saltwater and along protected and exposed coastlines. They prefer to haul out on gently sloping or tidally exposed habitats including reefs, offshore rocks and islets, mud and sandbars, sand and gravel beaches, and floating and shorefast ice (Calambokidis et al. 1987; Bigg 1981; Allen and Angliss 2011). In Cook Inlet, harbor seals haul out near available prey and in areas that avoid high anthropogenic disturbance. They also select sites of rock substrate and those near deep water (Montgomery et al. 2007). Typically, an individual in a given area uses one or two haulout sites. Breeding occurs generally in late spring through fall. Females aggregate on glacial fjords to give birth between May and mid-July (Kinkhart et al. 2008). Important pupping areas occur within Icy and Yakutat Bays and Kodiak Island (Allen and Angliss 2011). Most dives are less than 20 m (65 ft) deep and last less than 4 minutes, although dives can occur to depths of 500 m (1,640 ft) and last up to 20 minutes (Kinkhart et al. 2008). In Cook Inlet, harbor seal abundance increases with proximity to bathymetric depths of 20 m (66 ft) (Montgomery et al. 2007). Harbor seals are opportunistic feeders. Their diet varies with season and location; they primarily feed on fish, cephalopods, molluscs, and crustaceans (Kinkhart et al. 2008; Pauly et al. 1995). Feeding occurs in marine, estuarine, and occasionally fresh waters (Allen and Angliss 2011). The current estimate of the Gulf of Alaska stock is 45,975 with a minimum population estimate of 44,453 (Allen and Angliss 2011).

Climate Change. A major concern regarding marine mammals in Arctic and subarctic regions is the potential for climate change and associated changes in the extent of sea ice. Climate change will primarily affect marine mammals from loss of habitat, changes in prey availability, and potentially increased expansion of other species that are likely to cause competitive pressure on some species, as well as putting them at greater risk of predation, disease, and parasitic infections (Alter et al. 2010; Kovacs et al. 2011). Alteration of sea ice and increasing human presence and activities will cause extensive redistribution of mobile species, disappearance of non-mobile species throughout portions of their range, and possible species extinctions (Ragen et al. 2008). However, it is not possible at this time to identify the likelihood, direction, or magnitude of climate change on the marine mammals of Cook Inlet. The current state of climate change and its impacts on marine mammals would need to be considered in any subsequent environmental reviews for lease sales or other OCS-related activities.

3.8.1.2.2 Terrestrial Mammals. No terrestrial mammals listed under the ESA occur in the area of Cook Inlet. Approximately 40 species of terrestrial mammals not listed under the ESA occur in south central Alaska, including the American black bear (*Ursus americanus*), brown bear (*Ursus arctos;* also commonly known as the grizzly bear), caribou (*Rangifer tarandus*), Dall sheep (*Ovis dalli*), moose (*Alces americanus*), mountain goat (*Oreamnos americanus*), and Sitka black-tailed deer (*Odocoileus hemionus sitkensis*), American beaver (*Castor canadensis*), American marten (*Martes americana*), American mink (*Neovision vision*), Canadian lynx (*Lynx canadensis*), coyote (*Canis latrans*), ermine (*Mustela erminea*), gray wolf (*Canis lupus*), least weasel (*Mustela nivalis*), North American river otter (*Lontra canadensis*), red fox (*Vulpes vulpes*), and wolverine (*Gulo gulo*) (ADFG 2011a; McDonough 2007; Peltier 2007; Van Daele and Crye 2007). The following information describes the life history attributes, distribution, and seasonal movement of select terrestrial big game and furbearer species expected to use coastal habitats in the Cook Inlet Planning Area or nearby coastal habitats in the Gulf of Alaska.

American Black Bear (*Ursus americanus*). In Alaska, American black bears occur throughout most forests and coastal areas. However, they do not occur on the Seward Peninsula, Yukon-Kuskokwim Delta, north of the Brooks Range, several islands in the Gulf of Alaska and from the Alaska Peninsula beyond the area of Lake Iliamma. However, they do inhabit most islands in Southeast Alaska except for Admiralty, Baranof, Chichagof, and Kruzof (ADFG 2011a). About 100,000 American black bears occur in Alaska; several thousand occur in south central Alaska, which encompasses Cook Inlet (ADFG 2011a; Peltier 2008). American black bears hibernate during winter. Following den entrance, pregnant females give birth to one to three cubs. On the Kenai Peninsula, average dates of den entrance and emergence are October 18 and April 26, respectively, although severe spring weather can delay den emergence (Schwartz et al. 1987). Breeding occurs during the summer. Apart from that time, American black bears are usually solitary, except for sows with cubs. Cubs remain with their mother through the first winter. American black bears make heavy use of coastal habitats in the spring following den emergence (McIlroy 1972; Johnson 2008). During the summer, salmon are common food sources (if available), but bears will also eat vegetation, insects, berries, winter-killed animals, and newborn moose calves (Johnson 2008). Large amounts of berries are particularly important to American black bears during the summer; often bears will switch from salmon to berries during this time.

Brown Bear (*Ursus arctos*). Brown bears (also commonly referred to as grizzly bears) occur throughout most of Alaska except on the islands south of Frederick Sound in southeast Alaska, west of Unimak in the Aleutian Islands, and on the Bering Sea islands (Eide et al. 2008). Recent genetic studies do not support the differentiation of brown bear subspecies (NatureServe 2011b). The brown bear mating season occurs from May to July. Pregnant females tend to enter their dens in the fall. Females give birth to one to four cubs in their dens between January and February and emerge from dens in June. Males enter their dens later than females and tend to emerge from them before females do. In the northern part of Alaska, brown bears may stay in their dens up to 8 months; in areas with relatively mild winters, they may stay active all winter (Eide et al. 2008). Cubs stay with their mothers for up to 3 yr, but fewer than half the cubs survive (Eide et al. 2008). Brown bear densities vary with the quality of the environment. For example, in areas of low productivity such as the North Slope, bear densities are as low as one bear per 777 km^2 (300 mi^2), while in areas of high productivity such as the Alaska Peninsula, Kodiak Island, and Admiralty Island, densities are as high as one bear per 39 to 65 km^2 (15 to 25 mi^2). Areas occupied by an individual bear overlap those used by other bears (Eide et al. 2008). In the early 1990s, the population for brown bears in Game Management Unit 16 (west side of Cook Inlet) was estimated to range between 586 and 1,156. Similar numbers were estimated in the early 2000s (Kavalok 2007).

Large males may weigh up to 680 kg (1,500 lb) in coastal areas but only 227 kg (500 lb) in interior areas (Eide et al. 2008). Brown bears are generally solitary, but may aggregate at feeding areas such as salmon spawning streams, sedge flats, open garbage dumps, or whale carcasses (Eide et al. 2008). Brown bears are omnivorous — their foods include grasses, sedges, berries, fish, ground squirrels, caribou, moose, domestic animals, garbage, and carrion (Eide et al. 2008). During spring, coastal bears rely heavily on beaches, meadows, and shorelines while foraging on newly emergent plants, carrion, and intertidal infauna such as clams. In summer and early fall, brown bears aggregate along coastal streams to feed on salmon and other spawning fish. The salmon runs are especially important to the Kodiak Island, Alaska Peninsula, and McNeil River brown bears; the salmon runs are available from late June to mid-December on Kodiak Island (Barnes 1990). Large amounts of berries are particularly important to brown bears during the summer; often bears will switch from salmon to berries during this time.

Moose (*Alces americanus*). Moose are associated with northern forests. They are most abundant in recently burned areas where dense stands of willow, aspen, and birch shrubs have propagated; timberline plateaus; and along major rivers of south central and interior Alaska (Crouse et al. 2008). Up to 200,000 moose occur in Alaska. Based on estimates made between 2000 and 2005, about 6,000 moose occur in the western Kenai Peninsula (which includes the eastern side of Cook Inlet), while about 2,000 moose occur in game management units that include the western portion of Cook Inlet (ADFG 2011a). Moose make seasonal movements to calving, rutting, and wintering areas. Females generally breed at 28 months, with breeding occurring in the fall. Calves are born from mid-May to early June after a gestation period of about 120 days. Calves remain with their mothers until about 1 yr old (Crouse et al. 2008). Moose consume willow, birch, and aspen twigs in the fall and winter; twigs, sedges, horsetail, pond weeds, and grasses in spring; and pond plants, forbs, and leaves of birch, willow, and aspen in summer (Crouse et al. 2008). Predation by wolves and bears limits population growth of moose in many locations in Alaska. Hunting and severe winter weather are also controlling factors on moose populations (Crouse et al. 2008).

North American River Otter (*Lutra canadensis*). River otters frequently occur in nearshore coastal waters, beaches, and intertidal areas throughout south central Alaska, where they forage on small fish, clams, crustaceans, and other invertebrates (Solf and Golden 2008). River otters in Alaska breed in May, with mating occurring in and out of the water (Solf and Golden 2008). One to six pups are born the following year any time from late January to June. River otters reach sexual maturity at 2 yr of age and live up to 20 yr (Solf and Golden 2008). Family units consisting of a female with her pups, with or without an adult male, travel only a few kilometers. Larger groups of neighboring family units (more than 10 individuals) form temporary associations. These groups travel over a wide area and apparently do not have exclusive territories (Solf and Golden 2008).

Sitka Black-Tailed Deer (*Odocoileus hemionus sitkensis*). Sitka black-tailed deer are native to wet coastal rainforests of southeast Alaska and north-coastal British Columbia. Transplants have led to the establishment of populations near Yakutat in Prince William Sound and on Kodiak and Afognak Islands (ADFG 2011b). Sitka black-tailed deer populations fluctuate depending on the severity of winters. They have a high reproductive potential, so they can generally rebound quickly from reduced populations (ADFG 2011b). From winter through early spring, they are mostly restricted to uneven-aged old-growth forest below 366 m (1,500 ft) in elevation. During extreme snow events, the deer may congregate in heavily timbered stands at lower elevation or even on beaches (ADFG 2011b). After the winter snow pack recedes, migratory deer move to high-elevation alpine and subalpine habitats, while resident deer remain at lower elevation forested areas. With the first heavy frost, deer occupying alpine and subalpine habitats descend to the upper forest (Merriam et al. 2008). Summer and winter home ranges average 454 ha (1,122 ac) and 107 ha (264 ac), respectively (Van Daele and Crye 2009). The distance between winter and summer home ranges is about 22 km (13 mi) for migratory deer and 0.8 km (0.5 mi) for resident deer (Merriam et al. 2008; Van Daele and Crye 2009). During summer, Sitka black-tailed deer feed on herbaceous vegetation and shrub leaves, while in winter they feed on evergreen forbs and woody browse (ADFG 2011b). The breeding season begins in late October and continues through November. Fawning occurs from late May to early June (ADFG 2011b). In 2008, about 60,000 Sitka black-tailed deer populated the Kodiak Archipelago with the population appearing to be decreasing (Van Daele and Crye 2009).

Climate Change. Cook Inlet coastal habitats are vulnerable to the effects of climate change. Sea level rise is expected to inundate low-lying coastal habitats (Nicholls et al. 2007). Changes in sea level and increases in storms and erosion could result in loss of low-lying habitats critical to productivity and welfare of some wildlife species (Clark et al. 2010). Moose have timing and synchrony or parturition area adaptations to long-term patterns in climate and may be more susceptible to climate change than other ungulates that are more adapted to climatic variability (Bowyer et al. 1998). Shorter winters caused by climate change may increase the threat from ticks and deer-borne parasites (Howard 2011). Because brown bears are opportunistic, omnivorous, and highly adaptable, climate change is not expected to threaten their populations due to ecological threats or constraints; however, it may lead to an increase in brown bear/human interactions, in part from later den entry and earlier den exit (Servheen and Cross 2010).

3.8.1.3 Alaska – Arctic

3.8.1.3.1 Marine Mammals. There are 15 species of marine mammals in the Arctic region (Beaufort and Chukchi Seas). Four of these species are listed as threatened or endangered under the ESA, one is a candidate species, and two are proposed for listing as threatened species (Table 3.8.1-4). The following information describes the life history attributes, distribution, and seasonal movement of these 14 marine mammal species within the Alaska OCS lease sale areas in the Arctic region (Beaufort and Chukchi Seas). These areas encompass and/or could impact marine mammals that occur in the Beaufort/Chukchian Shelf Level II Ecoregion and include the Chukchian Neritic and Beaufortian Neritic Level III Ecoregions. (The ecoregions are described in Section 3.2.5 and shown in Figure 3.2.2-3.)

Marine Mammals Listed under the Endangered Species Act.

Cetaceans: Mysticetes. The endangered bowhead whale (*Balaena mysticetus*) occurs in seasonally ice-covered waters of the Arctic and near Arctic, typically between 60°N and 75°N in the Western Arctic Basin (Allen and Angliss 2011). Critical habitat for the bowhead whale has not been identified because habitat issues were not a factor in the decline of the species (ADNR 2009). The Western Arctic stock is the only bowhead stock found in U.S. waters (Allen and Angliss 2011). As shown in Figure 3.8.1-4, bowhead whales generally migrate from winter breeding areas (November to March) in the northern Bering Sea, through the Chukchi Sea in the spring (March through June) where most calving occurs, and into the Canadian Beaufort Sea where they spend much of the summer (mid-May through September) (Allen and Angliss 2011).

TABLE 3.8.1-4 Arctic Marine Mammals

Species	Status[a]
ORDER CETACEA	
Suborder Mysticeti (baleen whales)	
Balaenoptera acutorostrata (minke whale)	–
Balaenoptera mysticetus (bowhead whale)	E/D
Balaenoptera physalus (fin whale)	E/D
Eschrichtius robustus (gray whale)	DL/D
Megaptera novaeangliae (humpback whale)	E/D
Suborder Odontoceti (toothed whales and dolphins)	
Delphinapterus leucas (beluga whale)	–
Monodon monoceros (narwhal)	
Orcinus orca (killer whale)	D
Phocoena phocoena (harbor porpoise)	–
ORDER CARNIVORA	
Suborder Pinnipedia (seals, sea lions, and walrus)	
Erignathus barbatus (bearded seal)	PT
Odobenus rosmarus divergens (Pacific walrus)	C
Phoca fasciata (ribbon seal)	–
Phoca hispida (ringed seal)	PT
Phoca largha (spotted seal)	–
Suborder Fissipedia (polar bears)	
Ursus maritimus (polar bear)	T/D

[a] Status: E = endangered under the ESA; T = threatened under the ESA; C = candidate for listing under the ESA; DL = delisted under the ESA; D = depleted under the MMPA (for the killer whale, it only applies to the AT1 group of eastern North Pacific transient killer whales); PT = proposed threatened under the ESA; – = not listed.

In the fall (September through November), bowheads were presumed to return along this general route, closer to shore across the Beaufort Sea, to the Bering Sea to overwinter in polynyas and along edges of the pack ice (Braham et al. 1980; Moore and Reeves 1993). Important winter areas in the Bering Sea include polynyas along the northern Gulf of Anadyr, south of St. Matthew Island, and near St. Lawrence Island. Some bowhead whales, thought to be part of the expanding Western Arctic stock, remain in the Bering and Chukchi Seas during summer (Rugh et al. 2003).

Incorporation of recent scientific and traditional knowledge has provided updated information on the movements and behavior of the Western Arctic bowhead whale stock. Based on satellite tracking of bowheads from August 1, 2005 through July 12, 2010, most whales do summer in the eastern Beaufort Sea (Quakenbush et al. 2010a). However, some whales also occur in the western portion of the Chukchi Sea in summer (Quakenbush et al. 2010a; Citta et al. 2012). In addition, some bowheads undergo long-distance movements during

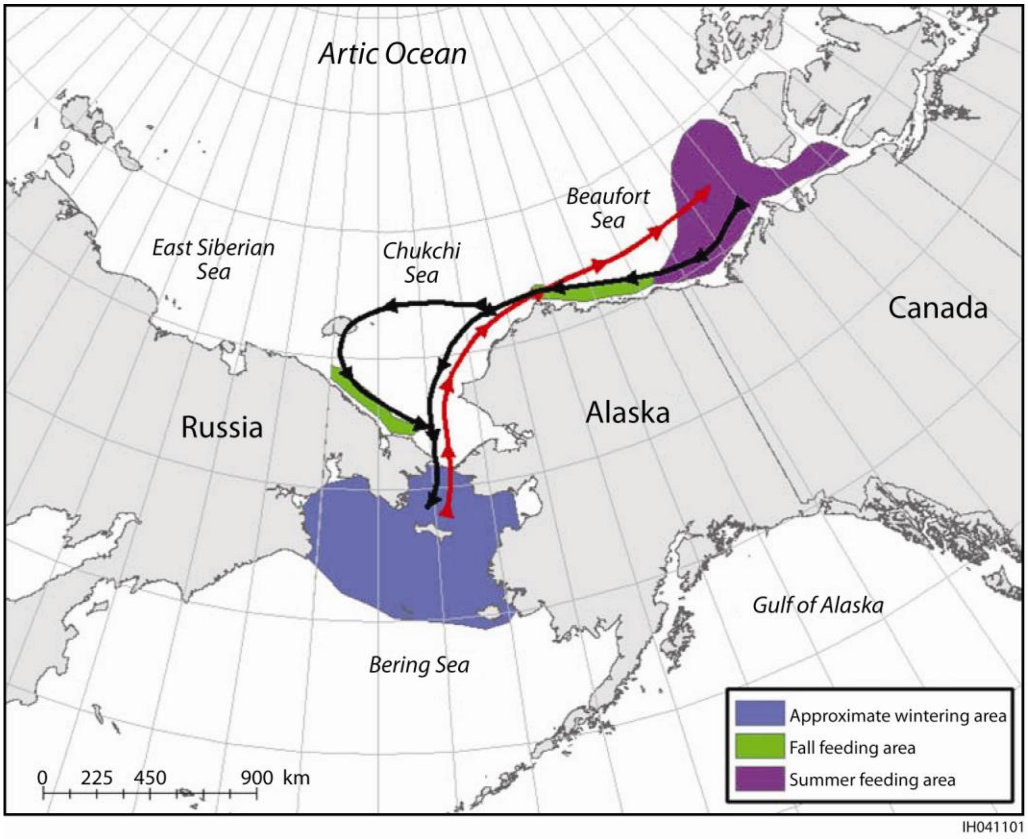


FIGURE 3.8.1-4 Generalized Migration Route, Feeding Areas, and Wintering Area for the Western Arctic Bowhead Whale Stock (Source: Moore and Laidre 2006)

summer. For example, one whale made a 1,400-km (870-mi) round trip from Amundsen Gulf to the north end of Banks Island in July, while three whales made trips from the Canadian Beaufort to Barrow and back (Quakenbush et al. 2010a).

The main fall migration begins in late August. The first whales are typically the larger ones, which establish the migration route in the Beaufort Sea. Migration through the eastern Alaskan portion of the Beaufort Sea continues through September and into October (Huntington and Quakenbush 2009). Figure 3.8.1-5 shows the fall movements of 19 satellite-tagged bowhead whales (Quakenbush et al. 2010b). The fall migration from Amundsen Gulf to Barrow included some whales that traveled inshore and others that traveled offshore (Quakenbush et al. 2010a). From Barrow to the Bering Sea, bowheads occur throughout much of the Chukchi Sea. All of the tagged whales traveled through Lease Sale Area 193 during the fall migration, but only one whale did so during the spring migration (Quakenbush et al. 2010a). Most whales traversed the lease sale area in less than one week; however, one whale remained in the area for 30 days (Quakenbush et al. 2010b). In addition, during the fall migration, several whales passed Barrow, then returned to Barrow for a period of time before completing their migration to the Bering Sea. Quakenbush et al. (2010a) noted that during fall, the area near Barrow and the northern half of Lease Sale Area 193 in the Chukchi Sea received a lot of use by bowheads; whereas the eastern

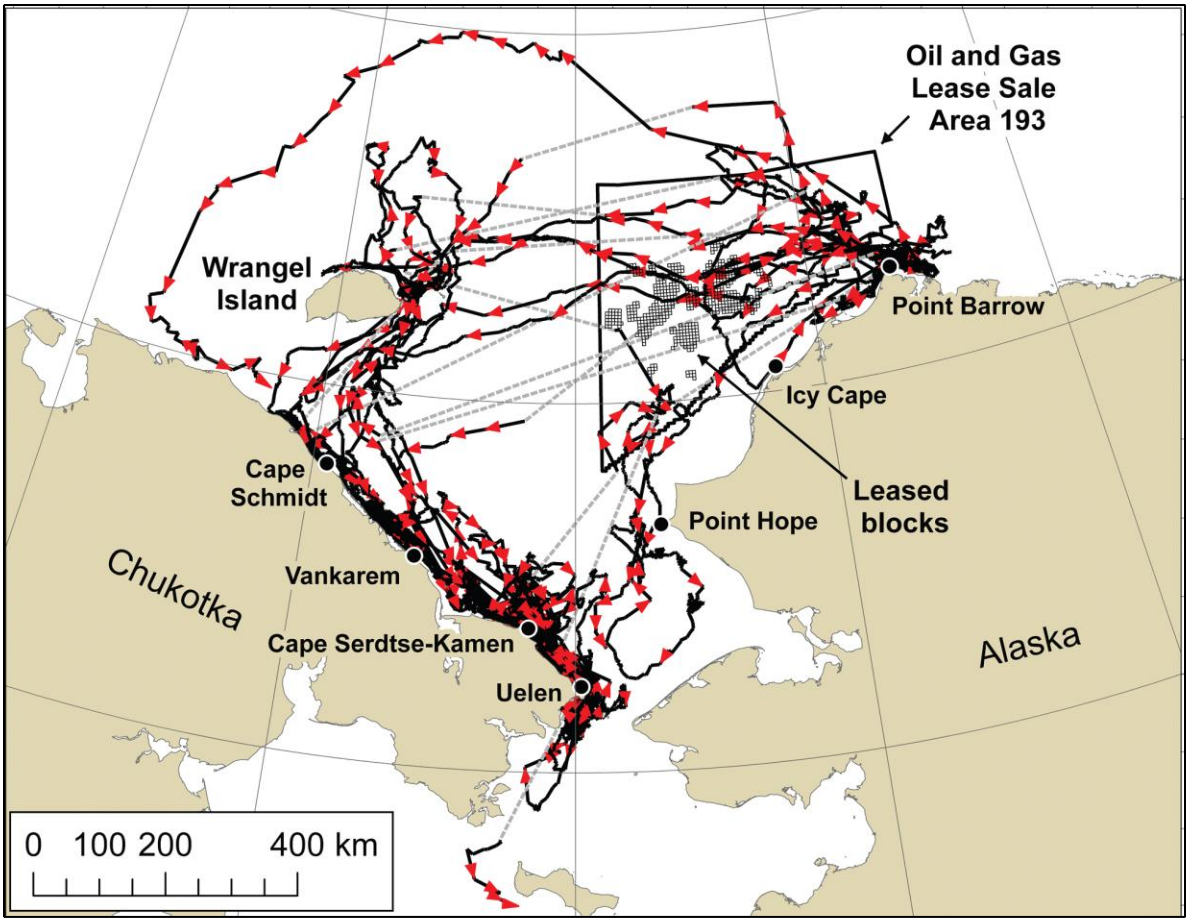


FIGURE 3.8.1-5 Tracks of Satellite-Tagged Bowhead Whales in the Chukchi Sea from 2006 through 2008 (August through December each year) (Quackenbush et al. 2010b)

Chukchi Sea, especially nearshore from Wainwright to the Bering Sea, was not used as often. The western Chukchi Sea, including nearshore areas, received extensive use during the fall (Quakenbush et al. 2010a).

Quakenbush et al. (2010a) noted that, rather than spending most of the winter in nearshore polynyas and near the ice edge, most bowheads spent most of their time in offshore areas of the Bering Sea in relatively heavy ice. In addition to sea ice, factors such as age, reproductive status, or prey availability likely account for the winter distribution of bowheads. Citta et al. (2012) discussed the winter movements of bowhead whales in the Bering Sea. The average date tagged whales entered the Bering Sea was December 14, and ranged from November 7 to January 11. All whales entered the Bering Sea between Cape Pe’ek and Big Diomede Island. The approximate winter range of tagged bowhead whales in the Bering Sea encompasses the area north of the 200-m (656-ft) isobath; west of a line connecting St. Matthew Island, St. Lawrence Island, and Nome; just north of the Bering Strait; and east of a line connecting Sireniki and Cape Navarin (Citta et al. 2012).

During spring, bowheads primarily migrate east of Little Diomede Island, up the coast of Alaska to Barrow, and then head straight to Amundsen Gulf (regardless of where ice leads are located). However, some bowheads migrate along the Chukotka Peninsula to the area west of Wrangel Island (Quakenbush et al. 2010a). In the past, bowheads first arrived near Wainwright in late April, but recently they arrive in early April and sometimes in March (Quakenbush and Huntington 2010). Three different waves of bowheads pass Wainwright in spring in the following order: (1) primarily small, young whales; (2) mid-sized whales; and (3) the largest whales and most of the mother-and-calf pairs. The third wave passes Wainwright in the second half of May and early June (Quakenbush and Huntington 2010). In the spring, bowheads have been observed calving, mating, and feeding in the nearshore lead near Wainwright and Barrow (Huntington and Quakenbush 2009; Quakenbush and Huntington 2010).

Except for land-fast ice, the presence of sea ice does not appear to limit the movements of whales in the spring in the Beaufort Sea or in the winter in the Bering Sea (Quakenbush et al. 2010a). However, sea ice does limit light penetration and wind-driven upwelling, which influences prey availability and thus whale movements (Quakenbush et al. 2010b). Bowhead feeding areas may have the physical and oceanographic factors necessary to concentrate zooplankton prey. Areas where bowhead whales spend time, and are likely feeding, include Amundsen Gulf, Barrow, Wrangel Island, the Chukotka coast between Wrangel Island and the Bering Strait, and western Bering Sea. Bowheads spend a good proportion of their time, even when traveling, feeding on or near the bottom. As whales may visit different feeding areas during different times, their movements become asynchronous; therefore, the complex pattern of fall movements is a combination of both migratory movements and movements to foraging areas. In spring, ice obstructs feeding opportunities; therefore, bowhead migratory movements are more predictable and consistent between the Bering Strait and Amundsen Gulf (Quakenbush et al. 2010a).

Most mating occurs in late winter and spring in the Bering Sea, although some mating occurs as late as September and early October (Quakenbush 2008; Allen and Angliss 2011). Most calving occurs during the spring migration in and adjacent to the eastern Chukchi Sea and the Beaufort Sea spring lead ice systems (MMS 2008a). Females give birth to a single calf every 3 to 4 yr (MMS 2008a).

Bowhead whales usually travel alone, in small groups of up to six whales, or in mother-calf pairs (ADNR 2009). Also, bowhead whales usually feed as individuals, but groups occasionally feed together in an echelon formation (Quakenbush 2008). Bowheads feed throughout the water column, including bottom or near-bottom feeding as well as surface feeding. Food items of bowheads include euphausiids, copepods, and amphipods (Quakenbush 2008; NMFS 2011a).

The best estimate of the abundance of the Western Arctic bowhead whale stock is 10,545 with a minimum population estimate of 9,472 (Allen and Angliss 2011). Overall, the stock appears to be healthy and increasing in population (Allen and Angliss 2011).

The endangered fin whale ranges from subtropical to Arctic waters and usually occurs in high-relief areas where productivity is probably high (Brueggeman et al. 1988). Their summer distribution extends from central California into the Chukchi Sea, while their winter range is restricted to the waters off the coast of California. In Alaskan waters, some fin whales feed in the Gulf of Alaska, while others migrate farther north to feed throughout the Bering and Chukchi Seas from June through October. There are few observations of fin whales in the eastern half of the Chukchi Sea and no documented occurrences of fin whales in the Beaufort Sea (MMS 2008b). From September through November, most fin whales migrate southward to California; however, a few animals may remain in the Navarin Basin (Brueggman et al. 1984). Northward migration begins in spring with migrating whales entering the Gulf of Alaska from early April–June (MMS 1996b).

Fin whales usually breed and calve in the warmer waters of their winter range (Mizrock et al. 1984). The fin whale feeds on concentrations of zooplankton (e.g., krill), fishes, and cephalopods (Pauly et al. 1995; Jefferson et al. 2006). Reliable abundance estimates for the Northeast Pacific fin whale stock are not available. A provisional estimate for the fin whale population west of the Kenai Peninsula is 5,700 (Allen and Angliss 2011).

The endangered humpback whale occurs worldwide in all ocean basins, although it is less common in Arctic waters. In winter, most humpback whales occur in the temperate and tropical waters. Humpback whales in the North Pacific are seasonal migrants to Arctic waters where they feed on zooplankton and small schooling fishes in the cool coastal waters of the western United States, western Canada, and the Russian Far East (NMFS 1991). The historic feeding range of humpback whales in the North Pacific encompassed coastal and inland waters around the Pacific Rim from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotck (Johnson and Wolman 1984; Allen and Angliss 2011). The observation of some individuals in the Beaufort Sea east of Barrow suggests a northward expansion of their feeding grounds (Zimmerman and Karpovich 2008; Allen and Angliss 2011). Current data demonstrate that the Bering Sea remains an important feeding area. During summer months, humpback whales will also enter the Chukchi Sea with rare observations in the western Beaufort Sea (Johnson and Wolman 1984; Hashagen et al. 2009; Allen and Angliss 2011). It is currently unknown whether the humpbacks observed in the southeastern Chukchi Sea and in the Beaufort Sea are part of the Western or Central stock.

NMFS recognizes three stocks of humpback whales occurring in U.S. waters, including the (1) California/Oregon/Washington and Mexico stock; (2) central North Pacific stock that migrates from Hawaii to northern British Columbia/Southeast Alaska and Prince William Sound west to Kodiak; and (3) western North Pacific stock that most likely migrates from Japan to waters west of the Kodiak Archipelago (the Bering Sea and Aleutian Islands) during the summer/fall (Berzin and Rovnin 1966; Allen and Angliss 2011). Winter/spring populations of humpback whales also occur near Mexico’s offshore islands. The western North Pacific stock spends winter and spring in waters off Japan and migrates to the Bering Sea, Chukchi Sea, and Aleutian Islands in the summer and fall (Berzin and Rovnin 1966; Allen and Angliss 2011). During migrations, humpbacks are pelagic. The central North Pacific stock winters in Hawaiian Island waters and migrates to northern British Columbia/southeast Alaska and Prince William Sound west to Kodiak Island in the summer and fall (Baker et al. 1990; Allen and Angliss 2011). In the Gulf of Alaska, concentration areas of humpbacks include the Portlock and Albatross

Banks and west to the eastern Aleutian Islands, Prince William Sound, and the inland waters of southeast Alaska (Berzin and Rovnin 1966).

Breeding and calving occur on the wintering grounds, and most births occur between January and March (Johnson and Wolman 1984). During the summer feeding period, the humpback whales generally occur nearshore. The central North Pacific stock of humpback whale feeding aggregations occur along the northern Pacific Rim. Humpback whale distribution in summer is continuous from British Columbia to the Russian Far East, with humpbacks present offshore in the Gulf of Alaska (Allen and Angliss 2011). Their diet consists of euphausiids, amphipods, mysids, and small schooling forage fishes (Jefferson et al. 2006; Pauly et al. 1995).

The minimum population estimate for the Western North Pacific humpback whale stock is approximately 732 individuals and that for the central North Pacific stock is approximately 5,833 individuals (Allen and Angliss 2011).

Pinnipeds. The bearded seal (*Erignathus barbatus*, proposed threatened [NMFS 2010c]) occurs throughout the Arctic and usually inhabits waters less than 200 m (660 ft) in depth in areas of broken, moving sea ice (Cleator and Stirling 1990; Allen and Angliss 2011). Most of the bearded seals in Alaska occur over the continental shelf of the Bering, Chukchi, and Beaufort Seas between 85°N and 57°N (Cameron and Boveng 2009). Bearded seal densities are greatest during the summer and lowest during the winter. Many of the seals that winter in the Bering Sea migrate north in April and May to the summer ice edge of the Chukchi Sea (Seal Conservation Society 2011). Others remain in the open waters of the Bering and Chukchi Seas (Seal Conservation Society 2011). During spring, bearded seals prefer areas that contain 70 to 90% sea ice coverage and are most abundant 32 to 161 km (20 to 100 mi) from shore, except for the nearshore concentration to the south of Kivalina (Allen and Angliss 2011). Bearded seals generally prefer ice habitat that is in constant motion and produces natural openings and areas of open water, such as leads, fractures, and polynyas for breathing, hauling out on the ice, and access to water for foraging. They usually avoid areas of continuous, thick, shorefast ice and rarely occur in the vicinity of unbroken, heavy, drifting ice or large areas of multi-year ice (Cameron et al. 2010).

Pupping takes place on top of the ice less than 1 m (3 ft) from open water (Kovacs et al. 1996) from late March through May mainly in the Bering and Chukchi Seas, although some pupping occurs in the Beaufort Sea. Breeding occurs around one month later following the weaning of pups. Bearded seals tend to be solitary (Nelson 2008a), but sometimes form loose aggregations in areas such as polynya systems. Bearded seals primarily feed on benthic prey such as crustaceans, mollusks, fishes, and octopuses (NMFS 2011a). In the 1970s, the estimated number of bearded seals in the Bering and Chukchi Seas was 250,000 to 300,000 (Nelson 2008a). Allen and Angliss (2010) stated that there are no current population estimates or trends for the Alaska stock of the bearded seal; however, NMFS (2010c) has given a population estimate for the Beringian DPS (which encompasses the Arctic region) of 155,000 individuals. Estimates provided in NMFS (2010c) are 3,150 bearded seals for the entire Beaufort Sea in June, and 27,000 bearded seals in the Chukchi Sea in the May–June timeframe. During the open water season, many seals from the Bering Sea follow the sea ice as it retreats north and the populations in the Beaufort and Chukchi Seas are believed to increase manyfold.

The ringed seal (*Phoca hispida*, proposed threatened [NMFS 2010d]) is circumpolar in distribution and is associated with ice for much or all of the year. It occurs throughout the Beaufort, Chukchi, and Bering Seas as far south as Bristol Bay (Allen and Angliss 2011). The ringed seal is the most abundant seal in the Arctic (Citta 2008). Ringed seals live on and under extensive, largely unbroken, shorefast ice, and generally occur over water depths of 10 to 20 m (33 to 66 ft) (ADNR 2009). They are generally solitary when hauled out on ice (ADNR 2009). Ice cover strongly influences ringed seal movements, foraging, reproductive behavior, and vulnerability to predation (Kelly et al. 2010b). In the winter/spring period, when ringed seals occupy shorefast ice, their home ranges extend from <1 to 27.9 km^2 (<0.4 to 10.8 mi^2). Ringed seals inhabiting shorefast ice in the Beaufort Sea occupy ranges averaging <2 km^2 (<0.8 mi^2) during April through early June (Kelly et al. 2010a). In summer/fall, ringed seals may range up to 1,800 km (1,120 mi) from their winter/spring home ranges and return to the same home range sites during the ice-bound months in the following year. They continue to use sea ice as resting platforms during the summer/fall period (Kelly et al. 2010a). Some ringed seals occur during ice-free periods in the Bering and Chukchi Seas (Citta 2008). Primary pupping habitat is located on fast ice along the coasts of St. Lawrence Island, Norton Sound, and the Yukon River Delta. Ringed seals are monogamous to weakly polygamous (Kelly et al. 2010b). When sexually mature, males establish territories during the fall and maintain them during the pupping season. Pups are born in late March and April in subnivian lairs that seals excavate above breathing holes in the ice (Kelly et al. 2010b). During the breeding and pupping season, adults on shorefast ice (floating fast-ice zone) usually move less than individuals in other habitats; they depend on a relatively small number of holes and cracks in the ice for breathing and foraging. Ringed seals molt between mid-May to mid-July, at which time they spend long periods on the ice (NMFS 2010d). They are capable of diving to depths over 500 m (1,640 ft) and dives can last up to 39 minutes (Born et al. 2004). In the winter/spring, ringed seals feed under the ice while in summer/fall they feed either in open water or under the ice (Kelly et al. 2010a). Ringed seals preferred prey includes Arctic cod, herring, shrimps, and mysids (NMFS 2011a). A reliable population estimate for the Alaska stock is not available, but is assumed to be over 249,000 based on information published in 2002 and 2005 (see Allen and Angliss 2011).
Kelly et al. (2010b) estimated a reasonable population of ringed seals to be about 1 million.

The Pacific walrus (*Odobenus rosmarus divergens*), a candidate for listing under the ESA (USFWS 2011a), ranges throughout the shallow continental shelf waters of the Bering and Chukchi Seas, where its distribution is closely linked with the seasonal distribution of the pack ice. It occasionally moves into the eastern Siberian Sea and western Beaufort Sea during summer (Fay 1982). The Pacific walrus is an extremely social and gregarious animal that spends approximately one third of its time hauled out onto land or ice, usually in close physical contact with others. Group size can range from several individuals to several thousand individuals (USFWS 2011a). The Pacific walrus relies on sea ice as a substrate for resting, giving birth and nursing, isolation from predators, and passive transport to new feeding areas (USFWS 2009d). Spring migration usually begins in April, and most Pacific walruses move north through the Bering Strait by late June. During the summer months, most of the population moves into the Chukchi Sea; however, several thousand individuals, primarily adult males, use coastal haulouts in the Bering Sea (USFWS 2009d). Two large Arctic areas are occupied by Pacific walruses during summer — from the Bering Strait west to Wrangell Island, and along the northwest coast of Alaska from about Point Hope to north of Point Barrow. Within this area, summer/fall haulouts include Cape Lisburne, Corwin Bluff, Point Lay Barrier Islands, Icy Cape, Wainwright, Naokok, Asiniak Point, and Peard Bay (USFWS 2011b). Although a few Pacific walruses may move east throughout the Alaskan portion of the Beaufort Sea to Canadian waters during the open-water season, the majority of the population occurs west of 155°W, north and west of Barrow, with the highest seasonal abundance along the pack-ice front. With the southern advance of the pack ice in the Chukchi Sea during the fall (October to December), most of the Pacific walrus population migrates south of the Bering Strait, although solitary animals may occasionally overwinter in the Chukchi and Beaufort Seas. Breeding occurs in areas of broken ice from January through March, with calves born in late April or May of the following year (USFWS 2009d).

Most Pacific walrus feeding dives last 5 to 10 minutes, with a 1- to 2-minute surface interval between dives (USFWS 2009d). The diet primarily includes molluscs, snails, decapod crustaceans, amphipods, sea cucumbers, and segmented worms. Some walruses will occasionally eat seals (Fay 1985; USFWS 2009d).

Allen and Angliss (2011) provided estimates of the Pacific walrus population over the past several centuries. A minimum population of 200,000 animals occurred in the 18th and 19th centuries. Commercial harvests reduced the population to an estimated 50,000 to 100,000 by the 1950s. Between 1975 and 1990, the population estimate ranged from 201,039 to 234,020 animals, and the 2006 estimated minimum population was 129,000 animals. Major stressors to the Pacific walrus are subsistence harvest and loss of sea ice (USFWS 2011a).

Fissipeds. The federally threatened polar bear (*Ursus maritimus*) lives only on the Arctic ice cap in the Northern Hemisphere, mainly near coastal areas. The polar bear is considered a marine mammal because it principally inhabits the sea-ice surface rather than adjacent land masses (Amstrup 2003). In Alaska, polar bears primarily occur on the northern and northwestern coasts as far south as St. Matthew Island and the Pribilof Islands and extending north and eastward into the Chukchi and Beaufort Seas, from the Bering Strait to the Canadian border (Ray 1971). There are two polar bear stocks recognized in Alaska: the Southern Beaufort Sea stock and the Chukchi/Bering Seas stock (Figure 3.8.1-6). The Southern Beaufort Sea population ranges from the Baillie Islands, Canada, and west to Point Hope, Alaska. Individuals of the Bering/Chukchi Seas stock range widely on pack ice from Point Barrow, Alaska, west to the Eastern Siberian Sea. The stock's southern boundary in the Bering Sea is determined by the annual extent of the pack ice (Allen and Angliss 2011). These two stocks overlap between Point Hope and Point Barrow, Alaska, centered near Point Lay (Allen and Angliss 2011).

The USFWS designated critical habitat for the polar bear on December 7, 2010 (USFWS 2010b). Three habitat areas designated as critical habitat include barrier islands, sea ice, and terrestrial denning habitat. USFWS (2010b) contains figures showing the location of the critical habitat areas. These critical habitat areas total about 484,734 km^2 (187,157 mi^2) of lands and water within the United States. The barrier island habitat includes coastal barrier islands and spits along the Alaska coast. These areas are used for denning, refuge from human disturbance, access to maternal dens and feeding habitat, and travel along the coast. A total of 10,576 km^2 (4,083 mi^2) of barrier island habitat is identified as critical habitat (USFWS 2010b). The sea ice critical habitat occurs over the continental shelf and includes water 300 m (984 ft) or less in

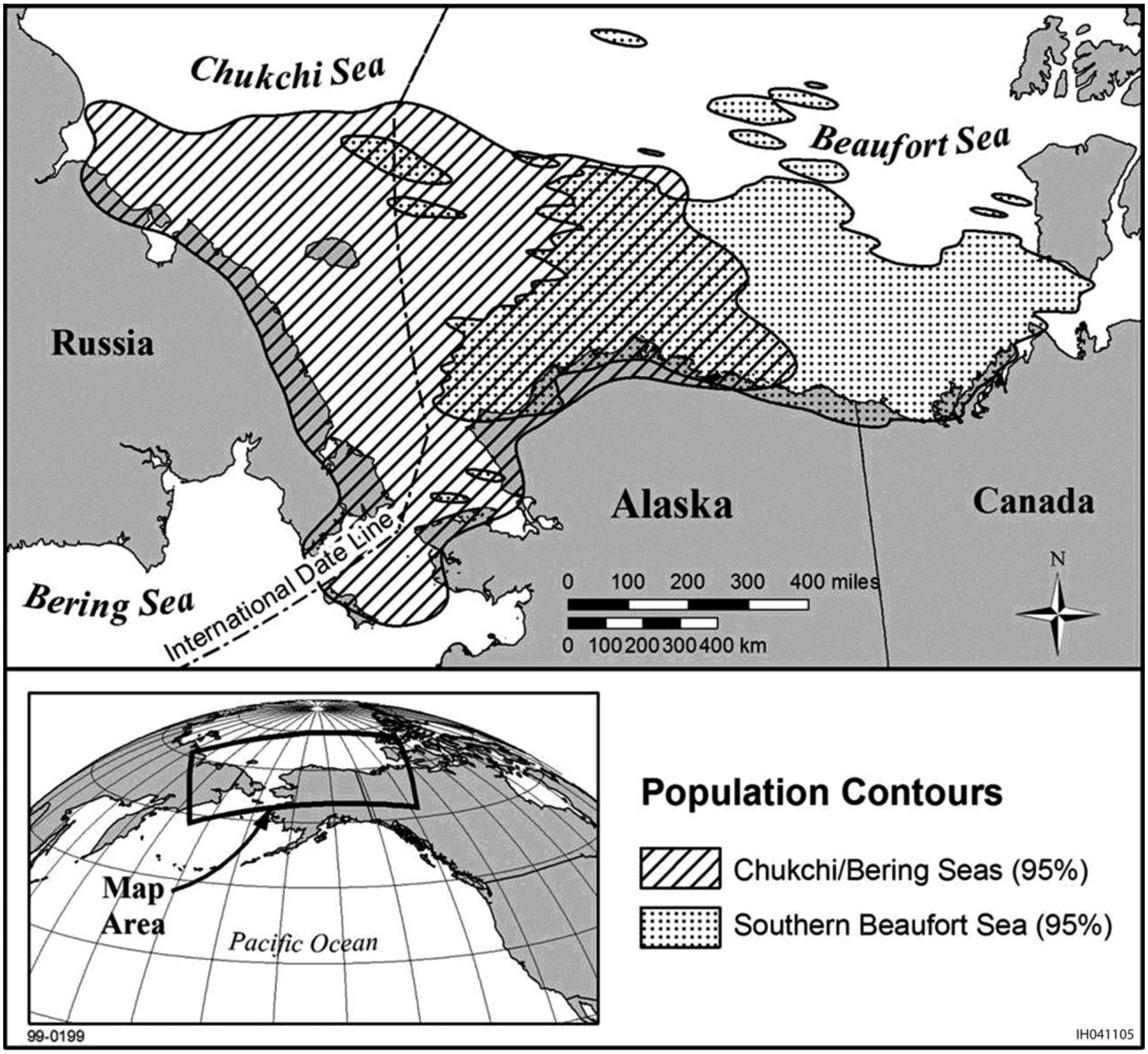


FIGURE 3.8.1-6 Distribution of Polar Bear Stocks in the Arctic Region (USFWS 2010c)

depth. Sea ice habitat is essential for most polar bear activities as a platform for hunting and feeding, searching for mates and for breeding, moving to terrestrial maternity denning areas, resting, and making long-distance movements. A total of 464,924 km^2 (179,508 mi^2) of sea ice habitat has been designated as critical habitat (USFWS 2010b). Terrestrial denning critical habitat includes lands within 32 km (20 mi) of the northern coast of Alaska between the U.S./Canadian border and Kavik River and within 8 km (5 mi) between the Kavik River and Barrow. A total of 14,652 km^2 (5,657 mi^2) of terrestrial denning habitat has been designated as critical habitat (USFWS 2010b).

Seasonal movements of polar bears reflect changing ice conditions and breeding behavior. In spring, polar bears in the Beaufort Sea overwhelmingly prefer regions with ice concentrations greater than 90% and composed of ice floes 2 to 10 km (1.2 to 6.2 mi) in diameter (Durner et al. 2004). Mature males range offshore in early spring, but move closer to shore during the spring breeding season. With the breakup of the ice during spring and early summer, polar bears move northward where they select habitats with a high proportion of old ice. To reach this ice, polar bears may migrate as much as 1,000 km (620 mi) (Amstrup 2003). As ice reforms in the fall, the bears move southward, and by late fall are distributed seaward of the Chukchi and Beaufort Sea coasts. During winter, polar bears prefer the lead ice system at the shear zone between the shorefast ice and the active offshore ice. Annual activity areas for female polar bears in the Beaufort Sea range from 13,000 to 597,000 km^2 (5,020 to 230,500 mi^2) with an average of 149,000 km^2 (57,530 mi^2) (Amstrup et al. 2000).

Pregnant and lactating females with newborn cubs are the only polar bears that occupy winter dens for extended periods (Lentfer and Hensel 1980; Amstrup and Gardner 1994). The key denning habitat characteristics are topographic features that catch snow for den construction and maintenance (USFWS 2008b). The main terrestrial denning areas for the Southern Sea stock in Alaska occur on the barrier islands from Barrow to Kaktovik and along coastal areas up to 40 km (25 mi) inland (Allen and Angliss 2011). Most onshore dens are close to the seacoast, usually not more than 8–10 km (5–6 mi) inland. Information on polar bear use of terrestrial habitat for maternity denning in and near the Prudhoe Bay oil field indicates that dens were located or associated with pronounced landscape features, such as coastal and river banks, as well as lake shores and abandoned oil field gravel pads (Durner et al. 2003). In the Beaufort Sea and to a limited extent the Chukchi Sea, females may den on the drifting pack ice (Schliebe et al. 2005). Females enter dens by late November, with young being born in late December or January (Lentfer and Hensel 1980). Polar bears do not have denning site fidelity, but do return to the general substrate (i.e., land or ice) and geographic area (e.g., eastern or western Beaufort Sea) (ADNR 2009). Females and cubs emerge from dens in late March or early April. Coastal areas provide important denning habitat for polar bears. More polar bears are now denning near shore, rather than in far offshore regions. Data indicated that approximately 64% of all polar bear dens in Alaska from 1997 to 2004 occurred on land, compared to approximately 36% of dens from 1985 to 1994 (Fischbach et al. 2007). Recent information indicates that survival rates of cubs-of-the-year are now significantly lower than they were in previous studies, and there has also been a declining trend in cub-of-the-year size for the Southern Beaufort Sea stock. Although many cubs are currently being born into the Southern Beaufort Sea Stock region, more females are apparently losing their cubs shortly after den emergence, lowering recruitment of new bears into the population (Regehr et al. 2006).

Polar bears normally occur at low densities throughout their range. Most of the year, polar bears are solitary or occur in family groups of a mother and her cubs (Lentfer and Small 2008). Polar bears do aggregate along the Beaufort Sea coastline in the fall in areas where harvesting and butchering of marine mammals occurs. Specific aggregation areas include Point Barrow, Cross Island, and Kaktovik (USFWS 2011j). Polar bear concentrations also occur during the winter in areas of open water, such as leads and polynyas, and areas where beach-cast marine mammal carcasses occur (USFWS 2011j).

The predominant prey item of polar bears in Alaska is ringed seals, and to a lesser degree bearded seals (Stirling and McEwan 1975; Stirling and Archibald 1977; Stirling and

Latour 1978) and spotted seals. To hunt seals in the Beaufort Sea, polar bears concentrate in shallow waters less than 300 m (1,000 ft) deep over the continental shelf and in areas with greater than 50% ice cover (Allen and Angliss 2011). In addition, bears may take walruses (Calvert and Stirling 1990), beluga whales (Freeman 1973; Heyland and Hay 1976; Lowry et al. 1987), caribou (Derocher et al. 2000; Brook and Richardson 2002), and other polar bears (Amstrup et al. 2006; Taylor et al. 1985). Cannibalism of cubs and juvenile bears by adult bears is not uncommon (Dyck and Daley 2002; Derocher and Wiig 1999). Polar bears also scavenge whale, seal, and walrus carcasses (USFWS 2008b). When regular prey items are not available, polar bears may consume small mammals, birds, eggs, and vegetation, although these foods are not important dietary components (USFWS 1994b). They also will consume human refuse (Amstrup 2003).

About 20,000 to 25,000 polar bears occur worldwide in 19 relatively discrete populations (USFWS 2008b). A reliable estimate for the Chukchi/Bering Seas stock does not exist, but the best information available provides a minimum population estimate of 2,000 individuals for the stock. There is also no reliable population trend for this stock (Allen and Angliss 2011). The best population estimate for the Southern Beaufort Sea stock is 1,526 individuals with a minimum population abundance of 1,397. This stock is experiencing a population decline due to loss of sea ice (partly due to climate change), potential overharvest, and human activities (including industrial activities) in nearshore and offshore environments (Allen and Angliss 2011).

Marine Mammals Not Listed under the Endangered Species Act.

Cetaceans: Mysticetes. The eastern North pacific population of the gray whale (*Eschrichtius robustus*) was removed from ESA listing in 1994 (USFWS and NMFS 1994). The gray whale (*Eschrichtius robustus*) occurs in the Gulf of Alaska in late March and April, moves into the Northern Bering Sea in May or June, and then enters the Chukchi and Beaufort Sea area in July or August (Rice and Wolman 1971; Consiglieri et al. 1982; Frost and Karpovich 2008). Gray whales migrate out of the Chukchi and Beaufort Seas at freezeup and migrate out of the Bering Sea during November to December (Rugh and Braham 1979). Section 3.5.4.2.1 provides additional information on the gray whale, including population estimates.

The minke whale (*Balaenoptera acutorostrata*) occurs from the Bering and Chukchi Seas south to near the equator with apparent concentrations of whales near Kodiak Island (Leatherwood et al. 1982; Rice and Wolman 1982). Very little is known about minke whale use of the Chukchi Sea, and they would not be expected to occur in the Beaufort Sea. Sightings are infrequent during the summer months in the Chukchi Sea. There are no estimates for minke whales in the Chukchi Sea, but numbers are clearly very low because it is the northern extreme of the species range (Brueggeman 2009). Section 3.5.4.2.1 provides additional information on the minke whale.

Cetaceans: Odontocetes. The beluga whale (*Delphinapterus leucas*) is a subarctic and Arctic species. Both the Beaufort Sea and Eastern Chukchi Sea stocks occur in the Arctic region. Beluga whales are associated with open leads and polynyas in ice-covered regions (Allen and Angliss 2011). Ice cover, tidal conditions, access to prey, temperature, and human interactions affect the seasonal distribution of beluga whales. They occur in ice-covered areas of the Bering Sea in winter and spring and in coastal waters of the Chukchi and Beaufort Seas in summer and fall. Some beluga whales migrate more than 2,700 km (1,500 mi) between the Bering Sea and the Mackenzie River estuary in Canada, sometimes moving more than 180 km (100 mi) per day. They will ascend large rivers and are apparently unaffected by salinity changes (Citta and Lowry 2008).

Small groups of 2 to 5 beluga whales are common, but they can occur in groups of up to 1,000 animals (Citta and Lowry 2008). Adult males will occur together in pods of 8 to10, while females occur in pods with juveniles and calves (Citta and Lowry 2008). Breeding occurs in March or April with calves being born between May and July after a gestation period of about 14.5 months. Calving occurs when herds are generally near or in their summer concentration areas (Citta and Lowry 2008). Fall migration occurs in September and October. While some belugas migrate along the coast (Johnson 1979), most migrate offshore along the pack-ice front (Moore et al. 2000b; Richard et al. 2001; Suydam et al. 2001).

Belugas shed their skin around July. To do this, they tend to concentrate in shallow water where there is coarse gravel to rub against (Citta and Lowry 2008). Feeding occurs over the continental shelf and in nearshore estuaries and river mouths. During summer, belugas feed primarily on various schooling and anadromous fishes and occasionally on cephalopods, shrimp, crabs, and clams. Winter foods are not known (Citta and Lowry 2008). Most feeding dives are to depths of 6 to 30 m (20 to 100 ft) and last up to 5 minutes; however, they can dive to over 860 m (2,800 ft) (Citta and Lowry 2008).

The best population estimate for the Beaufort Sea stock is 39,258 with a minimum estimate of 32,453 individuals; while the best population estimate for the Chukchi Sea stock is 3,710 individuals (which is also considered the minimum population size) (Allen and Angliss 2011). The population trend for the Beaufort Sea stock is unknown, and there is no evidence that the eastern Chukchi Sea stock is declining (Allen and Angliss 2011).

The narwhal (*Monodon monoceros*) typically occurs above the Arctic Circle. Narwhals are most common in Nunavut, Canada, west Greenland, and the European Arctic; but incidental sightings occur in the East Siberian, Bering, Chukchi, and Beaufort Seas (COSEWIC 2004; Jefferson et al. 2006). During summer, narwhals inhabit coastal areas with deep water and shelter from the wind. During the fall migration and, especially, while wintering in the pack ice, they prefer deep fjords and the continental slope at depths of 1,000 to 1,500 m (3,281 to 4,921 ft) (COSEWIC 2004). Narwhals often travel in small groups of under ten individuals, but do congregate in the hundreds during spring and fall migration. Peak mating occurs in mid-April with calving generally occurring in July and August following a gestation of up to 15.3 months (COSEWIC 2004). Prey items include fish and invertebrates including squid, shrimp, cod, and other demersal fish and crustaceans (COSEWIC 2004; Jefferson et al. 1993; Pauley et al. 1995). Population estimates for the Nunavut waters are up to 86,000 individuals (DFO 2008). There are no reliable population estimates or trends in population abundance for the narwhal in Alaska (Allen and Angliss 2011).

The harbor porpoise (*Phocoena phocoena*) ranges from Point Conception, California, to Point Barrow, Alaska (Allen and Angliss 2011 belong to the Bering Sea stock. The Bering Sea stock includes harbor porpoises that occur throughout the Aleutian Islands and all waters north of Unimak Pass (Allen and Angliss 2011). Harbor porpoises frequent waters less than 100 m (325 ft) in depth (Dahlheim et al. 2000). Mating likely occurs from June or July to October, with peak calving occurring the following May and June (Consiglieri et al. 1982). Harbor porpoises consume a wide variety of fish and cephalopods, apparently preferring non-spiny schooling fish such as herring, mackerel, and pollock (Houck and Jefferson 1999; American Cetacean Society 2006). The best population estimate for the Bering Sea stock is 48,215 with a minimum population estimate of 40,039 based on survey data that is over 10 yr old (Allen and Angliss 2011).

The killer whale (*Orcinus orca*) occurs along the entire Alaska coast within the Chukchi Sea, Bering Sea, Aleutian Islands, Gulf of Alaska, Prince William Sound, Kenai Fjords, and southeast Alaska. Some killer whales may also stray into the western portion of the Beaufort Sea. Killer whales that occur in the northern Bering Sea, Chukchi Sea, and Beaufort Sea move south with the advancing pack ice (Culik 2010). Within these areas, three genetically distinct ecotypes, or forms, of killer whales exist: resident, transient, and offshore (Allen and Angliss 2011). The whales found in the Arctic region likely belong to the eastern North Pacific Transient Stock. Members of this stock occur from California to Alaska, with some also occurring within Canadian waters (Allen and Angliss 2011). Section 3.5.4.2.1 provides additional information on the killer whales in Alaska.

Pinnipeds. The ribbon seal (*Phoca fasciata*) inhabits the North Pacific Ocean and adjacent fringes of the Arctic Ocean. In Alaskan waters, ribbon seals occur in the open sea, on the pack ice, and only rarely on shorefast ice (Allen and Angliss 2011), generally occurring in the open sea in summer and on the pack ice in winter (Nelson 2008b). The ribbon seal rarely occurs on land (Boveng et al. 2008). The ribbon seal ranges northward from Bristol Bay in the Bering Sea into the Chukchi and western Beaufort Seas (Allen and Angliss 2011). It inhabits the Bering Sea ice front from late March to early May. As the ice recedes in May to mid-July, ribbon seals move farther north in the Bering Sea, where they haul out on the receding ice edge (Allen and Angliss 2011). Many ribbon seals migrate into the Chukchi Sea for the summer (Allen and Angliss 2011. The ribbon seal is strongly associated with sea ice during its whelping, mating, and molting periods which occur from mid-March through June. During the remainder of the year, ribbon seals remain at sea feeding on fishes, cephalopods, and crustaceans (Nelson 2008a). Reliable population estimates and trends for the Alaska stock of the ribbon seal are not available, although there is a provisional estimate of 49,000 ribbon seals in the eastern and central Bering Sea based on aerial surveys done in 2003, 2007, and 2008 (see Allen and Angliss 2011). This estimate is consistent with historical estimates, which suggests no major changes in the ribbon seal stock over the past several decades (Allen and Angliss 2011).

Only the Bering Sea Distinct Population Segment of the spotted seal (*Phoca largha*) occurs in U.S. waters (NMFS 2011a). It occurs along the continental shelf of the Beaufort, Chukchi, and Bering Seas (Allen and Angliss 2011). It occurs year-round in the Bering Sea, while occurring in the Chukchi and Beaufort Seas in summer (Nelson 2008c). Terrestrial haul-out sites are generally located on isolated mud, sand, or gravel beaches or on rocks close to shore. Haul-out sites are apparently selected based on proximity to food (e.g., in Alaska, haul-out sites are located near herring and capelin spawning areas), lack of disturbance, and favorable tidal conditions (Boveng et al. 2009). Beaufort Sea coastal haul-out and concentration areas include the Colville River Delta, Peard Bay, Smith Bay, and Oarlock Island in Dease Inlet/Admiralty Bay, while along the Chukchi Sea coast they mostly haul out at Kasegaluk Lagoon but also at other locations to a lesser degree. Along the west coast of Alaska, spotted seals occur around the Pribilof Islands, Bristol Bay, and the eastern Aleutian Islands (Allen and Angliss 2011). Spotted seals frequently enter estuaries and sometimes ascend rivers, presumably to feed on anadromous fishes. Spotted seals migrate out of the Arctic region in the fall (September to mid-October) as the shorefast ice reforms and the pack ice advances southward. They spend the winter and spring periods offshore north of the 200-m (660-ft) isobath along the ice front throughout the Bering Sea where pupping, breeding, and molting occur (Lowry et al. 2000). Adult spotted seals forage at depths up to 300 m (984 ft), while pups can dive to 80 m (262 ft) (Boveng et al. 2009). Their diet includes a variety of fishes, crustaceans, and cephalopods (Nelson 2008b). A reliable population estimate for the Alaska stock is not available, but preliminary results provide a population estimate of over 59,000 individuals (Allen and Angliss 2011).

Climate Change. A number of reviews discuss the potential responses of Arctic marine mammals to climate change (e.g., Tynan and DeMaster 1997; Learmonth et al. 2006; Laidre et al. 2008; Moore and Huntington 2008; Ragen et al. 2008; Simmonds and Eliott 2009; Kovacs et al. 2011). Climate change will primarily affect marine mammals from loss of habitat (particularly the extent and concentration of sea ice), changes in prey availability, and potentially increased expansion of other species that are likely to cause competitive pressure on some species, as well as putting them at greater risk of predation, disease, and parasitic infections (Alter et al. 2010; Kovacs et al. 2011). These changes may alter the seasonal distributions, geographic ranges, migration patterns, nutritional status, prey species, reproductive success, and ultimately the abundance and stock structure of some marine mammal species. The capacity of Arctic marine mammals to adapt to new or different food sources will have a key role in their ability to cope with climate change, with generalists probably having a better chance of coping than specialists (Kovacs et al. 2011).

Climate change impacts on marine mammals can be either direct (e.g., effects of reduced sea ice and rising sea levels on seal haul-out sites, or species tracking a specific range of water temperatures in which they can physically survive); or indirect (e.g., changes in prey availability and increased susceptibility to disease or contaminants) (Learmonth et al. 2006). Predicted indirect impacts on cetacean species are decreased reproductive capacity, asynchrony in space or time with prey species, increased prevalence and/or susceptibility to disease, and loss of habitat (Simmonds and Eliott 2009). Alteration of sea ice and the productive food web associated with it, as well as increasing human presence and activities, will cause extensive redistribution of mobile species, disappearance of non-mobile species throughout portions of their range, and possible species extinctions (Ragen et al. 2008). For instance, the loss of sea ice could have some potential beneficial effects on bowhead whales by increasing prey availability (Moore and Laidre 2006). However, loss of sea ice would include increase 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; and changes in subsistence-hunting practices.

Species that seasonally occupy Arctic and subarctic habitats may move further north, remain there longer, and compete with endemic Arctic species (Moore and Huntington 2008). For example, humpback whales now occur as far north as the Beaufort Sea and fin whales occur farther north than usual within the Chukchi Sea. Higher calf counts in the spring are associated with years of delayed onset of freezeup in the Chukchi Sea. Killer whales appear to be extending their season of Arctic habitation and are expanding their range northward. Other species that may be shifting their summer distribution northward in the Arctic include the sei whale, blue whale, minke whale, and harbor porpoise (Kovacs et al. 2011). However, information is not sufficient to determine or predict whether short-term apparent changes in their distribution will persist and become longer term trends in the Arctic (MMS 2008b).

Changes in sea ice will reduce habitat available for ice-associated marine mammals that give birth on sea ice, hide from predators, seek shelter from inclement weather on ice fields, or consume ice-associated fish and invertebrate prey or ice-associated marine mammals (Kovacs et al. 2011). 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 ice-associated pinnipeds that rely on the ice platform for pupping, rest, and molting (Tynan and DeMaster 1997). The early breakup of sea ice has resulted in increased mortality of seal pups within their birth lairs (Stirling and Derocher 1993). In the Alaskan Beaufort Sea, ringed seal-lair abandonment began earlier each year from 1999 (May 21) to 2003 (April 28) and was associated with early onset of spring melt over the sea-ice cover and the snow pack turning isothermal, at which time the thermal and structural integrity of the lairs was compromised (Kelly et al. 2010b). Climate change may adversely affect populations of ringed seals as warmer temperatures and rain may collapse roofs of birth lairs, exposing pups to predators and to wet weather before they have enough blubber to insulate them (Kelly 2001; Ferguson et al. 2005; Citta 2008). Although longer periods of open water may increase prey accessibility, earlier spring break-up may force ringed seal pups into open water at an earlier age and expose them to increased risk of predation and thermal challenges (Ferguson et al. 2005). A loss of suitable sea ice due to climate change could isolate bearded seals from suitable benthic prey communities (Cameron and Boveng 2009).

Reductions in sea-ice coverage would adversely affect the availability of pinnipeds prey for polar bears (Stirling et al. 1999; Stirling and Derocher 1993). This can force polar bears ashore earlier than normal and in poorer condition. Lack of access to seals for a long period of time can cause a decline in polar bear health, reproduction, survival, and population size. Generally, polar bears cannot meet their caloric needs from just terrestrial sources of food (USFWS 2008b). Changing ice conditions due to climate change is expected to increase polar bear use of the coast during open-water seasons (June through November). Polar bears spending extended periods of time on land without an adequate food source may be nutritionally stressed animals and potentially more dangerous when encountering humans (USFWS 2009f). Monnett and Gleason (2006) speculated that mortalities due to offshore swimming during late-ice (or mild ice) years may be an important and unaccounted source of natural mortality given energetic demands placed on individual polar bears engaged in long-distance swimming. Drowning-related deaths of polar bears may increase in the future if the observed trend of pack ice regression and/or longer open water period continues. Polar bear survival, breeding rates, and cub litter survival decline with an increasing number of days per year that waters across the continental shelf are ice free (Regehr et al. 2010).

Pacific walruses have been showing negative impacts of sea-ice reductions (e.g., reports of abandoned calves at sea, and mothers and calves spending more time on land, where stampede incidents have caused significant mortality). The Pacific walrus may also be shifting its diet toward eating more seals and fewer benthic invertebrates (Kovacs et al. 2011). Decreases in summer extent of sea ice may decrease the access of Pacific walrus to their food resources and increase their exposure to polar bear predation (Kelly 2001).

Unusual Mortality Event in the Arctic. On December 20, 2011, NMFS declared an UME in the Arctic and Bering Strait region of Alaska. From mid-July through December 20, 2011, over 60 dead and 75 diseased seals (mostly ringed seals) were reported in Alaska (NMFS 2011k). Some diseased spotted and bearded seals were also reported (NMFS 2011l). The USFWS also identified diseased and dead walruses at the annual mass haulout at Point Lay (NMFS 2011k). Symptoms of the disease included skin sores (usually on the hind flippers or face) and patchy hair loss. Similar symptoms have been observed in ringed seals and walruses in Russia and ringed seals in Canada (NMFS 2011k). Necropsies have revealed fluid in the lungs, white spots on the liver, and abnormal growths in the brain. Undersized lymph nodes, indicating compromised immune systems, were also seen in some of the pinnipeds. Animals still alive also exhibited labored breathing and appeared lethargic. A single cause of the disease is not known, but tests have ruled out radionuclide exposure and a number of bacteria and viruses known to affect marine mammals (NMFS 2011k, 2012c,d). Potential causes of the disease being investigated include immune system-related diseases, fungi, man-made toxins, bio-toxins, contaminants, and stressors related to sea ice change (NMFS 2011k). Few cases of the disease were found from November 2011 through March 2012 (NMFS 2012d). Additional information on this UME can be found at NOAA(2012c) and USFWS (2012i). On April 6, 2012, the USGS (2012) reported that nine polar bears in the southern Beaufort Sea region near Barrow have been observed with alopecia (loss of fur) and other skin lesions. The cause of these symptoms, and whether they are related to similar symptoms for sei seals and walruses, is unknown at this time.

3.8.1.3.2 Terrestrial Mammals. No terrestrial mammals listed under the ESA occur in the Arctic region. Approximately 30 species of terrestrial mammals not listed under the ESA occur in Alaska’s Arctic region (Sage 1996); these species include big game species such as the brown bear (*Ursus arctos*), caribou (*Rangifer tarandus*), moose (*Alces alces*), Dall sheep (*Ovis dalli*), and muskox (*Ovibos moschatus*); furbearers such as the Arctic fox (*Alopex lagopus*), ermine (*Mustela ermine*), gray wolf (*Canis lupus*), least weasel (*Mustela rixosa*), North American river otter (*Lutra canadensis*), red fox (*Vulpes vulpes*), and wolverine (*Gulo gulo*); and small mammal prey species such as Alaska marmots, Arctic ground squirrels, Alaskan hare (*Lepus othus*), snowshoe hare (*Lepus americanus*), Alaska marmot (*Marmota broweri*), and the brown lemming (*Lemmus trimucronatus*) (ADFG 2011a; Carroll 2007; Szepanski 2007). Among these, the Arctic fox, brown bear, caribou, and muskox are the species most likely to be affected by proposed OCS oil and gas activities. The following information describes the life history attributes, distribution, and seasonal movement for these terrestrial mammal species in the Arctic region.

Arctic Fox (*Alopex lagopus*). In Alaska, the Arctic fox occurs in treeless coastal areas from the Aleutian Islands north to Point Barrow and east to the U.S./Canadian border (Stephenson 2008). Pups are born in dens that adults construct in sandy, well-drained soils of low mounds and river cutbanks (Stephenson 2008). In winter, dens provide shelter. In developed areas, Arctic foxes also use culverts and road embankments as denning sites (Audet et al. 2002). A den may cover more than 50 m^2 (540 ft^2) and contain up to 100 entrances. Den densities range from 1.0 den/2,500 km^2 (965 mi^2) to 1.0 den/12 km^2 (5 mi^2) (Audet et al. 2002). Arctic fox populations peak whenever lemmings and voles (their main prey) are abundant (Stephenson 2008). Other food sources include carrion, insects, berries, and newborn ringed seal pups (Frafjord 1993; Hammill and Smith 1991). Arctic foxes are the most common predator of Arctic nesting birds and their eggs. They will cache eggs to consume during the winter. A single Arctic fox is capable of caching hundreds of eggs per nesting season (Audet et al. 2002). Marine mammals are an important part of the diet of Arctic foxes that occur along the coast of western Alaska (Anthony et al. 2000). In winter, Arctic foxes primarily feed on remains of polar bear kills (USFWS 2008b), and many Arctic foxes venture onto sea ice to search for seal remains (Stephenson 2008). The availability of winter food sources directly affects the Arctic foxes’ abundance and productivity (Angerbjorn et al. 1991). During midwinter, Arctic foxes tend to be solitary except when congregating at carcasses of marine mammals or caribou (Stephenson 2008). Arctic foxes on the Prudhoe Bay oil field readily use developed sites for feeding, resting, and denning; their densities are equal to or greater in the oil fields than in surrounding undeveloped areas (Eberhardt et al. 1982; Ballard et al. 2000). Development on the Prudhoe Bay oil fields probably has led to increases in Arctic fox abundance and productivity (Burgess 2000).

Brown Bears (*Ursus arctos*). Population estimates for brown (grizzly) bears across the North Slope of Alaska are: 900 to 1,120 in Game Management Unit 26A (western North Slope) and 659 in Game Management Units 26B and 26C (eastern North Slope) (Carroll 2009; Lenart 2009c). Brown bears are solitary animals except when breeding or concentrating near high-value food sources. On the North Slope, brown bear densities vary from about 0.1 to 2.3 bears/100 km^2 (0.3 to 5.9 bears/100 mi^2), with a mean density of 0.4 bear/100 km^2 (1 bear/100 mi^2). The number of brown bears using the Prudhoe Bay and Kuparuk oil fields adjacent to the Liberty Project in the Beaufort Sea has increased in recent years. An estimated 60 to 70 brown bears, or approximately 4 bears/1,000 km^2 (10 bears/1,000 m^2), inhabit the oil field area (Shideler and Hechtel 2000). Brown bears in the oil field area can have large home ranges, between 2,600 to 5,200 km^2 (1,000 to 2,000 mi^2), and travel up to 50 km (31 mi) per day (Shideler and Hechtel 1995). Home range size is influenced by the distribution of food and by the individual’s age, sex, social status, condition, and foraging habits (Pasitschniak-Arts 1993). Home ranges overlap and there is no territorial defense (Pasitschniak-Arts 1993). Most brown bears den and hibernate during winter when food is scarce. On the North Slope, den sites are located in pingos, banks of rivers and lakes, sand dunes, and steep gullies in the uplands (Harding 1976; Shideler and Hechtel 1995). The grass meadows on the bluffs along the Colville River provide forage for brown bears during the spring. Common foods include berries, nuts, vegetation, roots, insects, fish, ground squirrels, birds and their eggs, carrion, and human garbage. In the Arctic region, brown bears will also prey on newborn muskoxen and particularly caribou and will occasionally prey on healthy adults of these species. Large males prey on newborn brown bear cubs and occasionally females (Pasitschniak-Arts 1993).

Caribou (*Rangifer tarandus*). Within the coastal habitats adjacent to the Arctic region occur two large caribou herds — the Western Arctic Herd (WAH) and the Porcupine Caribou Herd (PCH) — and two smaller herds — the Teshekpuk Lake Herd (TLH) and the Central Arctic Herd (CAH) (Figure 3.8.1-7). While the calving areas are separate for each herd, some intermingling occurs on winter and summer ranges (ADNR 2009; Lenart 2009a). Caribou herd size naturally fluctuates (e.g., cycles of years of growth followed by years of decline) due to a number of factors such as weather patterns, overpopulation, predation, disease, and hunting (Valkenburg and Arthur 2008).

The WAH herd, covering about 363,000 km^2 (140,000 mi^2) (Dau 2009), ranges over northwestern Alaska from the Chukchi Coast east to the Colville River and from the Beaufort Coast south to the Kobuk River. Herd size estimates included 490,000 animals in 2003, 377,000 in 2007, and 348,000 in 2009 (ADFG 2011d).

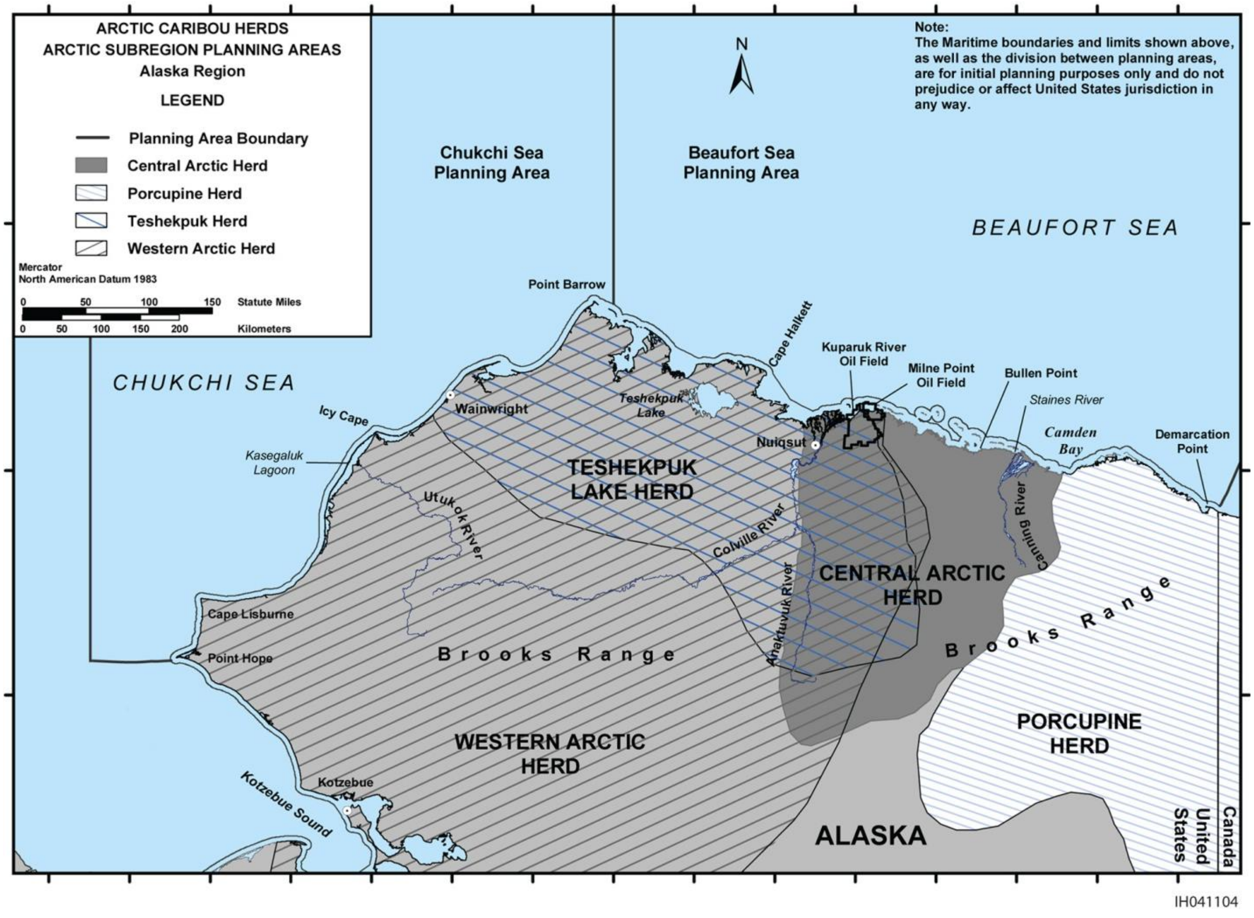


FIGURE 3.8.1-7 Distribution of Caribou Herds in the Arctic Region (Source: MMS 2007a)

The PCH, covering about 336,700 km^2 (130,000 mi^2) (Caikoski 2009), ranges south from the Beaufort Sea Coast, from the Canning River of Alaska in the west, eastward through the northern Yukon and portions of the Northwest Territories in Canada, and south to the Brooks Range. The herd peaked at 178,000 caribou in 1989, but had declined to 123,000 by 2001 (Caikoski 2009). A 2010 photocensus indicates the herd has grown to an estimated 169,000 caribou (ADFG 2011c).

The TLH primarily inhabits the central coastal plain north of the Brooks Range in spring and summer; its wintering areas encompass much of northwestern Alaska (Parrett 2009). The TLH occurs primarily within the National Petroleum Reserve-Alaska (NPR-A), with its summer range extending between Barrow and the Colville River. It uses the area around Teshekpuk Lake for calving, grazing, and insect relief (ADNR 2009). In some years, most of the TLH remains in the Teshekpuk Lake area all winter. In other years, part or all of the herd winters in the Brooks Range or within the range of the WAH and CAH. The TLH contained a record 64,106 caribou in 2008 (Parrett 2009).

The CAH ranges from the Itkillik River east to the Canning River and from the Beaufort Coast south into the Brooks Range. It occurs east and west of the Sagavanirktok River, and individuals show considerable movement between the eastern and western segments of the herd (Cronin et al. 2000; Lenart et al. 2009a). In 2008, the CAH totaled about 67,772 caribou (Lenart 2009a).

Most caribou herds migrate seasonally between their calving area, summer range, and winter range to take advantage of seasonally available forage resources; however, as previously mentioned, in some years the TLH may remain in the Teshekpuk Lake area the entire year. If movements are greatly restricted, caribou are likely to overgraze their habitat, perhaps leading to a drastic, long-term population decline. The winter diet of caribou consists predominantly of lichens and mosses, shifting to vascular plants during the spring (Thompson and McCourt 1981). However, when TLH caribou winter near Teshekpuk Lake, where relatively few lichens are present, the herd may consume more sedges and vascular plants.

Spring migration of parturient female caribou from the overwintering areas to the calving grounds starts in April (Dau 2009). Often the most direct routes are used; however, certain drainages and routes are used during calving migrations because they tend to be corridors free of snow or with shallow snow (Lent 1980). Bulls and non-parturient females generally migrate at a very leisurely pace, with some remaining on winter ranges until June. Severe weather and deep snow can delay spring migration, with some calving occurring en route. Cows calving en route usually proceed to their traditional calving grounds (USFWS 2008d).

The spring migration to traditional calving grounds consistently provides high nutritional forage to lactating females during calving and nursing periods, which is critical for the growth and survival of newborn calves. Calciphiles such as the sheathed cottonsedge (*Eriophorum vaginatum*) appear to be very important in the diet of lactating caribou cows during the calving season (Lent 1966; Thompson and McCourt 1981; Eastland et al. 1989), while shrubs (especially willows) are the predominant forage during the post-calving period (Thompson and

McCourt 1981). The winter availability of sedges, which are dependent on temperature and snow cover, probably affects specific calving locations and calving success.

Cows reach calving grounds from mid-May to the first few days in June, with calving occurring late May through early June (Dau 2009; ADNR 2009). The sequential spring migration, first by cows and later by bulls and the rest of the herd, is a strategy for optimizing the quality of forage as it becomes available with snowmelt on the Arctic tundra (Whitten and Cameron 1980). The earlier migration of parturient cow caribou to the calving grounds also could reduce forage competition with the rest of the herd during the calving season.

Insect-relief areas become important during late summer when oestrid fly and mosquito harassment peaks (Valkenburg and Arthur 2008). Harassment by insects reduces foraging efficiency and increases physiological stress (Hagemoen and Reimers 2002). Caribou use various coastal and upland habitats for relief from insect pests, including areas such as sandbars, spits, river deltas, some barrier islands, mountain foothills, snow patches, and sand dunes. Stiff breezes in these settings prevent insects from concentrating and alighting on the caribou. Members of the TLH generally aggregate close to the coast for insect relief, but some small groups gather in other cool windy areas such as the Pik Dunes located about 30 km (19 mi) south of Teshekpuk Lake (Hemming 1971; Person et al. 2007). Caribou aggregations move frequently from insect-relief areas along the Arctic coast (CAH, WAH, and especially the TLH) and in the mountain foothills (some aggregations of the WAH) to and from green foraging areas. After calving along the coast, much of the PCH will move back into the Brooks Range foothills for insect relief.

During the post-calving period in July through August, caribou generally attain their highest degree of aggregation. They join into increasingly larger groups, foraging primarily on the emerging buds and leaves of willow shrubs and dwarf birch (Thompson and McCourt 1981). In the PCH and WAH, continuous masses of animals can number in the tens of thousands. Cow/calf groups are most sensitive to human disturbance during this period.

Fall migration begins from mid-August through late September and can last through late November. Migration is triggered by weather conditions such as the onset of cold weather or a snowstorm (ADNR 2009). Once on wintering grounds, caribou are relatively sedentary until spring migration initiates (Dau 2009). The primary winter range of the WAH is located south of the Brooks Range along the northern fringe of the boreal forest. During winters of heavy snowfall or severe ice crusting, caribou may overwinter within the mountains or on the Arctic Slope (Hemming 1971). Even during normal winters, some caribou of the WAH overwinter on the Arctic Coastal Plain (Davis et al. 1982). The TLH generally calves south of Teshekpuk Lake. The herd is distributed all around the lake by late June and by late July is spread widely from the Colville River to Barrow. The herd is again south of the lake by late August. Major wintering concentrations occur southeast of the lake and in the foothills of Brooks Range (Parrett 2009). The CAH overwinters primarily in the northern foothills of the Brooks Range (Lenart 2009a).

The movement and distribution of caribou over the winter ranges reflect their need to avoid predators and their response to wind (storm) and snow conditions (depth and snow density), which greatly influence the availability of winter forage (Henshaw 1968; Bergerud and Elliot 1986). The numbers of caribou using a particular portion of the winter range are highly variable from year to year (Davis et al. 1982; Whitten 1990). Range condition, distribution of preferred winter forage (particularly lichens), and predation pressure all affect winter distribution and movements (Johnson et al. 2001; Joly 2011).

Muskox (*Ovibos moschatus*). Indigenous populations of muskox were extirpated in the 1800s in northern Alaska (Smith et al. 2008). As a result of restoration efforts, numbers of muskoxen in Alaska had grown to about 3,800 individuals by the year 2000. This included 650 on Nunivak Island, 250 on Nelson Island, 550 in north-central and northeastern Alaska, 450 in northwestern Alaska, 1,800 on the Seward Peninsula, and 100 on the Yukon-Kuskokwim Delta (Smith et al. 2008). Between the years 2000 and 2006, the numbers in north-central and northwestern Alaska declined by about 200 individuals. The most likely factors causing this decline are severe winters, predation by bears and wolves, and the limited availability of winter forage (Smith et al. 2008). Smith et al. (2008) concluded that muskoxen populations elsewhere in Alaska will continue to increase and expand their range. Lenart (2009b) stated that the likely combined population of muskoxen in Game Management Units 26A (eastern portion), 26B, and 26C, which comprise the Arctic Slope area, is less than 300 individuals. There is little or no overlap of habitat and feeding sites between muskoxen and caribou (Lent 1988).

Unlike caribou, muskoxen are sedentary, but will engage in limited movement in response to seasonal changes and variations in snow cover and vegetation. Being poor diggers, their winter habitat is generally restricted to areas with minimal snow accumulations or areas blown free of snow (Smith et al. 2008). They also use willow-shrub riparian habitats along the major river drainages on the Arctic Slope year-round. Calving takes place from mid-April through June (Lent 1988). Distributions of muskoxen during the calving season, summer, and winter are similar, with little movement during winter (Reynolds 1992). The breeding season occurs from August to October with calves born the following April to June (Smith et al. 2008). During the mating season, harems consist of 5 to 15 females and subadults with one dominant bull; mixed male and female winter herds may contain up to 75 animals. Some non-breeding bulls may form bull-only herds during spring (Smith et al. 2008). Muskoxen are herbivores and consume grasses, sedges, forbs, and woody plants (Smith et al. 2008).

Climate Change. An increase in temperature associated with climate change is not expected to directly affect most terrestrial mammals. Physiological tolerance to heat load would allow most species to survive, but changes in habitat through climate-vegetation linkages are expected to influence terrestrial mammal distributions (Johnston and Schmitz 1997). Climate change is predicted to increase the number and geographic range of large rain-on-snow events. When rain falls on snowpack, the rain either pools at the surface or trickles down to the soil below the snowpack, then freezes into a sheet of ice. Such events have been known to cause death due to starvation to muskoxen and caribou because they are unable to break through the ice to browse on plants under the snow (Putkonen and Roe 2003; Joyce 2009).

Other effects of climate change on caribou herds potentially include alteration in habitat use, migration patterns, foraging behavior, quality of forage, and demography (Lenart et al. 2002; Vors and Boyce 2009; Sharma et al. 2009). If climate change brings about a longer growing season, the amount of plant biomass available for caribou may increase and likely decrease calf abortion, improve birth mass of calves, and increase parturition rates (Couturier et al. 2009; Tews et al. 2007); this would increase the survival and fecundity of migratory caribou and may also decrease the dependence of caribou on lichen (Sharma et al. 2009). However, adverse effects can occur if there is a mismatch between the timing of increased resource demands by caribou and resource availability. In West Greenland, this has caused an increase in offspring mortality and a decrease in offspring production (Post and Forchhammer 2008). It is also possible that climate change may lead to an overlap of herds in spring that could increase competition on the calving grounds or change their distribution (Post and Forchhammer 2008).

The absence or incomplete formation of ice on large streams and rivers can result in delays in crossing and possibly drowning of some migratory caribou (Sharma et al. 2009). Increased insect harassment appears to be a key climate change related factor that may adversely impact caribou (Weladji et al. 2002; Sharma et al. 2009). In addition, warming temperatures will benefit free-living bacteria and parasites whose survival and development is limited by lower temperatures. Climate warming may also favor the release of persistent environmental pollutants, some of which can affect wildlife immune systems and may favor the increased rates of some diseases (Bradley et al. 2005). Overall, climate change is predicted to negatively impact caribou body condition and demography (Couturier et al. 2009; Miller and Gunn 2003).

Potential changes in habitat across the North Slope due to development and climate change may influence the distribution and abundance of muskoxen in the future (Smith et al. 2008). Population declines in muskoxen are proposed to occur due to changes in forage availability, insect harassment, parasite load, infectious diseases, and habitat availability (Ytrehus et al. 2008). The absence or incomplete formation of ice on large streams and rivers can possibly result in drowning of muskoxen (Sharma et al. 2009).

Red foxes prey on and are superior hunters to Arctic foxes. Their expansion into the range of the Arctic fox, which has already begun, will continue as the tundra warms. In addition, Arctic fox prey (lemming and voles) are expected to have their population cycles disrupted and their numbers decrease as the climate changes (Hersteinsson and Macdonald 1992; Sillero-Zubiri and Angerbjorn 2009).

Because brown bears are opportunistic, omnivorous, and highly adaptable, climate change it is not expected to threaten their populations due to ecological threats or constraints; however, it may lead to an increase in brown bear/human interactions, in part from later den entry and earlier den exit (Servheen and Cross 2010).

3.8.2 Marine and Coastal Birds

3.8.2.1 Marine and Coastal Birds of the Northern Gulf of Mexico

The northern GOM and its ecoregions possess a diverse bird fauna composed of resident marine and coastal species (Clapp et al. 1982; Sibley 2000). The bird fauna of the region also includes many species that inhabit northern latitudes and pass through the region in large numbers during spring and fall migrations (Russell 2005), or move into coastal habitats of the GOM to overwinter. For example, in the fall, many migratory species arrive at the northern GOM coast and then fly several hundred miles directly across the open waters or westward along the coast to wintering areas in Central and South America (Lincoln et al. 1998).

3.8.2.1.1 Nonendangered Species. Nearly all birds, regardless of Federal ESA listing, are protected by the Migratory Bird Treaty Act of 1918 as well as by State laws. The northern GOM, with its diverse array of terrestrial and aquatic habitats, supports a diverse avifauna of well over 600 species (Table 3.8.2-1). Many of these species may be found in more than one of the five GOM States, while a much smaller subset are largely restricted to a particular State or locale. For example, the brown pelican (*Pelecanus occidentalis*) is ubiquitous throughout the GOM States, while the endangered Mississippi sandhill crane (*Grus canadensis pulla*) is only found in Mississippi.

Although more than 400 species have been reported in the northern GOM, many of these species would not be likely to occur in marine and coastal habitats where they could encounter OCS oil and gas activities. Instead, these species occur in more interior, terrestrial habitats. Species that would be most likely to encounter, and thus be potentially affected by, OCS oil and gas activities are the aquatic/semi-aquatic species that rely on coastal and marine habitats. Within any individual GOM State, these species account for between 34 and 40% of all species reported from the State. Among these aquatic/semi-aquatic species, several species are very uncommon or incidental in occurrence, being occasional visitors or transients that in some cases may only be observed once every few years (Table 3.8.2-1). These species account for no more than 10% of all species reported from any of the GOM States. The occurrence of some other species is based on observations of individuals following large storm events such as hurricanes. For example, the brown noddy (a type of tern) has been reported only six times from Alabama, and three of those were following the passage of Hurricanes Frederick (1979), Isidore (2002), and Ivan (2004) (Alabama Ornithological Society 2011).

There are six general categories of marine and coastal birds that occur in the GOM region for at least some portion of their life cycle: seabirds, shorebirds, wetland birds, waterfowl, passerines, and raptors (Table 3.8.2-2). The first four categories represent birds that greatly utilize marine and coastal habitats (such as beaches, mud flats, salt marshes, coastal wetlands, and embayments), and thus these birds have the greatest potential for interacting with at least some phases of OCS-related oil and gas development activities, and for being affected by accidental oil spills that reach those habitats. For any of these categories, the occurrence and

TABLE 3.8.2-1 Number of Bird Species Reported from the Gulf Coast States

State	Total Number of Reported Species	Number of Aquatic/Semi-aquatic Species that Could Occur in Coastal and Marine Habitats[a]	Number of Aquatic/Semi-aquatic Species that are Very Uncommon or Incidental in Occurrence[b]
Florida[c]	510	189 (37%)	29 (6%)
Mississippi[d]	408	155 (38%)	37 (9%)
Alabama[e]	413	165 (40%)	35 (8%)
Louisiana[f]	471	172 (37%)	45 (10%)
Texas[g]	636	215 (34%)	65 (10%)

[a] Species that use coastal and marine aquatic habitats for nesting and/or foraging. Values in parentheses indicate the percent contribution of the aquatic/semi-aquatic species to the total number of species reported for the State.

[b] Species that are infrequently observed; many are currently in review regarding occurrence. Values in parentheses indicate the percent contribution of aquatic/semiaquatic species to the total number of species reported for the State.

[c] Source: Florida Ornithological Society 2011.

[d] Sources: Mississippi Ornithological Society 2007; Mississippi Coast Audubon Society 2010.

[e] Source: Alabama Ornithological Society 2006.

[f] Source: Louisiana Bird Records Committee 2011.

[g] Source: Texas Ornithological Society 2011.

abundance of individual species and types of birds varies considerably, both spatially and temporally.

Seabirds spend a large portion of their lives on or over seawater and may be found in both offshore and coastal waters of the northern GOM, where they feed on fish and invertebrates. This category is represented by four orders of birds, and includes gulls, terns, and phalaropes; loons; frigatebirds, pelicans, tropicbirds, cormorants, gannets, and boobies; and storm-petrels and shearwaters (Table 3.8.2-2). Some birds (such as the boobies, petrels, and shearwaters) inhabit only pelagic habitats in the GOM, including deeper waters of the continental slope and GOM basin. Most GOM seabird species, however, inhabit waters of the continental shelf and adjacent coastal and inshore habitats of the estuarine and neritic ecoregions. The temporal occurrence of seabirds in the GOM varies greatly among species and groups. Some species (e.g., northern gannet [*Morus bassanus*], black tern [*Chlidonias niger*]) may be fairly common in some areas in winter although they breed outside the GOM, while others (e.g., least tern [*Sternula antillarum*]) are most common in summer months when they breed in the GOM. Still other species, such as many of the gulls and other terns and the brown pelican, may be present year round and nest in appropriate habitats in the GOM.

TABLE 3.8.2-2 Marine and Coastal Birds of the Gulf of Mexico

Category	Order	Common Name	Representative Types
Seabirds	Charadriiformes	Gulls and terns Phalaropes	Ring-billed gull, laughing gull, common tern, Caspian tern
	Pelicaniformes	Frigatebirds Pelicans Tropicbirds Gannets and boobies	Magnificent frigatebird, brown pelican, northern gannet
	Procellariiformes	Storm-petrels Shearwaters	Band-rumped storm-petrel, Audubon's shearwater
Shorebirds	Charadriiformes	Plovers Oystercatchers Stilts and avocets Sandpipers, snipes, and allies	Semipalmated plover, American oystercatcher, willet, black-necked stilt
Wetland birds	Ciconiiformes	Bitterns, egrets, and herons Storks Ibises and spoonbills	Great blue heron, snowy egret, wood stork, white ibis
	Gruiformes	Cranes Limkins Rails and coots, and gallinules	Sandhill crane, sora, American coot
	Pelicaniformes	Cormorants	Double-crested cormorant
	Podicipediformes	Grebes	Pied-billed grebe, horned grebe
Waterfowl	Anseriformes	Ducks, geese, and swans	Blue-winged teal, mallard, red-breasted merganser, ring-necked duck, bufflehead, surf scoter
	Gaviiformes	Loons	Common loon
Passerines	Passeriformes	Perching birds	Warblers, swamp sparrow, thrushes, marsh wren, boat-tailed grackle
Raptors	Falconiformes	Birds of prey	Osprey, bald eagle

Shorebirds are represented by a single order and include the plovers, oystercatchers, stilts, avocets, sandpipers, and other similar forms (Table 3.8.2-2). These are typically small wading birds that feed on invertebrates in shallow waters and along beaches, mudflats, sand bars, and other similar areas. Shorebirds may be solitary or occur in small- to moderate-sized single-species flocks, although large aggregations of several species may be encountered, especially during migration. Shorebirds are generally restricted to coastline margins except when migrating, and would not be expected to occur over open waters of the continental shelf, slope, and basin areas of the GOM. Many North American shorebirds seasonally migrate between the high Arctic and South America, passing through the GOM during migration (Lincoln et al. 1998). Certain coastal and adjacent inland GOM wetlands serve as important habitats for overwintering shorebirds, and as temporary feeding and resting habitats for migrating shorebirds (see the later discussion on important bird areas of the GOM).

Overwintering shorebird species remain within specific areas throughout the season and typically utilize the same areas year after year; many of these areas in the northern GOM have been identified important bird areas (for example, ABC 2011; Audubon Society 2011a; see later discussion in this section). Overwintering shorebirds, as well as those that nest in spring and summer in specific areas, may be especially susceptible to habitat loss or degradation unless they move to other suitable habitats (if available) when their habitats are disturbed.

The wetland birds include a diverse array of birds from four orders (Table 3.8.2-2) that typically inhabit most coastal aquatic habitats of the northern GOM, including freshwater swamps and waterways, brackish and saltwater wetlands, and embayments. This group includes the large and small wading birds such as herons, egrets, cranes, rails, and storks, as well as diving birds such as cormorants and grebes. Most wetland birds are year-round residents of GOM coastal areas, with colonial or solitary nesting behaviors. Colonial nesting sites may be used year after year, typically being abandoned only following some sort of major disturbance (such as severe storm damage). Wetland birds feed on primarily fish and invertebrates (Sibley 2000). Similar to the shorebirds, this category may be especially susceptible to habitat loss or degradation unless they move to other suitable habitats when their current habitats are disturbed; colonial nesting habitats would be most difficult to replace.

Waterfowl are a diverse and important group that includes ducks, geese, loons, and swans. More than 30 species have been reported from coastal waters, beaches, flats, sandbars, and wetland habitats throughout the northern GOM (Sibley 2000). These birds forage on surface and submerged aquatic vegetation and aquatic invertebrates. There are three general groups of ducks. The surface-feeding ducks, such as the mallard (*Anas platyrhynchos*) and American widgeon (*A. americana*), use shallow freshwater and saltwater marshes throughout the northern GOM, and many are present throughout the year. In contrast, bay ducks (such as the ring-necked duck [*Aythya collaris*]) are diving ducks that frequent coastal bays and river mouths, typically overwintering in the northern GOM and nesting elsewhere. The sea ducks are diving ducks that occur in marine habitats except during the breeding season. Some species have developed salt glands to aid them in using saltwater habitats. Example species include the bufflehead (*Bucephala albeola*) and Barrow's goldeneye (*B. islandica*). The mergansers are fish-eating diving birds that overwinter in coastal habitats in the GOM. Geese and swans forage on vegetation in coastal lakes, rivers, and marshes and, with the exception of the Canada goose (*Branta canadensis*), they overwinter in the GOM and spend the rest of the year in other areas.

The passerines are perching birds, and include the sparrows, warblers, thrushes, blackbirds, wrens, and many other types of birds (Table 3.8.2-2). While the northern GOM provides suitable habitat and supports a wide diversity of year-round resident passerine species, many species are winter residents that move into the GOM in the fall from farther north to overwinter before returning to breeding areas in more northern latitudes.

Raptors are the birds of prey. While most prey on birds and small mammals in terrestrial habitats, two species are fish eaters and if present may forage in coastal freshwater and saltwater habitats. These species are the bald eagle and the osprey, and they may be found year round in the GOM and nesting in suitable habitats.

3.8.2.1.2 Birds Listed under the Endangered Species Act. The ESA was passed in 1973 to address the decline of fish, wildlife, and plant species in the United States and throughout the world. The purpose of the ESA is to conserve "the ecosystems upon which endangered and threatened species depend" and to conserve and recover listed species (ESA; Section 2). The law is administered by the Department of the Interior's USFWS and the Department of Commerce's NMFS. The USFWS has primary responsibility for terrestrial and freshwater organisms, while the NMFS is responsible primarily for marine species such as salmon and whales.

Under the law, species may be listed as either "endangered" or "threatened." The ESA defines an endangered species as any species that is in danger of extinction throughout all or a significant portion of its range (ESA; Section 3(6)). A threatened species is one that is likely to become an endangered species within the foreseeable future throughout all or a significant part of its range (ESA; Section 3(20)). All species of plants and animals, except pest insects, are eligible for listing as endangered or threatened. The ESA also affords protection to "critical habitat" for threatened and endangered species. Critical habitat is defined as the specific areas within the geographical area occupied by the species at the time it is listed on which are found physical or biological features essential to the conservation of the species and that may require special management considerations or protection (ESA; Section 3(5)(A and B)). Except when designated by the Secretary of the Interior, critical habitat does not include the entire geographical area that can be occupied by the threatened or endangered species (ESA; Section 3(5)(C)).

Some species may also be listed as "candidate" species (ESA; Section 6(d)(1) and Section 4(b)(3)). The USFWS defines candidate species as plants and animals for which the USFWS has sufficient information on their biological status and threats to propose them for listing as endangered or threatened under the ESA, but for which development of a listing regulation is precluded by other higher priority listing activities (USFWS 2001a). The NMFS defines candidate species as those whose status is of concern but about which more information is needed before they can be proposed for listing. Candidate species receive no statutory protection under the ESA, but by definition these species may warrant future protection under the ESA.

Several species of federally endangered, threatened, or candidate species of birds occur in the northern GOM during at least part of the year (Table 3.8.2-3). These include species that use primarily coastal beach and wetland habitats. The threatened or endangered species are the Audubon's crested caracara (*Polyborus plancus audobonii*), the Mississippi sandhill crane, the piping plover (*Charadrius melodus*), the roseate tern (*Sterna dougallii dougallii*), the whooping crane (*Grus americana*), and the wood stork (*Mycteria americana*). A single candidate species, the red knot (*Calidris canutus rufa*), is also reported from coastal habitats along the northern GOM. Among the threatened and endangered species, five are found in habitats within the OCS GOM Planning Areas where they could be affected by OCS oil and gas activities, and four are

TABLE 3.8.2-3 Species Listed as Endangered, Threatened, or Candidate under the Endangered Species Act That May Occur in Coastal or Marine Habitats of the Northern Gulf of Mexico

Species	Status	FL	AL	MS	LA	TX
Audubon's Crested Caracara	T	+	–	–	–	–
Mississippi Sandhill Crane	E	–	–	+	–	–
Piping Plover	T/E	+	+	+	+	+
Red Knot	C	+	+	+	+	+
Roseate Tern	T	+	–	–	–	–
Whooping Crane	E	–[a]	–	–	–[a]	+
Wood Stork	E	+	+	–	–	–

[a] Reintroduced as non-essential experimental population (USFWS 2011c).

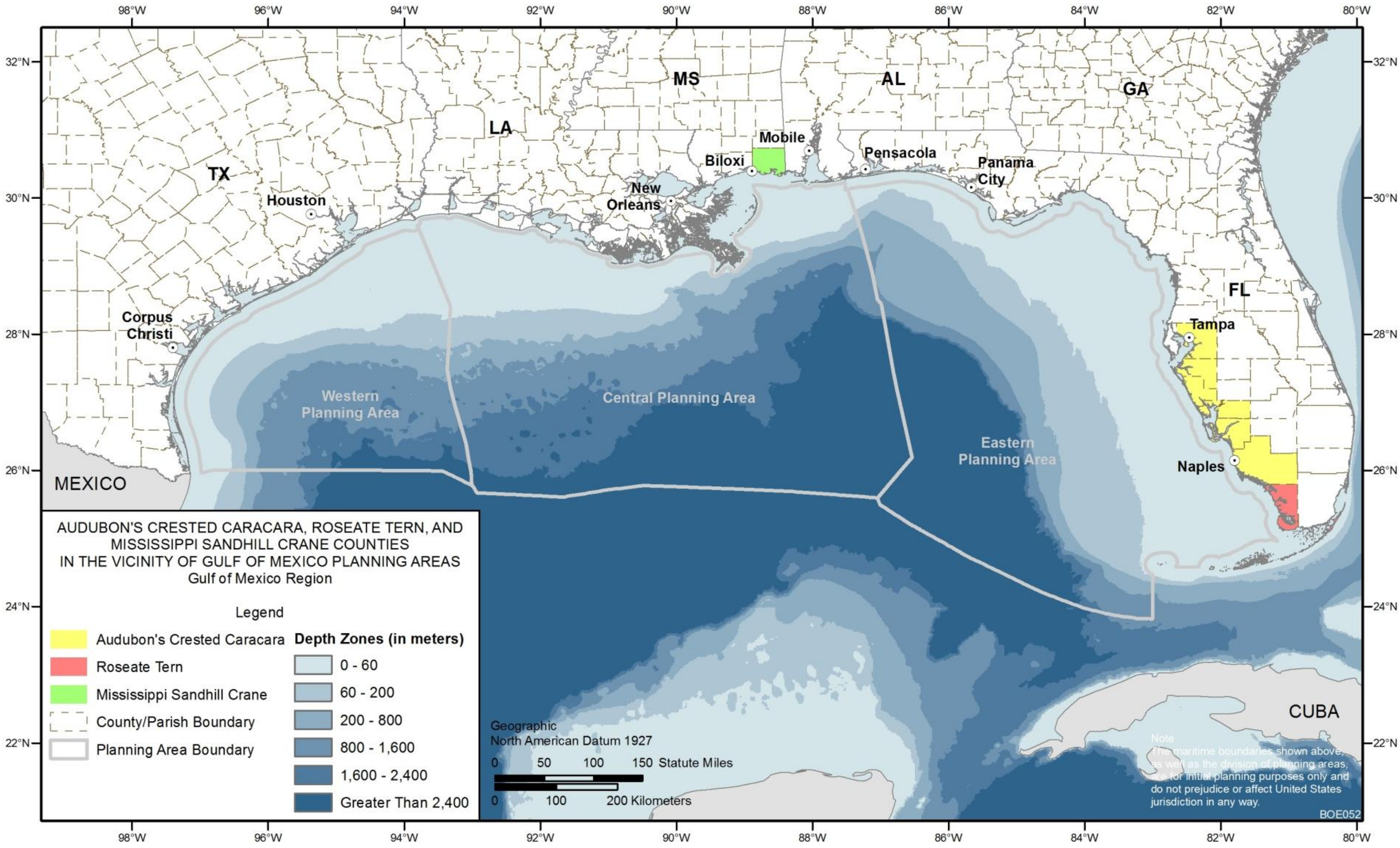
Source: USFWS 2011d.

reported from Florida (two species are exclusive to Florida) in areas where they could be affected by a catastrophic oil spill but not by normal OCS oil and gas operations.

The Audubon's crested caracara is a large, diurnal raptor that is primarily associated with open country (pastureland, cultivated fields, and semidesert) but has been reported from coastal lowlands and beaches in some areas (USFWS 1999b). Nesting occurs in trees or cacti where possible, but crested caracaras will also nest on rock ledges or in brush in treeless areas. Crested caracaras commonly feed on roadkill and are often associated with vultures (USFWS 1999b). This species is currently listed as threatened for populations found in six coastal counties in Florida and has also been reported from coastal counties in Texas and Louisiana (USFWS 2011d; Figure 3.8.2-1). Because of its habitat preferences, this species is not expected to occur in areas where it could be affected by shore-based OCS-related oil and gas activities. In the event of an oil spill contacting coastlines in these counties, this species could be affected, if present.

The endangered Mississippi sandhill crane is a long-necked, long-legged wading bird that stands about 1.2 m (4 ft) tall. Habitats for this species include open savannas, swamp edges, young pine plantations, and wetlands along pine forests (NatureServe 2011a). Nesting territories are occupied year after year (NatureServe 2011a). It feeds on aquatic invertebrates, reptiles, amphibians, insects, and aquatic plants, picking food items from the ground surface or probing into the substrate. The only known wild population (about 120 individuals) occurs on or near the Mississippi Sandhill Crane Wildlife Refuge in Jackson County, Mississippi (Figure 3.8.2-1). Major reasons for the decline of this species include habitat loss, human predation, and human disturbance (USFWS 1991b).

The roseate tern is a seabird that commonly ventures into oceanic waters; however, its western Atlantic population is known to occur in the far southeastern GOM to breed in scattered colonies along the Florida Keys (NatureServe 2011a; Saliva 1993; USFWS 2011d). This species



Note
The maritime boundaries shown above, as well as the division of planning areas, are for initial planning purposes only and do not prejudice or affect United States jurisdiction in any way.

FIGURE 3.8.2-1 Coastal Counties from Which the Federally Endangered Mississippi Sandhill Crane and Roseate Tern, and the Federally Threatened Audubon's Crested Caracara, Have Been Reported (USFWS 2011d)

nests in colonies on isolated islands, rubble islets, dredge-spoil, and rooftops in southern Florida. Feeding roseates hover over schools of fish and plunge-dive to seize the fish (USFWS 2012b). It is currently listed as endangered for populations along the U.S. Atlantic Coast from Maine to North Carolina, Canada, and Bermuda; it is listed as threatened in Florida, Puerto Rico, the Virgin Islands, and the remaining western hemisphere and adjacent oceans. Historically, this species ranged along the Atlantic temperate coast south to North Carolina; in Newfoundland, Nova Scotia, and Quebec, Canada; and in Bermuda (USFWS 2011d). In the northern GOM, this species has only been reported from Monroe County at the extreme southwest tip of Florida (Figure 3.8.2-1).

The piping plover is a shorebird that inhabits coastal sandy beaches and mudflats. This species nests in sand depressions lined with pebbles, shells, or driftwood. Piping plovers forage for various small invertebrates along ocean beaches, on intertidal flats, and along tidal pool edges (NatureServe 2011a). This species is currently in decline and listed as endangered in the Great Lakes watershed (breeding range of the Great Lakes population of this species) and as threatened in the remainder of its range. It is listed as a result of historic hunting pressure, and loss and degradation of habitat. The threatened piping plover is reported from coastal counties in each of the GOM States except Mississippi, and the endangered piping plover is reported from coastal counties of Mississippi (USFWS 2011d). Critical wintering habitat has been designated in each of the GOM Coast States for all three populations (Atlantic, Great Lakes, and Great Plains) of the piping plover (66 FR 36038–36143) (Figure 3.8.2-2).

The whooping crane is a wetland species that nests within western Canada and the north-central United States, and overwinters on salt flats and wetland habitats along the Aransas National Wildlife Refuge on the Texas Coast. During the winter, whooping cranes forage for blue crabs, clams, and wolfberry (USFWS 2011d). It is currently listed as endangered over its entire range, except where listed as an experimental population (Figure 3.8.2-3). Three populations occurring in four of the GOM States (AL, FL, LA, MS) are designated as nonessential experimental. It is endangered because of historic hunting pressure and habitat loss and degradation. Critical habitat has been designated for this species in the GOM along the Texas coast (including Aransas National Wildlife Refuge) (43 FR 20938–20942).

The red knot is the only candidate bird species currently identified as occurring in the northern GOM. This highly migratory species travels between nesting habitats in mid- and high-Arctic latitudes and southern non-breeding habitats in South America and portions of North America (southern Atlantic and GOM coasts). Its population has exhibited a large decline in recent decades, and is now estimated in the low ten thousands (NatureServe 2011a). Red knots forage along sandy beaches, tidal mudflats, salt marshes, and peat banks for bivalves, gastropods, and crustaceans (USFWS 2011i). Horseshoe crab eggs are a critical food resource for this species, and it is believed that overharvest and population declines of horseshoe crabs may be a major reason for the decline of red knot numbers. Within the northern GOM, this species has been reported from coastal counties in each of the GOM States (USFWS 2012a) (Figure 3.8.2-3). In the event of an oil spill contacting coastlines in these counties, this species could be affected, if present.

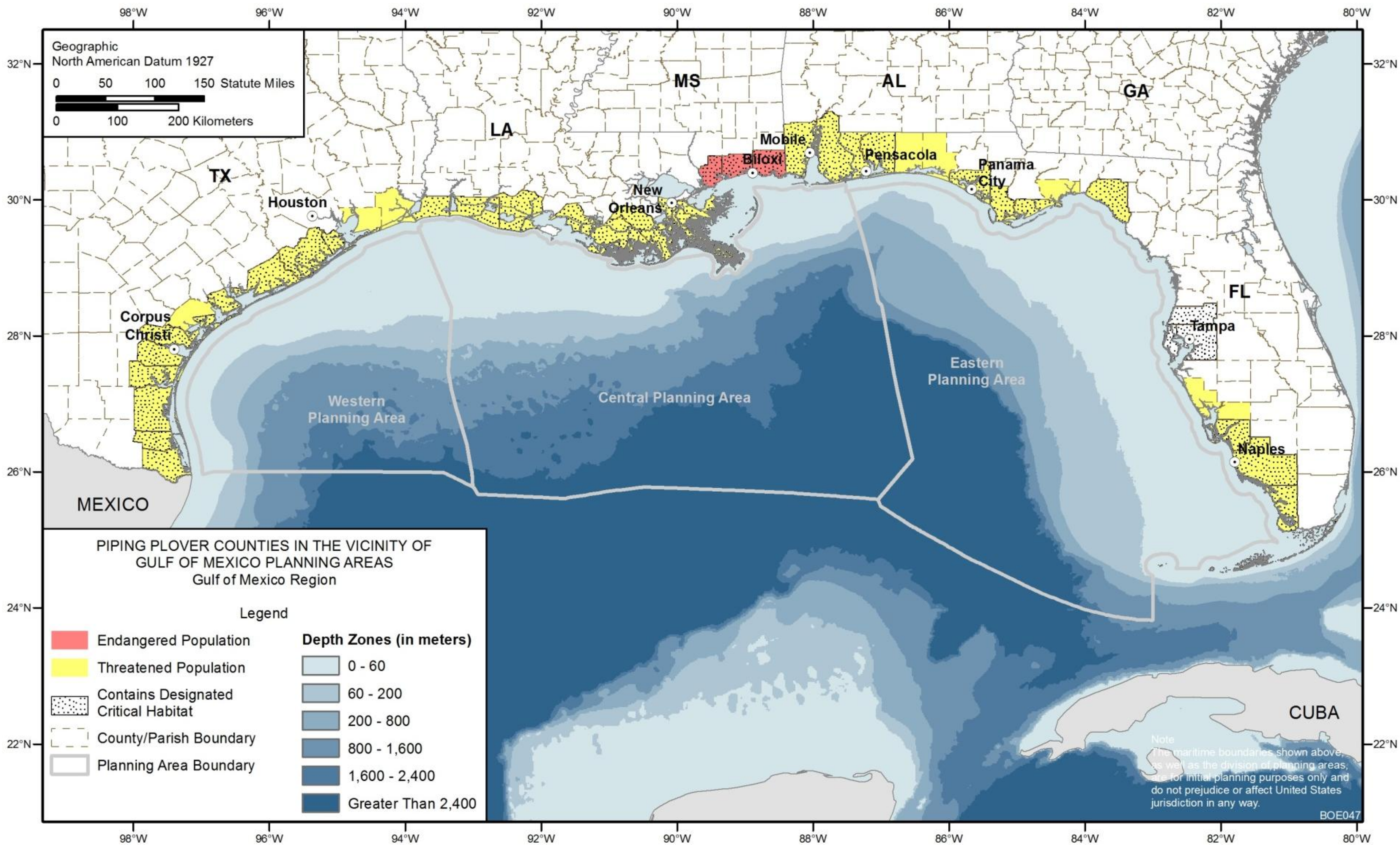


FIGURE 3.8.2-2 Coastal Counties from Which the Federally Threatened and Endangered Populations of Piping Plover Have Been Reported (USFWS 2011d)

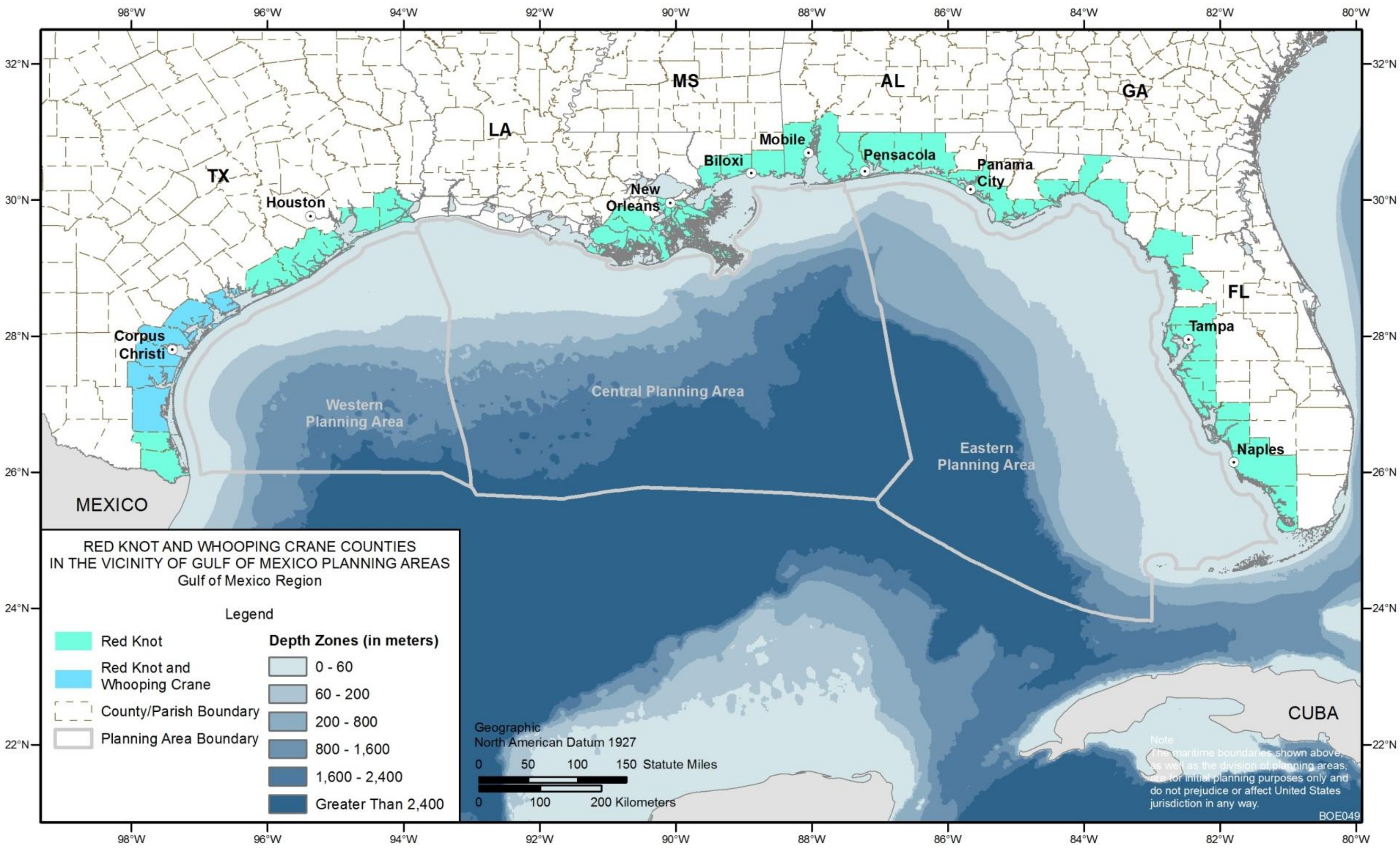


FIGURE 3.8.2-3 Coastal Counties from Which the Federally Endangered Whooping Crane and the Federal Candidate Red Knot Have Been Reported (USFWS 2011d)

The wood stork is the only stork that regularly occurs in North America. The published range of this wading bird is Alabama, Florida, Georgia, Mississippi, North Carolina, and South Carolina, where this species is classified as endangered (USFWS 2011d). While a year-round resident of Florida and Georgia, the wood stork does occur in other GOM coast States (Figure 3.8.2-4). A non-endangered population of wood stork migrates north from Mexico after breeding and can be found in Texas and Louisiana (USFWS 2011d). Wood storks frequent freshwater and brackish coastal wetland habitats. This species nests mostly in upper parts of cypress trees, mangroves, or dead hardwoods over water or along streams or shallow lakes. No critical habitat has been designated for this species. Wood storks forage in shallow water and flooded fields for mainly small fish (NatureServe 2011a).

3.8.2.1.3 Migratory Birds. The GOM is an important pathway for migratory birds, including many coastal and marine species and large numbers of terrestrial species (Lincoln et al. 1998; USGS 2005). Most of the migrant birds (especially passerines or perching birds) that overwinter in the neotropics (tropical south Florida, Mexico, the Caribbean, Central America, and South America) and breed in eastern North America either directly cross the GOM (trans-GOM migration) or move north or south by traversing the GOM or the Florida peninsula (Figure 3.8.2-5) (Lincoln et al. 1998; Russell 2005).

Birds migrate in large, broad fronts that at times may number 2 million birds or more (USGS 2005). During the migration seasons, nearly all of the migratory birds of the eastern United States, as well as many western species, use the coastal plains of the northern GOM. Florida migrants then remain in place, cross to the Bahamas Archipelago, or travel directly across the Florida Straits and into the Antilles (Lincoln et al. 1998). Recent studies indicate that the flight pathways of the majority of the trans-GOM migrant birds during spring are directed toward the coastlines of Louisiana and eastern Texas (Morrison 2006). As many as 300 million birds may cross the GOM each spring (Russell 2005). During overwater flights, migrant birds (other than seabirds) sometimes use offshore structures, such as oil and gas production platforms, for rest stops or as temporary shelter from inclement weather. Spring migrants fly northward across the GOM, arrive on coastal habitats (especially those in Louisiana) with depleted energy reserves, and use those habitats for resting and rebuilding energy reserves. In the fall, migrants use food resources in the coastal habitats to build up energy reserves for migration southward either directly across the open waters of the GOM or along the GOM coast to Mexico and beyond.

3.8.2.1.4 Important Bird Areas. The northern GOM coast provides a diverse range of habitats that support the many migratory and resident bird species of the area. These habitats include coastal wetlands and marshes, mud flats, and beaches, which may be used for nesting, foraging, and for some species staging areas during spring and fall migration. While these habitats occur along the entire northern GOM coastline, some coastal areas may be especially important to birds living along or using the northern GOM, and it is areas such as these that, if impacted by oil and gas activities or accidental oil spills, could impact local or regional populations of the species relying on the affected habitats provided. Some of these areas are

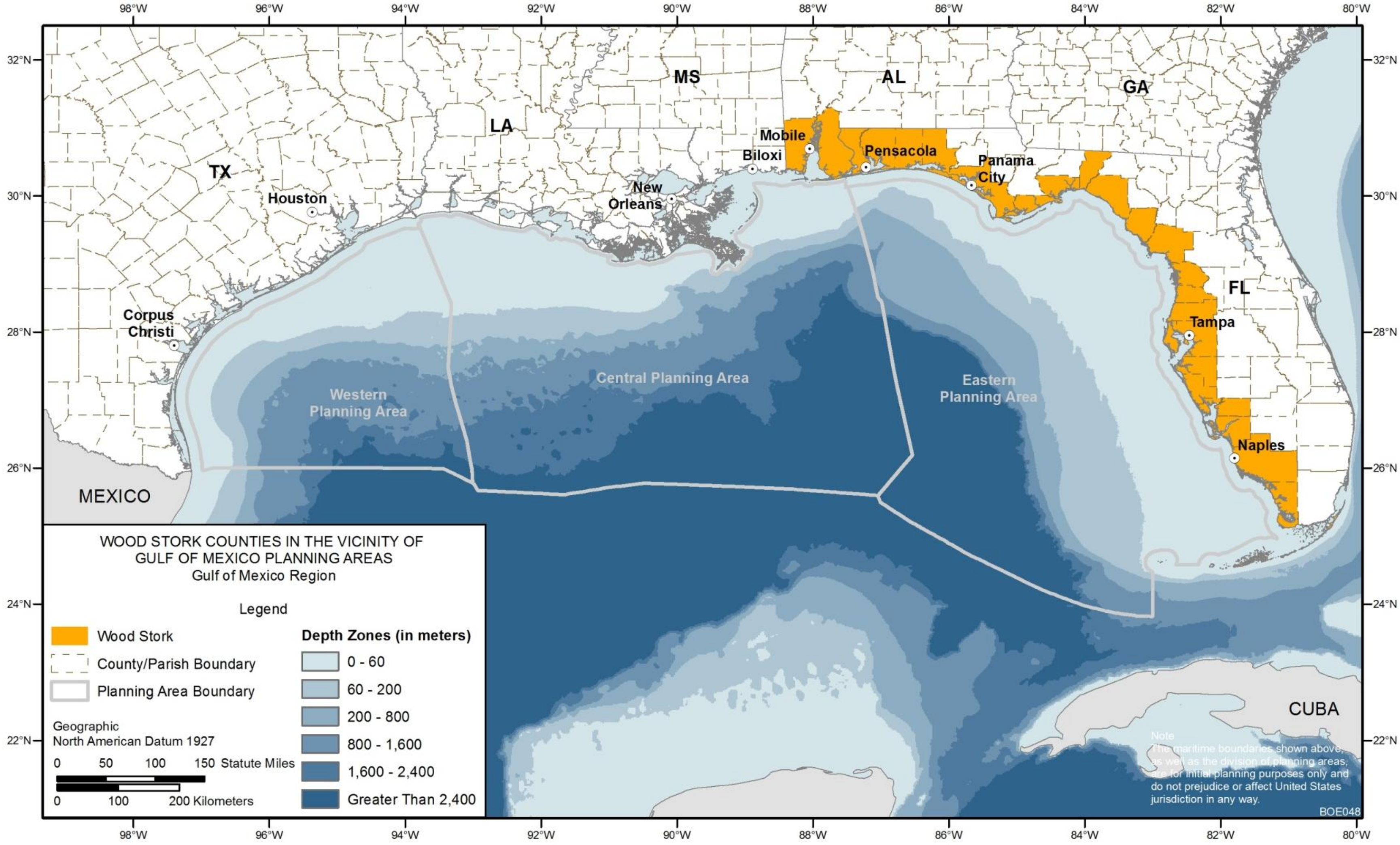


FIGURE 3.8.2-4 Coastal Counties from Which the Federally Endangered Wood Stork Has Been Reported (USFWS 2011d)

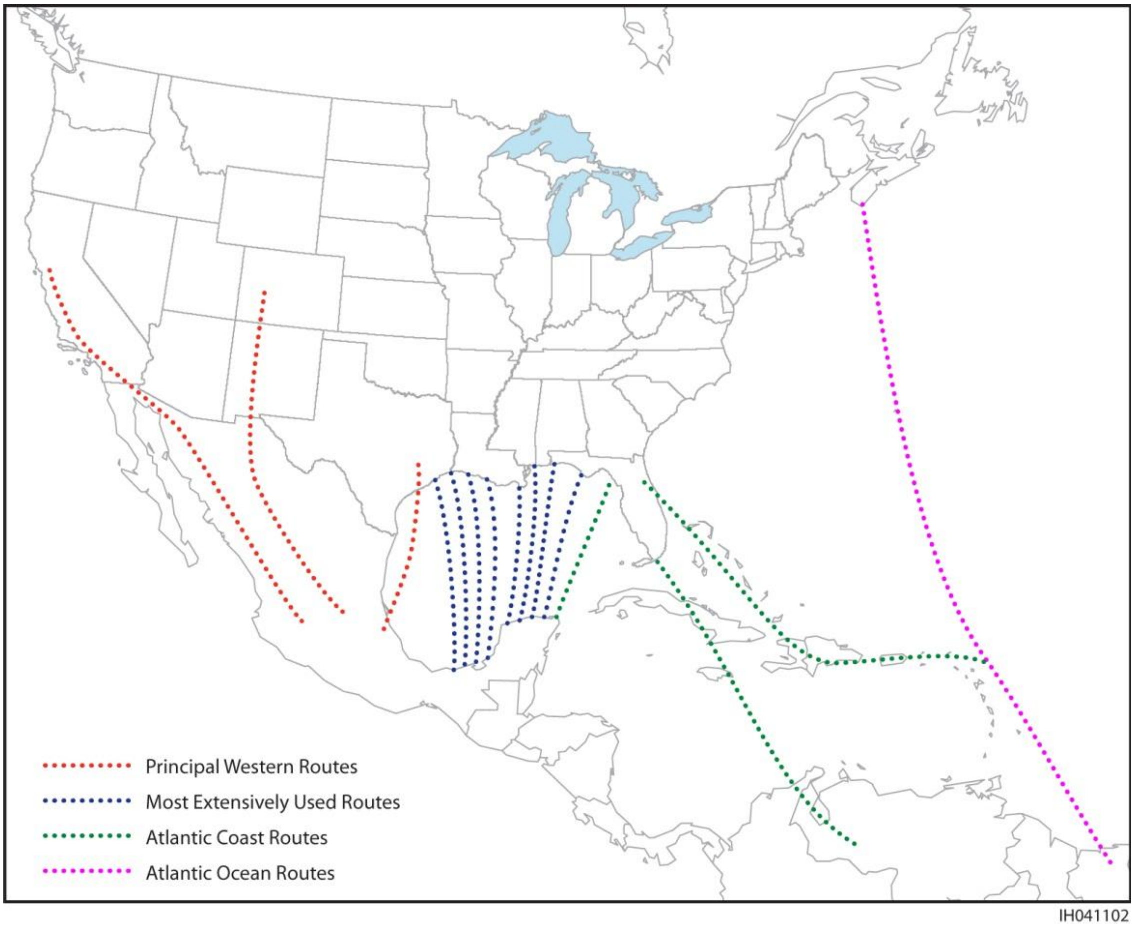


FIGURE 3.8.2-5 Primary Migration Routes Used by Birds in Passing from North America to Winter Quarters in the West Indies, Central America, and South America (The routes crossing the Gulf of Mexico are those most extensively used by birds and are also used by many species returning to North America in spring; specific routes taken by migrating birds may vary within and between years, depending on local and regional weather conditions, including storms and prevailing winds.) (Lincoln et al. 1998)

protected by Federal or State regulations (e.g., National Wildlife Refuges and National Parks), while others may have no legal protection.

Since its start in Europe in the 1980s, the Important Bird Area (IBA) concept has led to the identification and protection of some 3,500 sites worldwide that are considered as exceptionally important, even essential, for bird conservation (ABC 2011). Both the American Bird Conservancy (ABC) and the Audubon Society have identified a number of IBAs along the northern GOM coast (ABC 2011; Audubon Society 2011a). These IBAs are not afforded regulatory protection unless they occur on protected Federal (such as USFWS National Wildlife Refuges) or State lands or include ESA-designated critical habitat.

The ABC has identified 37 important bird areas in coastal counties along the northern GOM coast (Figure 3.8.2-6). Many of these sites include national wildlife refuges, national parks, national forests, State lands, conservation organization lands, and even some private lands. To be included, a site must, during at least some portion of the year, contain habitat that supports:

1. A significant population of a threatened or endangered species;
2. A significant population of a U.S. Watch List species;
3. A significant population of a species with a limited range; or
4. A significantly large concentration of breeding, migrating, or wintering birds, including waterfowl, seabirds, wading birds, raptors, or land birds (ABC 2011).

The IBAs along the northern GOM include 17 areas in Texas, 9 in Florida, 5 in Louisiana, and 3 each in Alabama and Mississippi (Table 3.8.2-4). This list is not all-inclusive and focuses only on those IBAs in coastal counties. Because these areas are located in coastal areas and, in some cases, are islands and seashores, they have a greater likelihood of interacting with OCS oil and gas activities in the GOM.

The Audubon Society has identified 52 IBAs for the northern GOM coast (Audubon Society 2011a). These include 8 sites in Texas, 6 in Louisiana, 7 in Mississippi, 4 in Alabama, and 27 in Florida; and only 7 of the Audubon IBA sites overlap with the ABC sites (Figure 3.8.2-7; Table 3.8.2-5).

Some of these IBAs are associated with specific, individual species. For example, the Aransas National Wildlife Refuge in Texas was established in 1937 as a refuge and breeding ground for migratory birds, and hosts the largest wild flock of endangered whooping cranes each winter. Similarly, the Gulf Coast Least Tern Colony Globally Important Bird Area in Mississippi supports the largest colony of the least tern.

Other sites provide important overwintering habitat for federally threatened piping plover, or provides foraging and resting habitat for large variety of waterfowl, shorebirds, wading birds, and migrating passerines. For example, Dauphin Island in Alabama is one of the few known breeding localities for snowy plover (*Charadrius alexandrines*), mottled duck (*Anas fulvigula*), and seaside sparrow (*Ammodramus maritimus*) (Audubon Society 2011b).

3.8.2.1.5 Climate Change and Gulf of Mexico Birds. Climate change effects are occurring on all continents and oceans, with atmospheric and ocean warming being observed in many locations (see climate change discussions presented in Section 3.3). Environmental responses in the GOM Planning Areas include climate change-related sea level rise, changes in precipitation and temperature patterns, changes in storm intensity, and potential for high erosion of GOM coasts (Woodrey et al. 2012).

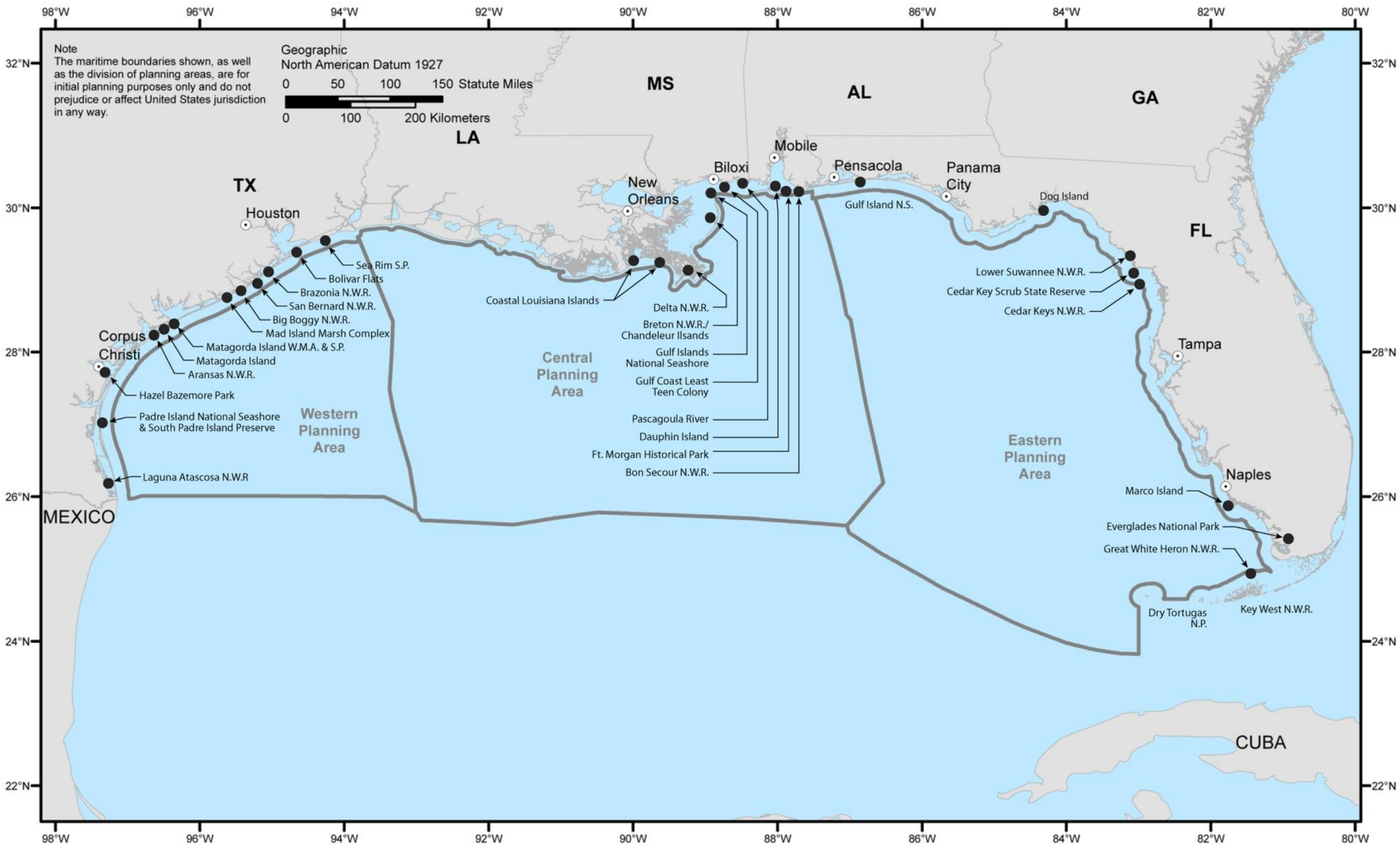


FIGURE 3.8.2-6 Important Bird Areas along the Northern Coast of the Gulf of Mexico (ABC 2011)

TABLE 3.8.2-4 Important Bird Areas Identified by the American Bird Conservancy for the Coastal Counties of the Northern Gulf of Mexico

State	Important Bird Area	County
Texas	Aransas National Wildlife Refuge	Aransas
	Columbia Bottomlands	Brazoria
	San Bernard National Wildlife Refuge	Brazoria
	Matagorda Island	Calhoun
	Laguna Atascosa National Wildlife Refuge	Cameron
	South Padre Island Preserve	Cameron
	Anahuac National Wildlife Refuge	Chambers
	Smith Point	Chambers
	High Island	Galveston
	McFadden National Wildlife Refuge	Jefferson
	Texas Point National Wildlife Refuge	Jefferson
	Sea Rim State Park	Jefferson
	Kings Ranch	Kenedy, Kleberg, Neuces, Willacy
	Padre Island National Seashore	Kenedy, Kleberg, Willacy
	Big Boggy National Wildlife Refuge	Matagorda
	Mad Island Marsh Wildlife Complex	Matagorda
	Hazel Bazemore County Park	Neuces
Louisiana	Breton National Wildlife Refuge	St. Bernard
	Catahoula National Wildlife Refuge	LaSalle
	Delta National Wildlife Refuge	Plaquemines
	Coastal Louisiana Islands	Cameron, Vermillion, Iberia, St. Mary, Terrebonne, LaFourche, Jefferson, Plaquemines, St. Bernard
Mississippi	Gulf Coast Least Tern Colony	Harrison
	Gulf Islands National Seashore[a]	Harrison, Jackson
	Mississippi Sandhill Crane National Wildlife Refuge	Jackson
Alabama	Bon Secour National Wildlife Refuge[a]	Baldwin
	Dauphin Island[a]	Mobile
	Fort Morgan Historical Park	Baldwin
Florida	Apalachicola National Forest	Wakulla, Franklin
	Cedar Key Scrub State Reserve	Levy
	Cedar Keys National Wildlife Refuge	Levy
	Dog Island[a]	Franklin
	Elgin Air Force Base[a]	Okaloosa
	Gulf Islands National Seashore[a]	Escambia, Santa Rosa
	Honeymoon Island State Recreation Area	Pinellas
	Ochlockonee River State Park	Franklin
	St. Marks National Wildlife Refuge[a]	Wakulla

[a] Also identified as an IBA by the Audubon Society; see Table 3.8.2-5.

Source: ABC 2011.

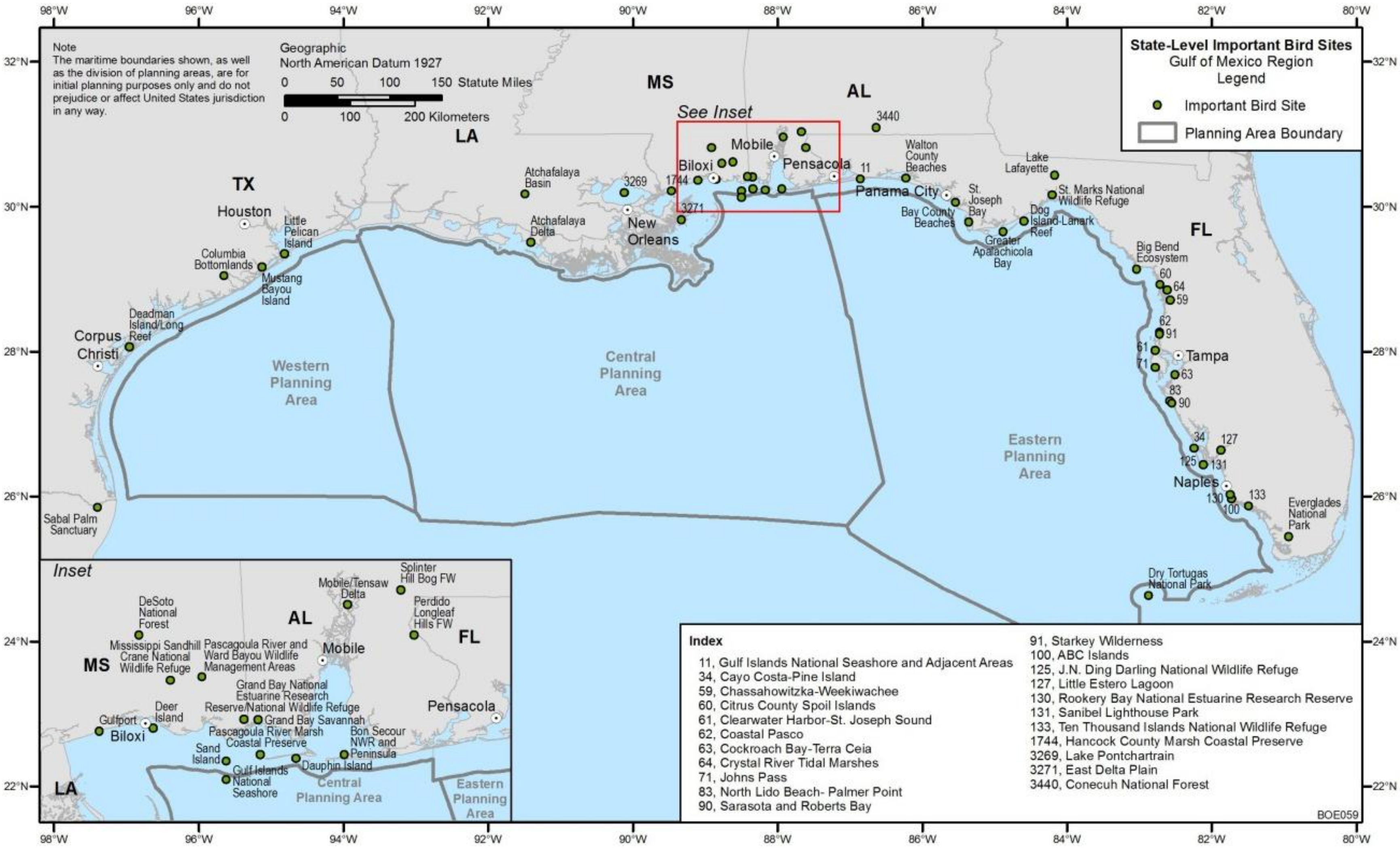


FIGURE 3.8.2-7 Important Bird Areas Identified by the Audubon Society for the Northern Coast of the Gulf of Mexico (Audubon Society 2011a)

TABLE 3.8.2-5 Important Birds Areas Identified by the Audubon Society for the Coastal Counties of the Northern Gulf of Mexico

State	Important Bird Area	County
Texas	Deadman Island/Long Reef	Aransas
	Islands South of South Bird Island	
	Little Pelican Island	Galveston
	Mustang Bayou Island	Brazonia
	Pelican Island	
	Port Bolivar Bird Sanctuaries-Horseshoe Marsh	
	Second Chain of Islands	
	Shamrock Island	
Louisiana	Active Delta (Mississippi River Birdsfoot Delta)	Plaquemines
	Atchafalaya Delta	Assumption, St. Mary, Terrebonne
	Barataria Terrebonne	Assumption, Jefferson, LaFrouche, Plaquemines, St. Charles, St. James, St. John the Baptist, St. Mary, Terrebonne
	Chenier Plain	Calcasieu, Cameron, Iberia, Jefferson Davis, St. Mary, Vermillion
	East Delta Plain	Orleans, Plaquemines, St. Bernard, St. Tammany
	Isles Dernieres-Timbalier Islands	Terrebonne
Mississippi	Deer Island	Harrison
	Grand Bay National Estuarine Research Reserve/National Wildlife Refuge	Jackson
	Gulf Islands National Seashore[a]	Harrison, Jackson
	Gulfport	Harrison
	Hancock County Marsh Coastal Preserve	Hancock
	Pascagoula River Marsh Coastal Preserve	Jackson
	Sand Island	Jackson
Alabama	Bon Secour National Wildlife Refuge[a] and Peninsula	Baldwin
	Dauphin Island[a]	Mobile
	Grand Bay Savannah	Mobile
	Mobile/Tensaw Delta	Baldwin, Mobile
Florida	ABC Islands	Collier
	Bay County Beaches	Bay
	Big Bend Ecosystem	Dixie, Levy, Taylor
	Cayo Costa-Pine Island	Lee
	Chassahowitzka-Weekiwachee	Citrus, Hernando, Pasco
	Citrus County Spoil Islands	Citrus
	Clearwater Harbor-St. Joseph Sound	Pinellas
	Coastal Pasco	Pasco
	Cockroach Bay-Terra Ceia	Manatee, Hillsborough
	Crystal River Tidal Marshes	Citrus
	Dog Island[a] -Lanark Reef	Franklin

TABLE 3.8.2-5 (Cont.)

State	Important Bird Area	County
Florida (Cont.)	Dry Tortugas National Park	Monroe
	Elgin Air Force Base[a]	Okaloosa
	Great White Heron National Wildlife Refuge	Monroe
	Gulf Islands National Seashore[a] and Adjacent Areas	Escambia, Santa Rosa
	J.N. Ding Darling National Wildlife Refuge	Lee
	Johns Pass	Pinellas
	Little Estero Lagoon	Lee
	North Lido Beach-Palmer Point	Sarasota
	Oscar Scherer State Park	Sarasota
	Pelican Shoal	Monroe
	Rookery Bay National Estuarine Research Reserve	Collier
	Sanibel Lighthouse Park	Lee
	Sarasota and Roberts Bay	Manatee, Sarasota
	St. Joseph Bay	Gulf
	St. Marks National Wildlife Refuge[a]	Jefferson, Wakulla, Taylor
	Starkey Wilderness	Pasco
	Ten Thousand Islands National Wildlife Refuge	Collier
	Walton County Beaches	Walton

[a] Also identified as an IBA by the ABC; see Table 3.8.2-4.

Source: Audubon Society 2011a.

Climate change in the GOM may be expected to result in short-term and long-term effects on marine and coastal birds of the region. These effects may be beneficial or detrimental in nature and could result in population-level effects on marine and coastal birds (NABCI 2010). Which species may be most affected and how they may respond to climate change over several decades are unknown.

Climate change may have a variety of adverse effects on marine and coastal birds of the GOM planning areas, with potential impacts mostly associated with loss of food and habitat. Increased water temperature and ocean acidification may affect invertebrate community distribution in terms of both species composition and total productivity. Invertebrates in nearshore areas are expected to experience the greatest hydrologic changes (see discussion of climate change impacts on aquatic invertebrates in Section 3.8.5.1). Changes in this prey base could affect shorebirds and waterfowl that forage on these invertebrates during nesting, staging, and migrating (Galbraith et al. 2002; Moller et al. 2008; NABCI 2010). Hatchling success of coastal nesting shorebirds may decline if hatch dates do not match patterns in the availability of food resources. Migrating shorebirds that stop over in the GOM to feed in coastal areas may not be able to gain the body weight necessary to reach their breeding grounds if the abundance of invertebrates is reduced (NABCI 2010).

Increased precipitation in the Mississippi River Basin due to climate change has been predicted to increase river discharge by 20%. This increased discharge is expected to increase the average extent of hypoxia on the northern GOM shelf (Howard 2012). These hypoxic conditions may affect prey availability for migratory and resident birds in the GOM planning areas.

Recent climate change projections suggest the global sea level will rise by 0.8–2.0 m (2.6–6.6 ft) by 2100 due to climate change (IPCC 2007a). The GOM has experienced some of the highest rates of sea level rise in the United States. Rising sea levels are expected to fragment or flood low-lying habitats such as salt marshes, sandy beaches, barrier islands, and mudflats (NABCI 2010). Sea level rise may reduce coastal wetland area, alter near-shore depth distributions, change estuarine/river interactions, and alter plant community composition. These habitat changes may contribute to enhanced competition among coastal bird species as foraging and habitat resources are reduced (Woodrey et al. 2012).

Climate change is expected to increase the intensity and frequency of tropical storms. The expected increase in sea level combined with tropical storm changes may lead to storm surges extending farther inland (Woodrey et al. 2012). This could potentially affect inland bird populations and habitats. Erosion and flooding are expected to increase as a result of more frequent severe storms, especially in the GOM, where coastal landforms are dominated by barrier islands, marshes, and deltas, which are easily eroded (Woodrey et al. 2012). High-intensity storms may degrade habitat and affect food resources for bird species, as well as cause direct mortality (O'Connell and Nyman 2011).

3.8.2.1.6 Effect of the Deepwater Horizon Event on Marine and Coastal Birds. With the exception of the passerines, most of the bird groups that occur in the northern GOM are associated with aquatic habitats, whether coastal and estuarine shorelines, wetlands, mudflats, and beaches, or open water areas such as bays and marine waters on the OCS. The DWH event resulted in the release of oil in the open waters of the OCS, with some of this oil moving to the coast and contacting coastal and shoreline habitats, and marine and coastal birds were exposed to the oil in affected coastal and open water habitats. The USFWS, as part of a multi-agency response to the DWH event, began reporting of oiled and dead birds, and established a program to provide accurate data regarding not only oiled and dead birds but also marine mammals and sea turtles (USFWS 2011e). Observations of direct exposure of birds included signs of visible oiling of feathers and other body surfaces. Indirect exposure through ingestion of oil or of food items contaminated with oil is expected to have occurred as well. In addition, the shoreline cleanup efforts of the DWH event may have disturbed nesting populations and degraded or destroyed habitat in some localized areas.

Table 3.8.2-6 presents a summary of the most recent DWH event bird impact data collected by the USFWS (USFWS 2011e). Over 6,600 individuals representing at least 129 bird taxa had been collected in the DWH event potential impact area as of May 12, 2011. Birds were reported as dead or alive in one of three categories: visibly oiled from the DWH event, visibly oiled from an undetermined source; and not visibly oiled. Of the birds most closely associated with aquatic habitats, seabirds represented the majority (79–90%) of birds reported for any of these categories, followed by wetland birds (5–10%) and shorebirds (3–7%), with laughing gulls

TABLE 3.8.2-6 Deepwater Horizon Event Bird Impact Data through May 12, 2011

Avian Category	No. of Taxa	Visibly Oiled; Attributed to DWH Event			Not Visibly Oiled			Visibly Oiled; Unknown Source			Grand Total
		Dead[a]	Live	Total	Dead	Live	Total	Dead	Live	Total	
Seabirds	32	1,822	480	2,302	2,324	0	2,324	654	271	925	5,551
Shorebirds	16	70	8	78	205	2	207	52	10	62	347
Wetland Birds	28	118	19	137	249	0	249	88	29	117	503
Waterfowl	14	9	3	12	34	0	34	10	8	18	64
Passerines	30	17	3	20	54	0	54	17	20	37	111
Raptors	9	2	1	3	15	0	15	4	3	7	25
Total	129	2,038	514	2,552	2,881	2	2,883	827	341	1,168	6,603

[a] Includes birds that were recovered live but subsequently died.

Source: USFWS 2011e.

representing 41% of all birds reported. In contrast, relatively few waterfowl (≤1%), passerines (≤3%), and raptors (<1%) were collected.

Birds that are heavily oiled usually do not survive. Oiled birds that do not perish shortly after oiling may experience more chronic physiological effects of oil exposure. Birds exposed through the ingestion of oil during feeding or grooming, or through inhalation, may also incur chronic, sublethal physiological effects. For example, ducklings fed crude oil for 8 weeks failed to develop normal flight feathers and exhibited symptoms of stress, such as a decrease in spleen weight and an increase in liver weight (Szaro et al. 1978). Adult ducks exhibited reduced body weight initially, but returned to a normal growth rate later in the study period (Patton and Dieter 1980). Hens fed crude oil exhibited a reduction in oviduct weight and a reduction in the number of eggs laid, but eggs of treated hens hatched as well as controls (Coon and Dieter 1981). Both weathered crude oil and oil dispersants applied to fertilized mallard duck eggs resulted in decreased hatching success, but the weathered oil was considerably less toxic than fresh crude oil (Finch et al. 2011; Wooten et al. 2011). Post-DWH event exposure may occur in habitats and media where oil in an unweathered toxic form may remain indefinitely. Chronic effects may not yet be evident, but may become realized at a later date. It is not known how sublethal exposure to oil from the DWH event may have affected marine and coastal birds of the GOM; any such effects may not be realized for several years. The impacts of DWH on marine and coastal birds of the GOM are still being studied, but this information is not needed at the programmatic stage to make a reasoned choice among alternatives (see Section 1.4.2, Incomplete and Unavailable Information).

3.8.2.2 Marine and Coastal Birds of Alaska – Cook Inlet

More than 492 naturally occurring species in 64 families and 20 orders have been identified in Alaska (University of Alaska 2011), and 237 species have been recorded in the Kodiak Island Archipelago (MacIntosh 1998). Birds traveling to and from breeding areas in interior Alaska, the North Slope, and west coast areas of Alaska use Cook Inlet during these movements. Annual use patterns of the Cook Inlet are characterized by the sudden and rapid occurrence of very large numbers of birds in early May followed by an abrupt departure in mid-to-late May; surveys conducted at this time have had counts of 150,000 birds or more per day (Gill and Tibbitts 1999).

3.8.2.2.1 Nonendangered Species. Representatives of six major groups of birds occur in the Cook Inlet Planning Area (Table 3.8.2-7). Among these groups, three may have the greatest potential for being affected by oil and gas leasing and development: (1) seabirds, which occur in open ocean waters; (2) waterfowl, which utilize a variety of freshwater and nearshore marine habitats; and (3) shorebirds, which utilize shoreline habitats throughout the planning area. Many of these species are migratory and may seasonally occur in locally large concentrations such as nesting colonies or as mobile flocks.

TABLE 3.8.2-7 Major Groups of Marine and Coastal Birds of the Cook Inlet Planning Area

Category	Order	Common Name	Representative Types
Seabirds	Charadriiformes	Gulls Terns Phalaropes Alcids	Mew gull, glaucius-winged gull, Arctic tern, red-necked phalarope, common murre, pidgeon guillomot, ancient murrelet
	Procellariiformes	Storm-petrels Shearwaters Albatrosses	Fork-tailed storm-petrel, northern fulmer, short-tailed albatross
Shorebirds	Charadriiformes	Jaegers Plovers Oystercatchers Sandpipers, snipes, and allies	Parasitic jaeger, black-bellied plover, black oystercatcher, dunlin, western sandpiper
Wetland birds	Gruiformes	Cranes	Sandhill crane
	Pelicaniformes	Cormorants	Double-crested cormorant
	Podicipediformes	Grebes	Horned grebe
Waterfowl	Anseriformes	Ducks, geese, and swans	Trumpeter swan, mallard, greater scaup, common goldeneye, harlequin duck
	Gaviiformes	Loons	Pacific loon, common loon
Passerines	Passeriformes	Perching birds	Warblers, boreal chickadee, American pipet, common redpoll
Raptors	Falconiformes	Birds-of-prey	Osprey, bald eagle

In the summer, seabirds and sea ducks are found along the coastlines of Cook Inlet. Colonial seabirds, except for gulls and terns, are mostly confined to the lower portions of the inlet where foraging areas are more abundant (Nature Conservancy 2003). The intertidal habitats of Cook Inlet are used by millions of shorebirds (such as western sandpipers [*Calidris mauri*] and dunlin [*C. alpine*]) during spring migration, and several species breed in the planning area. In the summer, Cook Inlet provides breeding habitat for migratory waterfowl, and during fall migration the inlet may be used by as many as 1 million migrating waterfowl. Waterfowl are valued as subsistence resources, and they also provide a sport-hunting resource. In contrast to conditions that lead to large numbers of birds being present in spring, summer, and fall, ice conditions limit overwinter use of the upper portions of the inlet by birds.

A number of large seabird colonies (i.e., ranging from 20,000 to multiple hundreds of thousands of individuals) occur in the subregion, including on the Chisik and Gull Islands in Cook Inlet, the Barren Islands south of Cook Inlet, and the Kodiak Island group (Stephensen and Irons 2003). Many smaller colonies, whose aggregate population represents a substantial concentration of seabirds, also occur in these areas.

The factors most responsible for the status of bird populations in the Cook Inlet Planning Area are associated with the availability and quality of wintering, migratory, and nesting habitats and the availability of food in those habitats. Changes in breeding habitat availability or quality and food resources during breeding could affect egg production and nesting success.

Bird density and diversity is lowest in winter. Typically, only a single species of shorebird, the rock sandpiper (*Calidris ptilocnemis*), remains through the winter in upper Cook Inlet, although some black turnstones (*Arenaria melanocephala*) and dunlins also may stay. The approximately 20,000 individuals may represent the entire Bering Sea breeding population of the rock sandpiper (Gill and Tibbitts 1999; Gill et al. 2002). The Kodiak area is also an important wintering ground for several species of waterfowl and seabirds (Forsell and Gould 1981; Larned and Zwiefelhofer 2001), including cormorants, scoters, long-tailed ducks (*Clangula hyemalis*), eiders, common murres (*Uria aalge*), murrelets, and crested auklets (*Aethia cristatella*). Winter bird counts in the area are among the highest in Alaska, with more than 1.5 million seabirds overwintering in nearshore waters surrounding Kodiak Island (USFWS 2011h). Emperor geese winter from the Aleutians to Kodiak. Lower Cook Inlet also is relatively important for overwintering waterfowl, murres, fulmars, and storm-petrels (Agler et al. 1995).

3.8.2.2.2 Birds Listed under the Endangered Species Act. Several species of federally endangered, threatened, or candidate species (see Section 3.8.2.1.2 for a discussion of the ESA and definitions of these categories) occur in the Cook Inlet Planning Area. These species are the federally endangered short-tailed albatross (*Phobastria albatrus*) and the federally threatened Steller's eider (*Polysticta stelleri*). Two candidate species, and Kittlitz's murrelet (*Brachyramphus brevirostris*) and the yellow-billed loon (*Gavia adamsii*), also occur in the planning area.

The short-tailed albatross is a long-winged seabird that was listed in 2000 as endangered in the United States (65 FR 46643), making it so designated throughout its range. This species was originally listed in 1970 under the then-Endangered Species Conservation Act of 1969, before passage of today's ESA. As a result of an administrative error and not because of any biological evaluation, this species was listed as endangered throughout its range except within the United States. This error was corrected in 2000 when this species was listed as endangered throughout its range. No critical habitat has been designated in marine waters within U.S. jurisdiction. The greatest current threat to this species is the potential volcanic eruption of Torishima, where most breeding occurs. Other existing threats include incidental catch in commercial fisheries, ingestion of plastics, contamination by oil and other pollutants, the potential for habitat usurpation or degradation by non-native species, and the adverse effects of climate change (USFWS 2008c).

Short-tailed albatross occurs in waters throughout the North Pacific, primarily along the east coasts of Japan and Russia; in the continental shelf edge of the Gulf of Alaska, along the Aleutian Islands; and in the Gulf of Alaska south of 64°N latitude (USFWS 2008c), and is a relatively frequent visitor to the South Alaska subregion. While once thought to number 5 million individuals, about 2,400 birds were known to exist in June 2008, with about 450–500 breeding pairs. This albatross is known to breed on only two small islands near Japan, with 80–85% of all breeding occurring on the active volcanic island of Torishima in the western Pacific.

During the non-breeding season, short-tailed albatrosses range along the Pacific Rim from southern Japan to northern California, primarily along continental shelf margins

(USFWS 2008c). On the basis of ship-based observations and telemetry data, this species may be relatively common nearshore where upwellings occur near the coast; this species should be considered a "continental shelf-edge specialist" rather than a coastal or nearshore species (Piatt et al. 2006). The shelf edge in the vicinity of the Cook Inlet Planning Area occurs about 121 km (75 mi) from the southern boundary of the planning area.

The Steller's eider is the smallest of the four eider duck species. This species breeds in the Arctic, and the Alaska breeding population was listed as threatened in 1997 (62 FR 31748). There are three breeding populations, two in Russia and one in Alaska (USFWS 2002). The Alaska breeding population nests primarily on the Arctic coastal plain, and is the only one of the three populations listed under the ESA as threatened. While the causes for the population decline observed for this species are unknown, possible factors affecting the Alaska population may include predation, hunting, ingestion of spent lead shot, habitat loss or degradation, and exposure to contaminants (USFWS 2002; NatureServe 2010b).

On the coastal plain, Steller's eiders breed on grassy edges of tundra lakes and ponds, or within drained lake basins. Although they nest in terrestrial environments, they spend the majority of their time in shallow marine waters. Steller's eider does not breed in the Southern Alaska Subregion. After nesting in the Arctic coastal plains, they move to protected marine areas to molt. Molting occurs at a number of locations in southwest Alaska, with the largest numbers of birds concentrating in four areas along the north side of the Alaska Peninsula (USFWS 2002). Three lagoons on the north side of the Alaska Peninsula have been designated as critical habitat for the Steller's eider (66 FR 8850).

After molting, many of the birds disperse to the Aleutian Islands, the south side of the Alaska Peninsula, Kodiak Island, and lower Cook Inlet (USFWS 2002; Larned 2006). Wintering birds usually occur in shallow waters (<10 m [30 ft] in depth) within 400 m (1,300 ft) of shore, unless the shallows extend farther offshore into bays and lagoons. Substantial numbers of Steller's eiders remain in lagoons on the north side of the Alaska Peninsula in winter until freezing conditions force them out. In Cook Inlet, the largest concentrations of sightings in 2004 were from the Homer Spit north to about Ninilchik and along the south central shore of Kamishak Bay on the inlet's west side (Larned 2006).

The Kittlitz's murrelet is a small diving seabird related to the puffins and murres. All of the North American and most of the world population of this species breed, molt, and winter in Alaska (USFWS 2006d). The North American population of this small diving seabird occupies coastal waters discontinuously from northern Southeast Alaska in the Gulf of Alaska, north to Point Lay in the Chukchi Sea during the nesting season. Wintering areas are not well known, and are assumed to include offshore waters in at least the Gulf of Alaska and Bering Sea portions of the range (USFWS 2006d). Spring migration extends from the third week of March to mid-June, fall migration from mid-July to late October, and breeding from mid-May to late August.

Based on apparent evidence of a population decline in the Prince William Sound area, the Kittlitz's murrelet was petitioned for listing in 2001 and became a candidate for listing in a May 2004 Candidate Notice of Review (69 FR 24877). This species is an uncommon and secretive breeder, choosing unvegetated scree slopes, coastal cliffs, talus above timberline, and barren ground, especially in the vicinity of advancing or stable glaciers or in recently glaciated areas, primarily in coastal areas but also up to 80 km (50 mi) inland (USFWS 2006d). Nests have been found in most coastal regions from southeast to western Alaska (Day et al. 1999). During breeding, Kittlitz's murrelets are found in several core population centers in Alaska, including Lower Cook Inlet (Agler et al. 1998; USFWS 2006d). Possible threats to this species include marine oil pollution, decreases in food stock, gillnet fisheries, and melting of glaciers (USFWS 2006d; NatureServe 2010c).

The yellow-billed loon is a migratory, fish-eating seabird that in Alaska nests in solitary pairs on the Arctic Coastal Plain and winters in more southern coastal waters of the Pacific Ocean (USFWS 2011d). This species became a candidate for listing as endangered or threatened in March 2009 with a listing priority of 8, primarily due to subsistence use of this species during migration (74 FR 12932). Yellow-billed loons typically nest near large, deep tundra lakes on low islands or near the edges of lakes to avoid terrestrial predators. In Alaska, nesting occurs from the Canning River westward to Point Lay, and migration occurs along coastlines of the Beaufort and Chukchi Seas (North 1994; NatureServe 2010d). During nesting, this species uses nearshore and offshore marine waters adjacent to their breeding areas for foraging in summer (74 FR 12932).

During non-breeding, this species spends most of its time in marine waters and uses open water leads for resting and feeding during migration. In Alaska, the yellow-billed loon winters in sparse numbers in nearshore marine waters from Kodiak Island to Prince William and throughout southeast Alaska (North 1994). Wintering habitats include sheltered marine waters less than 30 m (98 ft) deep, from 1.6 to 32 km (1 to 20 mi) offshore (74 FR 12932). Lower Cook Inlet is used in winter by overwintering birds and by immature and possibly non-breeding adults throughout the year.

3.8.2.2.3 Use of the Cook Inlet Planning Area by Migratory Birds. The coastal wetlands and bays along Cook Inlet provide important staging habitats for migratory birds, with large seasonal aggregations of waterfowl and shorebirds. The highest diversity and density of birds in coastal waters, particularly over the continental shelf, occur in spring when large numbers of loons, waterfowl, shorebirds, and seabirds return to nesting areas or stage there before migrating to areas farther north.

During spring migration (April–May), large numbers of birds arrive from southern wintering areas either to occupy breeding habitats along the northern Gulf of Alaska coast or to use habitats in the area as they stage for further migration northward to breeding areas in interior Alaska and along the Arctic Coastal Plain. During spring migration, species diversity and density along the northern Gulf of Alaska are greatest in exposed inshore waters and in bays and lagoons and associated tidal mudflats (e.g., Kachemak Bay), river deltas (e.g., Copper River Delta), and salt marshes, as well as along exposed outer coasts where large numbers of seabirds gather prior to nesting. This latter topography is common in many areas of this subregion, including the exposed outer coast between Prince William Sound and the lower Kenai Peninsula, much of the Kodiak Island archipelago, numerous islands and headlands along the south side of the Alaska Peninsula, and virtually all of the Aleutian Islands. Seabirds most frequently occupy bays and exposed inshore waters. Geese and dabbling ducks primarily use river floodplains and marshes, while diving ducks are most prevalent in bays. Shorebirds are found mainly on mudflats and gravel beaches, and gulls use a variety of habitats. During spring migration, millions of shorebirds make a critical stop on coastal intertidal mudflats to feed before continuing their northward migration. The largest number of migrating shorebirds occurs on the Copper River Delta where 10–12 million birds may stop each spring. About 36 species of shorebirds migrate through the northern Gulf of Alaska each spring (Cline 2005); their numbers are dominated by the western sandpiper, representing most of the world's population of 3-4 million.

Pelagic bird densities begin to decline in September, as shearwaters depart for the southern hemisphere breeding areas. Postbreeding alcids disperse from coastal nesting colonies for offshore areas, where they will spend the winter. Migration of waterfowl and shorebirds is more protracted in the fall than in the spring, and there is some evidence that some shorebird species bypass the Gulf of Alaska during fall. Only goose and dabbling duck densities increase in fall, as migrating birds move in from areas to the north and west.

Winter bird densities along the northern Gulf of Alaska are perhaps 20–50% of those in the summer. Most of the decrease reflects seasonal changes in species composition as many seabirds leave areas they occupied in summer. While seabird numbers are lowest during the winter, the Gulf of Alaska still is important for species that winter offshore such as the northern fulmar (*Fulmarus glacoalis*), fork-tailed storm-petrel (*Oceanodroma furcata*), black-legged kittiwake (*Rissa tridactyla*), and both murre and puffin species. Coastal wintering species along the northern Gulf of Alaska coast include Pacific (*Gavia pacifica*), red-throated (*G. stellate*), and yellow-billed loons; red-necked grebe (*Podiceps grisegena*); herring (*Larus argentatus*), mew (*L. canus*), and glaucous-winged (*L. glaucescens*) gulls; ancient (*Synthliboramphus antiquus*) and marbled (*Brachyramphus marmortus*) murrelets; and Cassin's (*Ptychoramphus aleuticus*) and parakeet (*Aethia psittacula*) auklets. In the winter, waterfowl densities increase substantially as a number of species migrate south from breeding areas on the Arctic coastal plain to overwinter along the coast; sea ducks are the most abundant waterfowl present in winter. These include king (*Somateria spectablis*) and common (*S. mollissima*) eiders; long-tailed and harlequin (*Histrionicus histrionicus*) ducks; black (*Melanitta Americana*) and surf scoters (*M. perspicillata*) and Barrow's goldeneye.

3.8.2.2.4 Important Bird Areas of the Cook Inlet Planning Area. As discussed above, Cook Inlet and the Cook Inlet Planning Area provide a diversity of habitats for resident and migratory marine and coastal birds. While habitats such as mudflats, sand and gravel beaches, lagoons, and islands may be found throughout Cook Inlet and some areas are considered as being particularly important to birds living along or using the northern Gulf of Alaska. Areas in Cook Inlet that may be considered as important to overwintering and migratory birds have been identified by a number of organizations.

Because of its importance to shorebirds of the Pacific Flyway, Kachemak Bay in Lower Cook Inlet has been designated as Western Hemisphere Shorebird Reserve. Western Hemisphere Shorebird Reserves (WHSR) are designated by the WHSR Network (WHSRN), a multinational shorebird conservation organization whose mission is to conserve shorebirds and their habitats through a network of key sites across the Americas[12] (WHSRN 2009a). The first WHSR designated site was Delaware Bay in the United States; there are currently 85 sites in 13 countries. Kachemak Bay in Cook Inlet is a WHSR of international importance, being designated in 1994. WHSR sites are considered of international importance if they support at least 100,000 shorebirds annually, or at least 10% of the biogeographic population for a species. Kachemak Bay received international importance status on the basis of it supporting more than 100,000 shorebirds annually. The bay has about 515 km (320 mi) of shoreline, which together with tides of as much as 9 m (30 ft), provides an abundance of intertidal habitat for migrating shorebirds. In addition, 36 species of shorebird have been reported from the area (WHSRN 2009b). Within Kachemak Bay, the Fox River Flats Critical Habitat Area (managed by the Alaska Department of Fish and Game) serves as a major staging area for thousands of waterfowl and a million or more shorebirds during spring migration.

Kachemak Bay and Fox River Flats are two of 21 sites that have been identified by the Audubon Society as Important Bird Areas (IBAs) in the Cook Inlet area (Audubon Alaska 2011; see discussion of IBAs in Section 3.8.2.1.4). This identification has no regulatory consequences but does provide information on avian habitats of Cook Inlet. Among these 21 sites (Table 3.8.2-8), 14 occur adjacent to or within the Cook Inlet Planning Area, and because of their locations these areas and their avian fauna have a greater likelihood of interacting with OCS oil and gas activities in the Cook Inlet Planning Area. The remaining sites occur in the upper reaches of Cook Inlet, above Kalgin Island (Figure 3.8.2-8), and would not be expected to be affected by normal oil and gas exploration and development activities. While the Swanson Lakes IBA is located inland of the Cook Inlet coast, the waterfowl and shorebirds that use this area likely also use Cook Inlet waters and shorelines for foraging, and thus could also be affected by oil and gas activities. All of the sites provide migratory staging, resting, foraging, and/or breeding habitat for a wide variety of marine and coastal birds, and especially seabirds, waterfowl, and shorebirds. Except for the Swanson Lakes IBA, most of the Cook Inlet IBAs are coastal in nature, several are islands, and one (Cook Inlet, Marine IBA) is an open water area.

3.8.2.2.5 Climate Change and Cook Inlet Birds. Climate change effects are occurring on all continents and oceans, with atmospheric and ocean warming being observed in many locations (see climate change discussions presented in Section 3.3). Environmental responses to climate change in the Cook Inlet Planning Area may include loss of sea ice and permafrost thawing (Lemke et al. 2007), changes in precipitation, erosion/siltation, increased storm severity, and additional concerns that are associated with the climate change-related sea level rise (Carter and Nielsen 2011; NRDC 2011).

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[12] U.S. members of the WHSRN council include, among others, the National Audubon Society, the U.S. Department of Agriculture Forest Service, the U.S. Geologic Survey, the U.S. Fish and Wildlife Service National Wildlife Refuge System, and the Nature Conservancy.

TABLE 3.8.2-8 Important Birds Areas in Cook Inlet (Audubon Alaska 2011)

Important Bird Area	County	Importance/important Species/Bird Groups
Kachemak Bay, South Shore[a]	Kenai Peninsula	Waterfowl, shorebirds, Steller's eider
Redoubt Bay	Kenai Peninsula	Hosts 70% of all migrating shorebirds in spring; largest known world concentration of Tule white-fronted goose; waterfowl
Swanson Lakes	Kenai Peninsula	Trumpeter swan; highest density of nesting common loons in North America; significant assemblage of migratory terrestrial species
Trading Bay	Kenai Peninsula	Entire population of Wrangell Island snow goose use site and mouth of Kenai River as spring migratory staging area; spring stopover site for shorebirds
Tuxedni Bay[a]	Kenai Peninsula	Supports up to 20% of the estimated 1.2 million shorebirds using western Cook Inlet intertidal areas; western sandpiper; waterfowl
Barren Islands[a]	Kenai Peninsula	One of largest populations of nesting seabirds in Gulf of Alaska; 18 breeding species, >400,000 seabirds
Clam Gulch[a]	Kenai Peninsula	Supports >1% of the biogeographic population of wintering Steller's eider
Homer Spit[a]	Kenai Peninsula	Steller's eider; large numbers of shorebirds in spring migration; 5% global population of rock sandpipers overwinter
Fox River Flats[a]	Kenai Peninsula	Major world site for migratory birds; thousands of waterfowl and millions of shorebirds; major spring staging area for geese and ducks, large wintering waterfowl population
Cook Inlet, Marine[a]	Kenai Peninsula Kodiak Island	Short-tailed albatross, shearwaters, seabirds, storm-petrels, fulmers, murres, tufted puffins
Uganik Bay and Viekoda Bay[a]	Kodiak Island	14 seabird colonies, >100 resident breeding pairs of black oystercatcher; foraging/nesting habitat for Kittlitz's murrelet and other alcids
Wide Bay[a]	Kodiak Island	Waterfowl use in spring and fall; Steller's eider; overwintering by Emperor goose; seabird colonies; Kittlitz's murrelet
Susitna Flats	Matanuska-Susitna	Waterfowl and shorebirds, especially during spring migration; among highest shorebird diversity of any site in Cook Inlet; entire world population of rock sandpiper winters here (October–April)
Kenai River Flats	Kenai Peninsula	Supports nearly entire population of Wrangell Island (Siberia) snow goose during spring migration; shorebirds, waterfowl, sandhill crane; large colonies of herring and mew gulls
Amakdedulia Cove[a]	Kenai Peninsula	Supports 1% of a subspecies of the double-crested cormorant; large numbers of sea ducks in summer

TABLE 3.8.2-8 (Cont.)

Important Bird Area	County	Importance/important Species/Bird Groups
Northwest Afognak Island[a]	Kodiak Island	Nesting and foraging habitat for variety of seabirds and shorebirds; 125–150 breeding pairs of black oystercatcher
Goose Bay	Matanuska-Susitna	Important spring and fall migratory resting/feeding habitat for waterfowl; snow goose, Canada goose, trumpeter swan, tundra swan
Anchor River[a]	Kenai Peninsula	Multi-species assemblages of migratory terrestrial birds
Chugach Islands[a]	Kenai Peninsula	Significant foraging area for seabirds; albatrosses, puffins, cormorants, gulls, all three murrelet species
Contact Point[a]	Kenai Peninsula	Over 1,000 seabirds of seven species nest here; high numbers of seaducks, gulls, diving ducks, and dabbling ducks in spring
Palmer Hay Flats	Matanuska-Susitna	Large numbers of waterfowl in spring

[a] Site occurs adjacent to or within the Cook Inlet Planning Area.

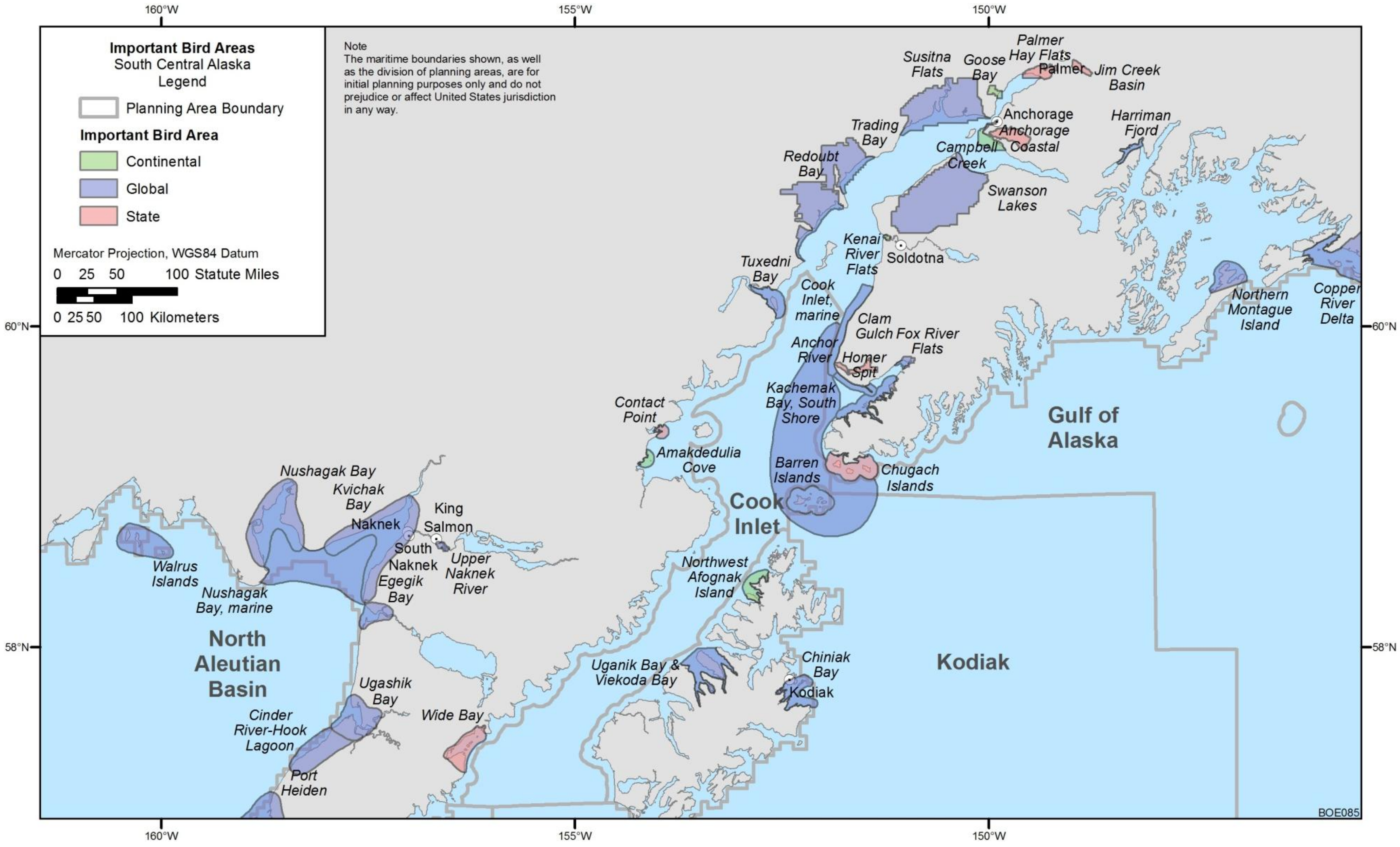

FIGURE 3.8.2-8 Important Bird Areas of the Cook Inlet Planning Area (Audubon Alaska 2011)

The potential effects of sea ice loss, permafrost thawing, and sea level rise may have a variety of adverse effects on marine and coastal birds of the planning area, with potential impacts associated mostly with loss of food and habitat. Sea level rise and altered precipitation, temperature, and river discharge regimes may affect invertebrate communities in terms of both species composition and total productivity (see discussion of climate change impacts on aquatic invertebrates in Section 3.8.5.2). Changes in this prey base could affect shorebirds and waterfowl that forage on these invertebrates during nesting, staging, and migrating (Galbraith et al. 2002; Moller et al. 2008; NABCI 2010). Although sea level rise may have some impact on coastal habitats of the Cook Inlet, at least parts of the region are not expected to be as greatly affected as other regions of Alaska. Coastal uplift of the local landmass is predicted to counterbalance much of the effect of rising seas and marshlands will likely keep up with sea level changes as they capture sediment and grow vertically (NRDC 2011).

The Cook Inlet coastline is susceptible to erosion during high-tide storms and may be affected by increased storm severity due to climate change (NRDC 2011). Degradation or loss of coastal wetlands in the Cook Inlet due to increased erosion may affect migratory bird species that rely on this area for stopover sites. For example, Fox River Flats is a major world site for migratory birds and loss of this habitat would affect thousands of waterfowl and millions of shorebirds.

The presence of landfast ice in Cook Inlet creates a productive marine ice biome that is essential for a variety of marine biota. Ice formation occurs primarily on the western side of Cook Inlet, but climate change may result in changes in ice formation. A reduction in ice scour could result in changes to marine productivity as well as the distribution, composition, and abundance of marine invertebrates (ACIA 2005; Moline et al. 2008) (see Section 3.8.5.2). Such changes could affect the prey base for seabirds, influencing their ability to provide food for chicks as well as preparing for the fall migration.

Climate change in Cook Inlet may be expected to result in short-term and long-term effects on marine and coastal birds of the region. These effects may be beneficial or detrimental in nature and could result in population-level effects on marine and coastal birds. Which species may be most affected and how they may respond to climate change over several decades are unknown.

3.8.2.3 Marine and Coastal Birds of the Beaufort and Chukchi Seas Planning Areas

As discussed earlier, more than 492 naturally occurring species in 64 families and 20 orders have been identified from Alaska (Johnson and Herter 1989; University of Alaska 2011). Because of the limited seasonal nature of open water and snow-free conditions, the Beaufort and Chukchi Seas support a much smaller number of avian species. For example, only about 180 species have been reported from the Arctic National Wildlife Refuge (ANWR 2010), while a 1999–2001 summer survey of birds in the western Beaufort Sea detected 30 species (primarily waterfowl) (Fischer and Larned 2004). Most birds occurring in the Beaufort and Chukchi Seas and their adjacent coastal habitats are migratory, being present for all or part of the period between May and early November. The avian fauna of these regions largely falls into two categories: (1) birds that arrive in spring at coastal breeding areas, breed and raise young, and then depart in fall to southern wintering areas; and (2) birds that migrate along the coast on their way to and from breeding areas elsewhere on the Arctic coast. Some groups, such as the passerines, are largely absent from coastal habitats along the Arctic coast, generally occurring as rare, casual, or accidental visitors.[13] A majority of species nesting in coastal areas are waterfowl and shorebirds, although in some locations seabirds occur in large nesting colonies.

3.8.2.3.1 Nonendangered Species. Although representatives of six major groups of birds have been reported from the planning areas (Table 3.8.2-9), three may be especially important because they have the greatest potential for being affected by oil and gas leasing and development: (1) seabirds, which occur in open ocean waters; (2) waterfowl, which use a variety of freshwater and nearshore marine habitats; and (3) shorebirds, which use shoreline habitats throughout the planning area. Members of these groups are migratory and occur seasonally, and some may occur in locally large concentrations in locations such as nesting colonies or as mobile flocks. The bays, inlets, and river mouths along the Beaufort and Chukchi Seas provide breeding, foraging, and staging areas for millions of shorebirds, seabirds, and waterfowl (Johnson 1993).

Seabirds. There are three general categories of seabirds: cliff-nesting species, Bering Sea breeders and summer residents of the Beaufort and Chukchi Seas, and high-Arctic species. The cliff dwelling species, such as the common and thick-billed (*Uria lomvia*) murres, the horned (*Fratercula corniculata*) and tufted (*F. cirrhata*) puffins, and the black-legged kittiwake, typically nest on cliffs, rock ledges, and sloping island surfaces on mainland cliffs, rocky headlands, and islands (Ainley et al. 2002; Audubon Alaska 2011; Hatch et al. 2009; Piatt and Kitaysky 2002a, b). These birds typically feed on fish and invertebrates, and many breed in colonies (some in mixed colonies) which in some locations may number 100,000 birds or more (Ainley et al. 2002; Audubon Alaska 2011). During breeding, these species may travel as much as 80 km (50 mi) from nest sites or colonies to forage on the continental slope and shelf (Gaston and Hipfner 2000; Hatch et al. 2000; Ainley et al. 2002; Hatch et al. 2009). Two major seabird colonies are present on the east coast of the Chukchi Sea (Cape Thompson and Cape Lisburne) consisting primarily of thick-billed murres, common murres, and black-legged kittiwakes, but also including horned puffins and tufted puffins (National Audubon Society 2012).

The Bering Sea breeders and summer residents of the Beaufort and Chukchi Seas include species such as the northern fulmar, the short-tailed shearwater (*Puffinus tenuirostris*), and the parakeet least (*Aethia pusilla*) and crested auklets. These species feed mostly on fish and invertebrates, and may forage as much as 100 km (62 mi) from breeding areas. They are colonial breeders (Jones 1993a, b; Jones et al. 2001; USFWS 2006e; Hatch and Nettleship 1998). Some of these species are among the most abundant birds in Alaskan waters. For example, the

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[13] "Rare" — occurring regularly within its normal range, but in very small numbers; "casual" — beyond normal range, but irregular observations occur over several years; "accidental" — far from normal range and observations are unlikely and not expected.

TABLE 3.8.2-9 Marine and Coastal Birds of the Beaufort and Chukchi Seas Planning Areas

Category	Order	Common Name	Representative Types
Seabirds	Charadriiformes	Gulls Terns Alcids Jaegers	Glaucous gull, common murre, horned puffin, Arctic tern, parasitic jaeger
	Procellariiformes	Storm-petrels Shearwaters Albatrosses	Short-tailed shearwater
Shorebirds	Charadriiformes	Phalaropes Plovers Oystercatchers Sandpipers, snipes, and allies	Dunlin, red phalarope
Wetland birds	Gruiformes	Cranes	Sandhill crane
	Podicipediformes	Grebes	Horned grebe
Passerines	Passeriformes	Perching birds	Warblers, sparrows, raven
Waterfowl	Anseriformes Gaviiformes	Ducks, geese, and swans Loons	Long-tailed duck, common eider, king eider, greater white-fronted goose, lesser snow goose, tundra swan, Pacific loon, red-breasted merganser
Raptors	Falconiformes	Birds-of-prey	Snowy owl

least auklet is one of the most abundant seabirds in North America (Jones 1993a), while the short-tailed shearwater is one of the most abundant species in pelagic Alaskan waters. Hundreds of thousands of shearwaters may be found in pelagic areas of the Chukchi Sea in late summer (USFWS 2006e; Audubon Alaska 2011). The northern fulmar is another very abundant species. About half of all North American colonies of this species occur in Alaska. Although there are no known nesting colonies along the Beaufort or Chukchi Seas, tens of thousands of this species may be found in pelagic waters of the Chukchi Sea in late summer (Audubon Alaska 2011).

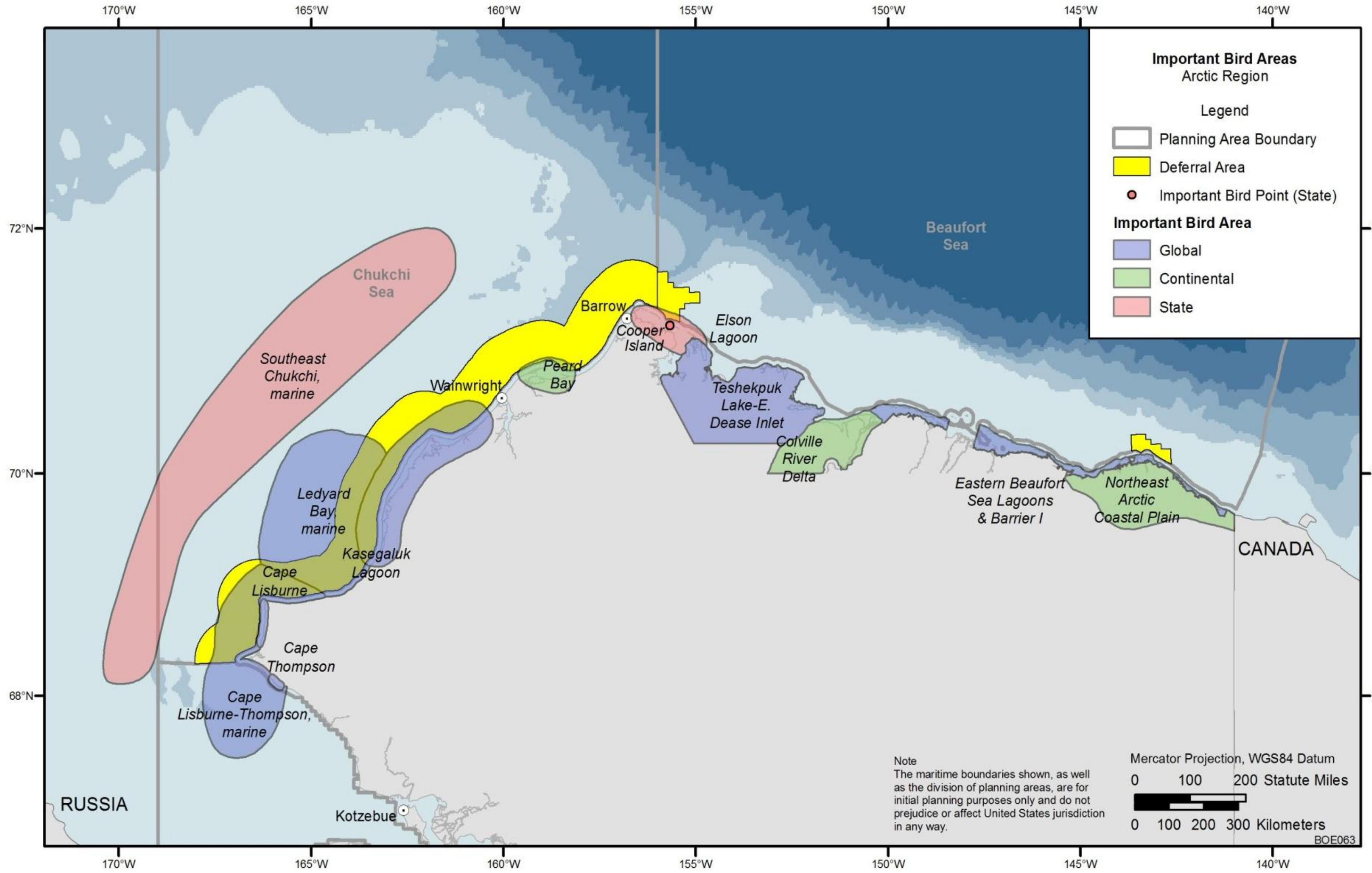
The high-Arctic seabirds are species that either breed in or migrate through Arctic habitats along the Arctic Ocean. Representative species include the black guillemot (*Cepphus gyrlle*), several species of gull (Ross’s gull [*Rhodostethia rosa*], ivory gull [*Pagophila eburnean*], and glaucous gull [*Larus hyperboreus*]), several species of jaegers (pomerine jaeger [*Stercorarius pomarinus*], parasitic jaeger [*S. parasiticus*], and long-tailed jaeger [*S. longicaudus*]), and the Arctic tern (*Sterna paradisaea*). The black guillemot occurs in both planning areas, nesting in isolated pairs or in small colonies along rocky coasts with adjacent shallow waters (Butler and Buckley 2002). Cooper Island (east of Barrow) supports the largest breeding colony in Alaska, and the easternmost colony occurs on the Beaufort coast of the Yukon Territory (Butler and Buckley 2002; Audubon Alaska 2011). Some of the gulls (e.g., Ross's and ivory) do not breed in Arctic Alaska habitats, but are present in fall before moving to wintering areas in the Bering Sea (Divoky et al. 1988; Mallory et al. 2008). The glaucous gull occurs in both the Beaufort and Chukchi Seas and breeds along marine and freshwater coasts, tundra, offshore islands, cliffs, shorelines, and ice edges, and may breed in mixed avian colonies with geese, ducks, and cliff-breeders (Gilchrist 2001). The jaegers are common in summer in the Chukchi Sea, moving into the Bering Sea in the fall. The Arctic tern is a rare species that may be found in pelagic waters of the Chukchi Sea.

Waterfowl. A variety of waterfowl occur in the Beaufort and Chukchi Sea Planning Areas, including loons (Pacific, yellow-billed, and red-throated), ducks (including the long-tailed duck, common eider, king eider) and geese (Pacific brant [*Branta bernicla nigricans*], greater white-fronted goose [*Anser albifrons frontalis*], lesser snow goose [*Chen caerulescens caerulescens*], and tundra swan [*Cygnus columbianus*]). Many of the waterfowl migrate along the west coast of Alaska into the Chukchi Sea and/or Beaufort Sea in spring, where they breed in freshwater and coastal habitats (e.g., Divoky 1987; Ely and Dzubin 1994; Goudie et al. 2000; Robertson and Savard 2002). Some species, such as the common eider, breed colonially along marine coasts (Goudie et al. 2000), while others such as the king eider may breed in more interior locations. Following nesting, many of the species move to molting areas in coastal areas of the Beaufort Sea and Chukchi Sea, where they may stay for several weeks before continuing their fall migrations to wintering grounds farther south. Important molting and fall migration station areas include Peard Bay, Kasegaluk Lagoon, and Teshekpuk Lake along the Chukchi Sea coast (Johnson 1993; Lysne et al. 2004).

Shorebirds. Many of the shorebirds associated with the Beaufort and Chukchi Seas breed on the tundra, but also rely on coastal areas such as beaches, barrier islands, lagoons, and mudflats for some portion of their lifecycle. These coastal areas provide important feeding grounds that prepare the birds for their fall migration to southern winter grounds (Powell et al. 2010). As many as 29 shorebird species have been reported to breed on the Arctic Coastal Plain; the National Petroleum Reserve-Alaska has been estimated to have as many as 6 million breeding shorebirds in summer (Alaska Shorebird Group 2008). Common shorebird species that breed on or migrate through the Arctic Coastal Plain include the dunlin, pectoral sandpiper (*Caldris melanotos*), semipalmated sandpiper (*C. pusilla*), and red phalarope (*Phalaropus fulicarius*) (Alaska Shorebird Group 2008; Powell et al. 2010).

Breeding species typically use shallow freshwater tundra ponds (polygons), marshes, and freshwater rivers and deltas (Alaska Shorebird Group 2008). Following breeding, migrating birds use a number of staging areas along the Chukchi and Beaufort Sea coasts, including river deltas and coastal lagoons (Alaska Shorebird Group 2008). Important post-breeding shorebird areas include Elson Lagoon and the Colville River Delta along the Beaufort Sea, and Peard Bay and Kasegaluk Lagoon on the Chukchi Sea (Figure 3.8.2-9). Kasegaluk Lagoon is one of the longest lagoon-barrier island systems in the world, and is used by 19 different species of shorebirds during fall migration (Alaska Shorebird Group 2008).

3.8.2.3.2 Birds Listed under the Endangered Species Act. There are two species that are listed as threatened under the ESA (see Section 3.8.2.1.2 for a discussion of the ESA and for



Note
The maritime boundaries shown, as well as the division of planning areas, are for initial planning purposes only and do not prejudice or affect United States jurisdiction in any way.

FIGURE 3.8.2-9 Important Bird Areas along the Beaufort Sea and Chukchi Sea Coasts (Audubon Alaska 2011) definitions of listing categories) that occur in the Beaufort and Chukchi Sea Planning Areas and that could be affected by OCS oil and gas activities. These species are the spectacled eider (*Somatria fischeri*) and the Alaska breeding population of the Steller's eider. In addition, Kittlitz's murrelet and the yellow-billed loon, both Federal candidate species, occur in the coastal and inland waters of the Chukchi Sea Planning Area.

The spectacled eider was listed in 1993 as threatened throughout its range in Alaska and Russia (58 FR 27474). The USFWS also has designated critical habitat (wintering area) considered to be essential for the conservation of spectacled eider (66 FR 9146). On Alaska's North Slope or Arctic Coastal Plain (ACP), an average of 6,841 spectacled eiders (about 2% of the world population) are present each summer (Larned et al. 2005). Spectacled eiders generally nest at low density (about 0.22–0.25 birds/km^2) within about 80 km (50 mi) of the coast, primarily west of the Sagavanirktok River (Larned et al. 2005, 2006). Highest densities occur south of Oliktok Point, from Harrison Bay to south of Smith Bay, and Admiralty Bay/Barrow southwest to Wainwright (Larned et al. 2005, 2006).

Male and female spectacled eiders pursue quite different schedules and movement patterns between the nesting period and arrival at the wintering area. Males leave the breeding grounds as incubation begins, usually early June to early July, and begin a molt migration, stopping in bays and lagoons to molt and stage prior to fall migration. Important molting and staging areas include Harrison Bay, Smith Bay, Peard Bay (east of Point Belcher), Kasegaluk Lagoon (south of Icy Cape), and Ledyard Bay (a critical habitat unit) (east of Cape Lisburne) (Figure 3.8.2-9) (Johnson 1993; Larned et al. 1995a, b). The median departure of females and young-of-the-year from the breeding grounds is late August (Petersen et al. 2000). Ledyard Bay is one of the primary molting areas for females breeding on the ACP (Larned et al. 1995a).

The Steller's eider is the smallest of the four eider species. The Alaskan breeding population of Steller's eider has been listed since 1997 as threatened under the ESA (62 FR 31748). The USFWS also has designated (2001a) critical habitat for the Steller's eider (66 FR 8850). See Section 3.8.2.2.2 for a discussion of the status of this species. There are three breeding populations, two in Russia and one in Alaska (USFWS 2002). The Alaska breeding population nests primarily on the ACP, and is the only one of the three populations listed under the ESA. On the ACP, this species breeds on grassy edges of tundra lakes and ponds or within drained lake basins (Fredrickson 2001). Although they nest in terrestrial environments, they spend the majority of their time in shallow marine waters. After nesting in the ACP, they move to protected marine areas to molt. Molting occurs at a number of locations in southwest Alaska, with largest numbers of birds concentrating in four areas along the north side of the Alaska Peninsula (USFWS 2002).

The Kittlitz's murrelet is a small diving seabird related to the puffins and murres. All of the North American and most of the world population of this species breed, molt, and winter in Alaska (USFWS 2006d), where this species may be found in coastal waters discontinuously from northern southeast Alaska in the Gulf of Alaska, north to Point Lay in the Chukchi Sea during the nesting season (Day et al. 1999). Although wintering areas remain largely unknown, Kittlitz's murrelets have been observed around Prince William Sound, Kenai Fjords, Kachemak Bay, Kodiak Island, Sitka Sound, and in the northern Gulf of Alaska along the Alaska Coastal

Current and mid-shelf regions (USFWS 2011g). This species is an uncommon and secretive breeder, choosing unvegetated scree slopes, coastal cliffs, talus above timberline, and barren ground, primarily in coastal areas but also up to 80 km (50 mi) inland. Because of the absence of suitable habitat, this species is not believed to nest east from Cape Beaufort in the western Chukchi Sea (Day et al. 1999).

The yellow-billed loon is a migratory seabird that in Alaska nests in solitary pairs on the Arctic Coastal Plain and winters in more southern coastal waters of the Pacific Ocean (USFWS 2011d). Yellow-billed loons typically nest near large, deep tundra lakes on low islands or near the edges of lakes to avoid terrestrial predators. In the Alaskan Arctic, nesting occurs from the Canning River westward to Point Lay, and migration occurs along coastlines of the Beaufort and Chukchi Seas (North 1994; NatureServe 2010d). During nesting, this species uses nearshore and offshore marine waters adjacent to their breeding areas for foraging in summer (74 FR 12932).

3.8.2.3.3 Use of the Chukchi and Beaufort Sea Planning Areas by Migratory Birds. As previously discussed in Section 3.8.2.3.1, the Chukchi and Beaufort Sea Planning Areas undergo extreme weather variability that results in a very distinct seasonal availability of habitat. As a consequence of these conditions, virtually all species of birds that have been reported from the Beaufort and Chukchi Sea Planning Areas are seasonal visitors that for the most part are absent in winter. In general, birds migrate to or through the area in spring. Some species (i.e., greater white-fronted goose) migrate to breeding habitats where they nest and raise young. Other species (i.e., ivory gull) pass through the two planning areas on their way to Arctic habitats in Canada, while still others (i.e., short-tailed shearwater) move into the area to forage in summer in offshore waters. In late summer and early fall, many species move to molting and staging areas in preparation for their fall migrations out of the Arctic habitats to southern wintering areas.

Spring. Many of the species that move into the Beaufort and Chukchi Sea Planning Areas in spring migrate into the area along the Bering Sea coast (e.g., Dickson and Gilchrist 2002). Arrival times generally coincide with the formation of ice leads. Migration times vary by species, but for most species spring migration occurs between late March and late May. For example, waterfowl species such as the long-tailed duck and common eider migrate northward in spring along the Chukchi Sea coast following the recurrent lead system in the ice and then migrate eastward in the Beaufort Sea region along a broad front, which may include inland, coastal, and offshore routes, from early May to mid-June (Johnson and Herter 1989; Goudie et al. 2000; Robertson and Savard 2002). Arrival dates for various species range from late April to early June. The availability of open water off river deltas and in leads determines migratory routes and distribution of loons, waterfowl, and seabirds during this time (Johnson and Herter 1989).

Summer. As discussed earlier, birds migrate into the Chukchi and Beaufort Sea Planning Areas in spring to breed, moving into appropriate habitats where they nest and raise young. Depending on the species, nesting habitats include islands, rocky coastlines, river deltas, lagoons, and all types of tundra habitat on the ACP. Shorebirds nest in virtually all types of tundra habitats in the Arctic subregion, shifting to wetter marine littoral, saltmarsh, and barrier island shoreline types for brood rearing where insects are more abundant (Alaska Shorebird Group 2008).

Late Summer and Autumn. After breeding, many species of waterfowl, particularly sea ducks, undergo a migration to molting areas prior to fall migration to southern wintering areas (Goudie et al. 2000; Fredrickson 2001; Robertson and Savard 2002; Larned et al. 2006). Most brood rearing and molting of loons, swans, and geese occurs on large lakes or in coastal habitats. Major concentrations of molting waterfowl occur from late June through August in several areas along the Beaufort and Chukchi Sea coasts, including Teshekpuk Lake, Simpson Lagoon, Peard Bay, Kasegaluk Lagoon, and Ledyard Bay (Figure 3.8.2-9) (Audubon Alaska 2011).

Fall migration times also vary by species, and in some cases by gender and age group. For example, male and nonbreeding or failed-breeding female common eiders migrate to coastal molting areas in Chukchi Sea lagoons and bays beginning in late June and early July (Johnson and Herter 1989). Some females with young may molt in Beaufort coastal lagoons before moving south to wintering areas from August to as late as November (Johnson and Herter 1989; Goudie et al. 2000). Male king eiders undertake a molt migration to Chukchi and Bering Sea areas from early July through August (Suydam 2000). Females migrate from mid-August into September, staging an average of 14 km (9 mi) offshore for 9–32 days in the Beaufort. Young leave the breeding areas in September and October.

Along the Chukchi Sea and Beaufort Sea coastlines, non-incubating members of shorebird pairs concentrate in coastal habitats as early as mid-June (Alaska Shorebird Group 2008; Powell et al. 2010). In late June to early July, individuals and flocks of non-breeding and post-breeding adults of several species move to habitats surrounding small coastal lagoons and river deltas (Taylor et al. 2010). In late July and early August, adults relieved of parental duties flock in shoreline areas, followed by juveniles in August and September. Parents with fledged young follow in several weeks, and juveniles form large flocks in mid- to late August, and most have departed the area by mid-September. From late September to mid-October, a majority of the world’s Ross’s gull population (4,500–16,000) migrates from the Russian Chukchi to shoreline habitats from Wainwright to Point Barrow and eastward to the Plover Islands (Divoky et al. 1988), returning in mid-October. Most black guillemots probably overwinter in leads in the Beaufort and Chukchi Seas.

3.8.2.3.4 Important Bird Areas. The Beaufort Sea and Chukchi Sea Planning Areas and adjacent coastal areas include 11 sites that have been identified as IBAs (Table 3.8.2-10) (Audubon Alaska 2011; see discussion of IBAs presented in Section 3.8.2.1.4).

3.8.2.3.5 Climate Change and Arctic Birds. Climate change effects have been observed to be occurring on all continents and oceans, with atmospheric and ocean warming being observed in many locations, but especially in the Arctic (see climate change discussions

TABLE 3.8.2-10 Important Birds Areas in the Beaufort Sea and Chukchi Sea Planning Areas

Important Bird Area	Area Importance/Important Species or Bird Groups
Teshekpuk Lake-E. Dease Inlet	High densities of breeding shorebirds; large numbers (>50,000) of molting geese, including up to 30% of the Pacific Flyway Brant goose population; breeding populations of spectacled and Steller's eider; some of the highest breeding densities of the yellow-billed loon in the Western Hemisphere.
Ledyard Bay, marine	Site supports large numbers of sea birds and waterfowl. As many as 100,000 common murres and thick-billed murres and 10,000 black-legged kittiwake have been reported during the breeding season, and more than 30,000 spectacled eider have been reported outside of the breeding season.
Kasegaluk Lagoon	Nineteen shorebird species have been reported from the site, with more than 25,000 birds present. Most abundant shorebirds include the red phalarope and dunlin. Peak single-day bird counts in August of as many as 2,500 birds.
Eastern Beaufort Sea lagoons and barrier islands	Used by breeding and post-breeding migratory waterfowl; long-tailed ducks are the most abundant species in late summer and early fall; lagoons used during molting by Canadian-breeding and Alaska-breeding ducks; 10,000+ phalaropes regularly use the lagoons.
Cape Thompson	Supports only one of two known seabird colonies on the east coast of the Chukchi Sea. Total seabird population estimated to be on the order of 350,000 birds; species include thick-billed and common murres and black-legged kittiwakes.
Cape Lisburne	Supports only one of two known seabird colonies on the east coast of the Chukchi Sea. Total seabird population on the order of 500,000 birds, primarily thick-billed and common murres and black-legged kittiwakes.
Peard Bay	A large deep bay used for breeding by Brant goose, common eider, and spectacled eider, and as a resting/staging area by waterfowl and shorebirds during migration.
Northeast Arctic Coastal Plain	Used by post-breeding lesser snow goose for pre-migration foraging, with peak annual numbers in excess of 300,000.
Cooper Island	Supports largest black guillemot colony in Alaska, and is the most northerly known breeding site for horned puffins. Also supports very large Arctic tern colony.
Southeast Chukchi, marine	Tens of thousands of northern fulmers and hundreds of thousands of short-tailed shearwaters can be found in this area in late summer; thousands of auklets (primarily 1st and 2nd year birds) as far north as Cape Lisburne.
Elson Lagoon	Site estimated to support as many as 20,000 shorebirds; wide offshore zone important for waterfowl; and common eiders nest on the barrier islands. This site is pending global/continental status.

Source: Audubon Alaska 2011.

presented in Section 3.3). Environmental responses in the Beaufort and Chukchi Sea Planning Areas include loss of sea ice (Parkinson 2000) and permafrost thawing (Lemke et al. 2007), changes in precipitation, and additional concerns that are associated with the climate change-related sea level rise and potential for high erosion of Beaufort and Chukchi Sea coasts (Proshutinsky et al. 2001; Mars and Housenecht 2007).

The potential effects of sea ice loss, permafrost thawing, and sea level rise may have a variety of adverse effects on marine and coastal birds of the two planning areas, with potential impacts mostly associated with loss of food and habitat. Sea level rise and altered precipitation, temperature, and river discharge regimes may affect littoral zone invertebrate communities in terms of both species composition and total productivity (see discussion of climate change impacts on aquatic invertebrates in Section 3.8.5.3). Changes in this prey base could affect shorebirds and waterfowl that forage on these invertebrates during nesting, staging, and migrating (Rehfisch and Crick 2003; Galbraith et al. 2002; Moller et al. 2008; Lovvorn et al. 2009; NABCI 2010). Atmospheric warming, coupled with altered precipitation regimes, is predicted to cause boreal forests to expand northward, displacing tundra-breeding birds into narrower coastal areas (NABCI 2010) (see Section 3.7.1.3 for a discussion of potential climate effects on Arctic tundra and coastal habitats). The loss of tundra wetlands on the coastal plain would reduce nesting habitat for a variety of birds as well as affect prey abundance and distribution of tundra-nesting species. If climate change alters the timing of food abundance, this could affect both nesting and migrating birds. The arrival, nesting, and hatching of many shorebird species are closely tied to the emergence of insects upon which the hatchlings depend (Alaska Shorebird Group 2008).

The presence of sea ice and landfast ice in the Arctic creates a productive marine ice biome that is essential for a variety of marine biota. Sea ice in the Arctic has been estimated to be decreasing by 3% per decade since the 1970s (see Section 3.3 for a more detailed discussion of sea ice and climate change). Loss of sea ice may affect marine productivity as well as the distribution, composition, and abundance of marine invertebrates (ACIA 2005; Moline et al. 2008) (see Section 3.8.5.3). Such changes could affect the prey base for seabirds, affecting their ability to provide food for chicks as well as preparing for the fall migration.

Climate change in the Arctic may be expected to result in short-term and long-term effects on marine and coastal birds of the region. These effects may be beneficial or detrimental in nature and could result in population-level effects on marine and coastal birds. Which species may be most affected and how they may respond to climate change over the several decades are unknown.

3.8.3 Reptiles

3.8.3.1 Life Stages and Habitats in the Gulf of Mexico

Five species of sea turtles — the green, hawksbill, Kemp’s ridley, leatherback, and loggerhead — are known to inhabit the GOM (Pritchard 1997), and all occur in coastal and offshore habitats in each of the GOM Planning Areas included in this PEIS. In addition to sea turtles, there are three additional federally protected reptile species that could occur in the GOM planning areas: Alabama red-belly turtle, gopher tortoise, and American crocodile. All eight reptile species are listed as either endangered or threatened species under the ESA. Habitat preferences and relative abundance of these species in the GOM are provided in Table 3.8.3-1. Other reptile species not discussed in this section that could occur in coastal or brackish environments may be listed as sensitive or species of concern by the USFWS or the States in the GOM Planning Region (e.g., diamondback terrapin [*Malaclemys terrapin*], gulf salt marsh snake [*Nerodia clarkia*]).

The life history of sea turtles includes four developmental stages: embryo, hatchling, juvenile, and adult. Habitats used and turtle mobility at each developmental stage are summarized in Table 3.8.3-2.

Habitat utilization and migrations of sea turtles vary depending upon these specific developmental stages and result in differential distributions (Marquez 1990; Ackerman 1997; Hirth 1997; Musick and Limpus 1997). Consequently, the degree of sea turtle vulnerability to specific human impacts may also vary between developmental stages. There are three types of life history patterns (see Table 3.8.3-1) followed by developing sea turtles, and sea turtles that occur in the GOM planning areas are generally considered to follow two of these life history types (Bolten 2003). The leatherback sea turtle exhibits the Type 3 life history pattern, in which both developmental and adult stages occur completely in the open oceanic zone. The other four sea turtles in the GOM planning areas (green, hawksbill, Kemp's ridley, and loggerhead) are believed to exhibit the Type 2 life history pattern, in which early development of hatchlings occurs in the open oceanic zone; later, juvenile and adult development takes place in neritic zones. Sea turtle eggs deposited in excavated nests on sandy beaches are especially vulnerable to coastal impacts. After hatching, hatchling turtles move immediately from these nests to the sea. Most species ultimately move into areas of current convergence or to mats of floating *Sargassum*, where they undergo primarily passive migration within oceanic gyre systems (Carr and Meylan 1980; Bolten 2003). The passive nature of hatchling turtles, along with their small size, makes them vulnerable in open-ocean environments. Pelagic *Sargassum* habitat is an important source of food and shelter for hatchling sea turtles. Developing sea turtles subsist on the shrimp, crabs, and other invertebrates that inhabit the *Sargassum* mats. A more detailed discussion of the distribution of *Sargassum* in the GOM is provided in Section 3.7.3.1.2. After a period of years, most juvenile turtles (defined as those which have commenced feeding but have not attained sexual maturity) actively recruit to nearshore developmental habitats within tropical and temperate zones. Juvenile turtles in some temperate zones also make seasonal migrations to foraging habitats at higher latitudes in summer months. The movements of turtles in tropical areas are typically more localized. When approaching sexual maturity, juvenile turtles move into adult foraging habitats. Thus, both juvenile and adult sea turtles may be vulnerable to impacts in both open-ocean and near-coastal environments but (unlike hatchlings) may actively avoid or escape certain impact-producing factors or conditions. Near the onset of nesting season, adult turtles move between offshore foraging habitats and nesting beaches. Mating may occur directly off the nesting beaches or remotely, depending on the species and population. During the nesting season, females become resident in the vicinity of the nesting beaches and may be more vulnerable to impacts within these near-coastal waters and on nesting beaches.

TABLE 3.8.3-1 Reptiles of the Gulf of Mexico That Are Listed under the Endangered Species Act

Species	Status	Juveniles or Hatchlings Potentially Present?	Habitat and Relative Abundance in the Gulf of Mexico
Family Cheloniidae			
Loggerhead turtle (*Caretta caretta*)	T[a]	Yes	Estuarine, coastal, and shelf waters. The most abundant sea turtle in the GOM (Dodd 1988). Total estimated nesting in the U.S. is approximately 68,000 to 90,000 nests per year (NOAA 2011c). Main U.S. nesting beaches are in southeast Florida and Florida Panhandle. Some reported nests in Texas through Alabama (NMFS and USFWS 1991). Exhibits the Type 2 life history pattern, in which early hatchling development occurs in the open oceanic zone, later followed by development in nearshore neritic zones (Bolten 2003).
Green turtle (*Chelonia mydas*)	T,E[b]	Yes	Shallow coastal waters, seagrass beds. Nesting in the U.S. primarily occurs along the central and southeast coasts of Florida where an estimated 200 to 1,100 females nest annually (NOAA 2011d). Exhibits the Type 2 life history pattern, in which early hatchling development occurs in the open oceanic zone, later followed by development in nearshore neritic zones (Bolten 2003).
Hawksbill turtle (*Eretmochelys imbricata*)	E	Yes	Coral reefs, hard-bottom areas in coastal waters; adults not often sighted in northern GOM. Least common of all sea turtles in the GOM; nesting limited to southeast Florida and the Florida Keys (NOAA 2011e). Exhibits the Type 2 life history pattern, in which early hatchling development occurs in the open oceanic zone, later followed by development in nearshore neritic zones (Bolten 2003).
Kemp’s ridley turtle (*Lepidochelys kempi*)	E	Yes	Shallow coastal waters, seagrass beds. Nests mainly at Rancho Nuevo, Mexico. Nesting also occurs along the Texas coast and portions of western Florida and Alabama. As many as 127 nests have been recorded annually along coastal Texas since 2000, and as many as 8,000 nests have been recorded annually at Rancho Nuevo, Mexico, since 2000 (NOAA 2011f). Exhibits the Type 2 life history pattern, in which early hatchling development occurs in the open oceanic zone, later followed by development in nearshore neritic zones (Bolten 2003).

TABLE 3.8.3-1 (Cont.)

Species	Status	Juveniles or Hatchlings Potentially Present?	Habitat and Relative Abundance in the Gulf of Mexico
Family Dermochelyidae			
Leatherback turtle (*Dermochelys coriacea*)	E	Yes	Slope, shelf, and coastal waters; considered the most pelagic of the sea turtles. Some nesting in the northern GOM, especially Florida Panhandle; nearest major nesting concentrations are in Caribbean and southeast Florida. In Florida, about 35 nests are observed each year (USFWS 2011f). Exhibits the Type 3 life history pattern, in which both developmental and adult stages occur completely in the open oceanic zone (Bolten 2003).
Family Emydidae			
Alabama red-belly turtle (*Pseudemys alabamensis*)	E	Yes	Known only to occur in southern Alabama and Mississippi in the lower Mobile River system. Known to occur in bays and river inlets along the coast. Nests are made on sand spoil banks, berms, and levees (NatureServe 2012).
Family Testudinidae			
Gopher tortoise (*Gopherus polyphemus*)	C,T[c]	Yes	Occurs in the southeastern Coastal Plain from southern South Carolina to extreme southeastern Louisiana. Populations that are listed as threatened under the Endangered Species Act can occur on upland habitats close to coastal marshes and ridges in Alabama, Louisiana, and Mississippi (USFWS 2011j).
Family Crocodylidae			
American crocodile (*Crocodylus acutus*)	T,E[d]	Yes	In the continental U.S., this species is known from coastal mangrove swamps, brackish bays, and inshore freshwater habitats in southern Florida. Nests at edges of riparian thickets, sandy beaches, or on banks of coastal creeks or mangrove swamps. The crocodile population in Florida is estimated between 1,400 and 2,000 individuals, not including hatchlings (USFWS 2007c).

TABLE 3.8.3-1 (Cont.)

Status: C = candidate species; E = endangered species; and T = threatened species under the Endangered Species Act of 1973.

[a] The loggerhead turtle is currently listed under the ESA as nine distinct population segments (DPSs). The south Atlantic DPS, which occurs in the GOM, is listed as threatened under the ESA (NOAA 2011c).

[b] Green sea turtles are listed as threatened, except in Florida, where breeding populations are listed as endangered.

[c] Within the GOM planning areas, the gopher tortoise is listed as threatened west of the Mobile and Tombigbee Rivers in Alabama, Mississippi, and Louisiana. It is listed as a candidate species east of the Mobile and Tombigbee Rivers in Alabama and Florida.

[d] American crocodiles are listed as threatened in Florida; endangered elsewhere.

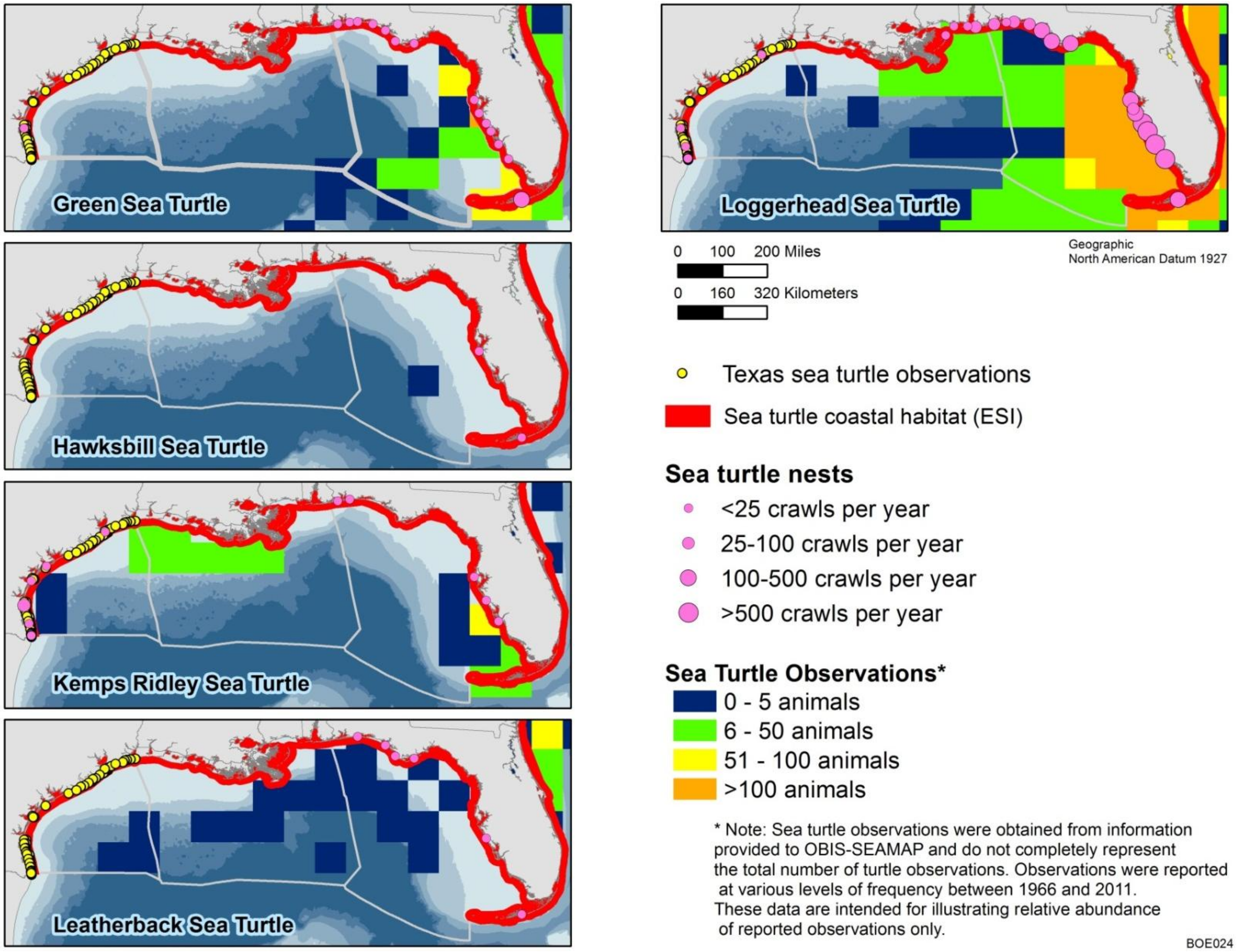
TABLE 3.8.3-2 General Sea Turtle Life Stages, Habitats, and Mobility in the Gulf of Mexico[a]

Developmental Stage	Habitat	Mobility
Embryo	Beaches	Stationary
Hatchling	Ocean/*Sargassum*	Passive migration
Juvenile	*Sargassum*/nearshore	Swimmers
Adult	Ocean	Swimmers

[a] These habitat-life-stage relationships are most similar to the Type 2 life history pattern reported in Bolten (2003) and most likely represent the life history of green, hawksbill, Kemp's ridley, and loggerhead sea turtles in the GOM planning areas.

Sea turtles are highly migratory and therefore have a wide geographic range. For this reason, each turtle species has the potential to occur throughout the entire GOM and may occur at suitable nesting beaches along the entire northern GOM coast. Areas of greater coastal and off-shore turtle observations have been provided to the Ocean Biogeographic Information System-Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP) (Read et al. 2011) and are shown in Figure 3.8.3-1. Also illustrated in Figure 3.8.3-1 are approximate locations of turtle nesting locations cataloged by the Wider Caribbean Sea Turtle Nesting Beach Atlas (Dow et al. 2007). Most observations and nesting activity occurs along western and northwestern Florida and consists of primarily loggerheads, green, leatherback, and a few Kemp's ridley turtles. There are reports of recent nesting in Alabama (loggerhead, Kemp's ridley, and green turtles) along Dauphin Island and the Gulf Islands National Seashore; in Mississippi (loggerhead turtles) along the Gulf Islands National Seashore; and in Louisiana (loggerhead turtles) within the Breton National Wildlife Refuge (Figure 3.8.3-1). All five sea turtle species have been observed to nest along areas of the Texas coast (Padre Island National Seashore) (NPS 2011). Hatchling turtles found in the offshore waters of the northern GOM may have originated from these nesting beaches or nest beaches in the southern GOM and Caribbean Sea. Juvenile turtles may move into shallow water developmental habitats across the entire northern GOM. In some species or populations, adult foraging habitats may be geographically distinct from their developmental habitats (Musick and Limpus 1997).

There are no designated critical habitats or migratory routes for sea turtles in the northern GOM. However, many coastal areas of the GOM may be used as preferred habitats (i.e., important sensitive habitats that are essential for the species within a specific geographic area). For example, seagrass beds in Texas lagoons and other nearshore or inshore areas (including jetties) for green sea turtles (Renaud et al. 1995) and bays and lakes, especially in Louisiana and Texas, for Kemp's ridley sea turtles. *Sargassum* mats are also recognized as preferred habitat for hatchlings (Carr and Meylan 1980). In general, however, the entire GOM coastal and nearshore areas can serve as habitat for marine turtles, as shown in the plot of marine turtle potential habitat from the USGS's GAP database in Figure 3.8.3-1.



* Note: Sea turtle observations were obtained from information provided to OBIS-SEAMAP and do not completely represent the total number of turtle observations. Observations were reported at various levels of frequency between 1966 and 2011. These data are intended for illustrating relative abundance of reported observations only.

FIGURE 3.8.3-1 Reported Observations of Sea Turtles and Suitable Habitat in the GOM (data presented in these maps were obtained from various sources including the Environmental Sensitivity Index [NOAA 1996], OBIS-SEAMAP [Read et al. 2011], Texas General Land Office [TGLO 2012], and the Wider Caribbean Sea Turtle Nesting Beach Atlas [Dow et al. 2007])

The Alabama red-belly turtle occurs in southern Alabama and Mississippi in the lower Mobile River system. It is most common in backwater habitats of the upper Mobile Bay in areas with submerged vegetation. It also occurs in river channels and brackish water and salt marsh areas of the lower Mobile River system. This species does not occur in pelagic regions of the GOM. Nesting occurs on sand spoil banks, berms, and levees (NatureServe 2012). Critical habitat for this species has not been designated. County-level occurrences of the Alabama red-belly turtle are shown in Figure 3.8.3-2.

The gopher tortoise occurs in the southeastern Coastal Plain from southern South Carolina to extreme southeastern Louisiana. Populations of the gopher tortoise have been divided into eastern and western regions. Populations in the eastern region occur east of the Mobile and Tombigbee Rivers in Alabama, Florida, Georgia, and South Carolina. Populations in the western region occur west of the Mobile and Tombigbee Rivers in Alabama, Mississippi, and Louisiana. Populations in the eastern region are currently not listed as threatened or endangered under the ESA (these populations are candidates for listing); however, populations in the western region are listed as threatened under the ESA (USFWS 2011j). Populations in the western region that are listed as threatened under the ESA can occur on upland habitats close to coastal marshes and ridges in Alabama, Mississippi, and Louisiana. Critical habitat for this species has not been designated. County-level occurrences of threatened populations of the gopher tortoise are shown in Figure 3.8.3-2.

The American crocodile occurs in the continental U.S. in southern Florida. It primarily inhabits coastal mangrove swamps, brackish bays, and inshore freshwater habitats. This species does not occur in pelagic regions of the GOM. Nesting occurs in riparian thickets, swamps, beaches, or along creeks. Designated critical habitat for the American crocodile occurs in southern Florida, including Everglades National Park and the Florida Keys. Areas of suitable habitat for the American crocodile, determined by the Environmental Sensitivity Index (NOAA 1996), as well as county-level occurrences of the species, are illustrated in Figure 3.8.3-2.

3.8.3.1.1 Factors That Could Affect Baseline Conditions during the Program.

Extreme Weather Events. Hurricanes Katrina and Rita, which hit the GOM coast in August and September 2005, respectively, adversely affected sea turtle habitats. Some nesting sites (approximately 50 nests) for Kemp’s ridley sea turtles were destroyed along the Alabama coast (Congressional Research Service 2005; USFWS 2006c), and 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 to seagrass beds may affect the local distribution and abundance of species that use these habitats, such as the green sea turtle and the Kemp’s ridley sea turtle.

Catastrophic Oil Spills. The recent oil spill associated with the DWH event may have had detrimental consequences to sea turtles that had direct contact with spilled oil. Following the DWH event, a total of 1,146 sea turtles were recovered from the GOM that had come in contact with or were located in areas that were once in the vicinity of spilled oil. The recovered turtles

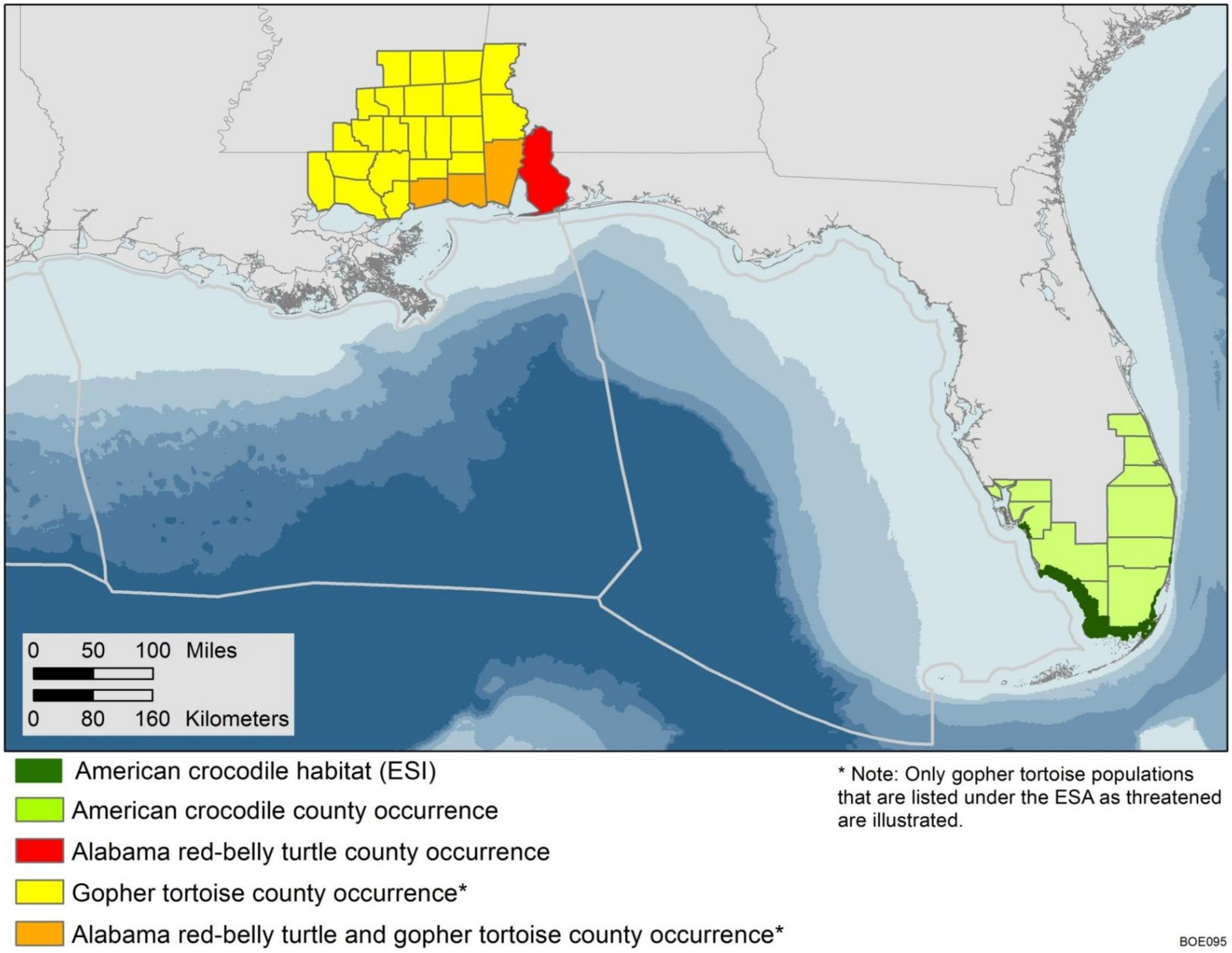


FIGURE 3.8.3-2 Reported County-Level Occurrences and Suitable Habitat for the American Crocodile, Alabama Red-belly Turtle, and Gopher Tortoise in the GOM Planning Areas (NOAA 1996; USFWS 2011d)

included adults or free-swimming juveniles of four species: green, hawksbill, Kemp's ridley, and loggerhead. However, the species of some recovered sea turtles could not be identified (Table 3.8.3-3). Of the total number of turtles recovered, approximately 53% were found dead and approximately 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). The cause of death of the deceased turtles remains unclear, but it is possible for turtles to ingest or inhale oil that could be potentially fatal without any noticeable external indications.

The DWH event also had the potential to affect sea turtle populations by fouling habitats such as seagrass beds and nesting beaches. 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, although the true ecological consequences of these effects are not known. This information, however, is not needed at the programmatic stage to make a reasoned choice among alternatives (see Section 1.4, Analytical Issues).

As a measure to prevent oil fouling of turtle nests and hatchlings, sea turtle nests along the GOM were collected and hatchlings were translocated to eastern Florida along the Atlantic coast. In total, turtle nests of three species were translocated following the DWH event: green, Kemp's ridley, and loggerhead. Nests of the Kemp's ridley turtle were most commonly translocated (Table 3.8.3-3) (NOAA 2012b).

Catastrophic spills such as the DWH event have the potential to affect other reptile species that may inhabit coastal or estuarine environments. Such species in the GOM Planning Areas include the American crocodile (*Crocodylus acutus*). This species inhabits brackish and freshwater environments and is primarily known to occur in coastal mangrove swamps in southern Florida (Table 3.8.3-3). Depending upon location and magnitude, catastrophic oil spills in the GOM have the potential to affect coastal mangrove and beach habitats in southern Florida for the American crocodile. However, there is no evidence that the DWH event affected habitat for this particular species.

3.8.3.2 Climate Change Effects on Reptiles

Climate change also has the potential to affect marine and coastal reptile species in the GOM Planning Areas over the next 40–50 yr. Climate change effects, including warming air and water temperatures, rising sea levels, and more intense storms, have been reported in many U.S. coastal regions. These climate change effects have been scientifically correlated with atmospheric concentrations of greenhouse gases. 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 turtles and crocodilians, subtle increases in atmospheric temperatures could skew sex ratios of hatchlings, which could have future population

TABLE 3.8.3-3 Sea Turtle Species Recovered, Turtle Nests Translocated, and Turtle Hatchlings Released in the Atlantic Ocean Following the Deepwater Horizon Event

Species	Recovered Alive	Recovered Dead	Total Recovered	Translocated Nests	Hatchlings Released
Green turtle (*Chelonia mydas*)	172	29	201	4	455
Hawksbill turtle (*Eretmochelys imbricata*)	16	0	16	0	0
Kemp's ridley turtle (*Lepidochelys kempii*)	328	481	809	5	125
Loggerhead turtle (*Caretta caretta*)	21	67	88	265[a]	14,216
Unknown turtle species	0	32	32	0	0
Total	537	609	1,146	274	14,796

[a] Does not include one nest that included a single hatchling and no eggs.

Source: NOAA 2012b.

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 or eliminate 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).

3.8.4 Fish

3.8.4.1 Gulf of Mexico

In the northern GOM, fish assemblages can be categorized by habitat use. Demersal fishes live on the seafloor and near bottom waters and are distinct from pelagic fishes, which reside in the water column. Within these categories, fish can be further classified by their depth preference and their location along the gradient from the continental shelf to the abyssal plain. Habitat use also varies across life stages. For example, many species of both pelagic and demersal fish inhabit coastal estuaries during their early life stages to take advantage of the shelter and abundant food resources provided by coastal habitat. Similarly, demersal fishes may spend their egg and larval stages in the upper water column, where phytoplankton resources are concentrated, before ultimately moving to bottom waters. There are also unique categories of fish, for example, diadromous species (fish migrating between fresh and salt water) that spend most of their adulthood in saltwater but spawn in freshwater (anadromous) or that live primarily in freshwater and spawn in saltwater (catadromous).

3.8.4.1.1 Diadromous Fishes. There are three anadromous fish species in the GOM: Gulf sturgeon (*Acipenser oxyrinchus desotoi*), striped bass (*Morone saxatilis*), and Alabama shad (*Alosa alabamae*). Anadromous species spawn in rivers but spend part of their lives in oceans. Gulf sturgeon populations have declined in the last century and they are now a federally listed threatened species. Striped bass are native to rivers entering the GOM from Florida to Texas, although existing data suggests their numbers were historically small and not sufficient to support a large commercial fishery. Striped bass populations began declining earlier this century, and by the mid-1960s had disappeared from all GOM rivers except for the Apalachicola-Chattahoochee-Flint River System and the Mobile-Alabama-Tombigbee River System of Alabama, Florida, and Georgia (GSMFC 2006). The decline has been attributed to pollution and dams that reduced access to spawning habitat and created adverse hydrologic conditions for eggs. The USFWS and the GOM States initiated cooperative efforts to restore and maintain striped bass populations in the late 1960s, primarily through stocking of hatchery-raised fingerlings, and this effort continues today.

The historic range of Alabama shad was similar to that of the striped bass but extended well up the Mississippi River drainage. Populations of Alabama shad have declined significantly over the years, and they were designated a species of concern by the NMFS in 1997 (http://www.nmfs.noaa.gov/pr/pdfs/species/alabamashad_detailed.pdf). Spawning populations exist in the Apalachicola River, Florida; the Choctawhatchee and Conecuh Rivers, Alabama; and the Pascagoula River, Mississippi. Dams that have been built on many southeastern rivers are thought to be a major reason for the decline of anadromous fish species in the GOM. Little is known about their distribution or habitat use in marine environments.

The catadromous American eel (*Anquilla rostrata*) also occurs within waters of the GOM, with young and maturing individuals found in nearly all the rivers, bays, lakes, and estuaries associated with the GOM. Adult American eels spend most of their lives in freshwater but eventually swim to the Sargasso Sea where they spawn and die (Eales 1968). The young eventually migrate to inland waters. Commercial fishing has significantly reduced eel numbers, and in September of 2011, the USFWS announced the initiation of a status review of the American eel to determine if a listing under the Endangered Species Act is warranted (50 CFR Part 17: 60431–60444).

3.8.4.1.2 Pelagic Fishes. Coastal pelagic fishes include larger predatory species such as mackerels (*Scomberomorus* spp.), bluefish (*Pomatomus saltatrix*), cobia (*Rachycentron canadum*), dolphin fish (*Coryphaena hippurus*), jacks (family Carangidae), and little tunny (*Euthynnus alletteratus*), as well as smaller forage species such as Gulf menhaden (*Brevoortia patronus*), Atlantic thread herring (*Opisthonema oglinum*), Spanish sardine (*Sardinella aurita*), round scad (*Decapterus punctatus*), and anchovies (family Engraulidae). Coastal pelagic species typically form schools, undergo migrations, grow rapidly, mature early, and exhibit high fecundity. These species are either managed by GMFMC or are important prey fish for other species. The larger predatory species may be attracted to large concentrations of anchovies, herrings, and silversides (family Atherinidae) that sometimes congregate in nearshore areas.

Fish inhabiting oceanic waters can be divided into epipelagic, mesopelagic, and bathypelagic, on the basis of their depth preference. Epipelagic fishes inhabit the upper 200 m (700 ft) of the water column in oceanic waters, typically beyond the continental shelf edge (Bond 1996). In the GOM, this group includes several shark species, swordfish (family Xiphiidae), billfishes (family Istiophoridae), flyingfish (*Parexocoetus brachypterus*), halfbeaks (family Hemiramphidae), jacks, dolphinfish, and tunas (family Scombridae). A number of the epipelagic species, such as dolphin fish, sailfish (*Istiophorus albicans*), white marlin (*Tetrapturus albidus*), blue marlin (*Makaira nigricans*), and tunas, are in decline and have important spawning habitat in the GOM. All of these epipelagic species are migratory, but specific patterns are not well understood. Many oceanic species are associated with floating seaweed (*Sargassum* spp.), jellyfishes, siphonophores, and driftwood, because they provide forage and/or nursery habitat. Most fish associated with floating seaweed are temporary residents, for example, juveniles of species that reside in shelf or coastal waters as adults. However, several larger species, such as dolphinfish, tuna, and wahoo, feed on the small fishes and fish attracted to *Sargassum* (GMFMC 2004).

Below the epipelagic zone, the water column may be layered into mesopelagic (200–1,000-m [656–3,281-ft]) and bathypelagic (>1,000-m [>3,281-ft]) zones. Recent surveys over the continental slope found 126 species (30 families) of juvenile and adult mesopelagic fishes, which were numerically dominated by lanternfishes (family Myctophidae), bristlemouths (family Gonostomatidae), and hatchetfishes (family Sternoptychidae) (Ross et al. 2010). Mesopelagic fishes spend the daytime at depths of 200–1,000 m (656–3,281 ft), but migrate vertically at night into food-rich near-surface waters. Mesopelagic fishes, while less commonly known, are important ecologically because they transfer significant amounts of energy between mesopelagic and epipelagic zones over each daily cycle. The lanternfishes are also important prey for meso- and epipelagic predators (e.g., tunas) (Hopkins et al. 1996).

Deeper dwelling (bathypelagic) fishes inhabit the water column at depths greater than 1,000 m (3,000 ft). This group is composed of little-known species such as snipe eels (family Nemichthyidae), slickheads (family Alepocephalidae), bigscales (family Melamphaidae), and whalefishes (family Cetomimidae) (McEachran and Fechhelm 1998; Rowe and Kennicutt 2009). Most species are capable of producing and emitting light (bioluminescence) to aid communication. In general, deep-water species produce demersal eggs (Bond 1996) that are attached to the substrate.

3.8.4.1.3 Demersal Fishes. Demersal fish in the GOM can be generally characterized as soft-bottom fishes or hard-bottom fishes, according to their association with particular substrate types. Soft-bottom habitat is relatively featureless and has much lower species diversity than the more structurally complex hard bottom habitat. Thus species richness is lower in the Central and Western Planning Area compared to the Eastern Planning Area, where hard-bottom habitat is abundant.

In recent trawl surveys, Atlantic croaker (*Micropogonias undulatus*), longspine porgy (*Stenotomus caprinus*), and Atlantic bumper (*Chloroscombrus chrysurus*) were the most abundant demersal soft-bottom fishes on the continental shelf from south Texas to Alabama (Table 3.8.4-1; SEAMAP 2010). However, geographic divisions exist because soft-bottom fishes generally prefer certain types of sediments over others; this tendency led to the naming of three primary fish assemblages according to the dominant shrimp species found in similar sediment/depth regimes (Chittenden and McEachran 1976; reviewed in GMFMC 2004). In the GOM, pink shrimp are found in waters up to about 45 m (148 ft) over calcareous sediments. Common members of the pink shrimp assemblage include Atlantic bumper, sand perch (*Diplectrum formosum*), silver jenny (*Eucinostomus gula*), dusky flounder (*Syacium papillosum*), and pigfish (*Orthopristis chrysoptera*). This assemblage is typified by the west Florida shelf in the Eastern Planning Area. Fishes associated with brown shrimp and white shrimp are found on more silty sediments and are typical of the Western and Central Planning Areas. The brown shrimp assemblage extends to 91 m (299 ft). Porgies (family Sparidae), searobins (family Triglidae), batfish (family Ogcocephalidae), goatfish (family Carangidae), lefteye flounders (family Bothidae), lizardfishes (family Synodontidae), butterfishes (family Stromateidae), cusk-eels (family Ophidiidae), toadfishes (family Batrachoididae), and scorpionfishes (family Scorpaenidae) characterize the brown shrimp assemblage. The white shrimp assemblage exists in 3.5 to 22 m (11 to 72 ft) of water, and dominant fish include drums (family Scianenidae), Atlantic croaker, snake mackerels (family Trichiuridae), threadfins (family Polynemidae), sea catfishes (family Ariidae), herrings (family Clupeidae), jacks (family Carangidae), butterfishes (family Stromateidae), and flounders (family Bothidae). Many fish species in the white and brown shrimp assemblages spawn in shelf waters and spend their early life stages in estuaries (GMFMC 2004).

Another important habitat for demersal fishes on the continental shelf is the hard bottom. The term “hard bottom” generally refers to exposed rock, but can refer to other substrata such as coral and clay, or even artificial structures. Reef fishes such as sea basses (family Serranidae), snappers (family Lutjanidae), grunts (family Haemulidae), porgies (family Sparidae), squirrelfishes (family Holocentridae), angelfishes (family Pomacanthidae), damselfishes (family Pomacentridae), butterflyfishes (family Chaetodontidae), surgeonfishes (family Acanthuridae), parrotfishes (family Scaridae), and wrasses (family Labridae) inhabit hard-bottom habitats in the GOM (Dennis and Bright 1988). Recent surveys of reef fish from Texas to Florida indicate vermillion snapper (*Rhomboplites aurorubens*), red snapper (*Lutjanus campechanus*), and red porgy (*Pagrus pagrus*) are the most abundant large reef fish (Table 3.8.4-2; SEAMAP 2010).

Although reef fish are associated with hard-bottom habitat as adults, some species can be found over soft sediments as well. Like soft sediment species, many hard-bottom demersal fish are estuarine dependent and spend their juvenile states in coastal habitat. Oil and gas platforms serve as artificial hard-bottom sites and attract reef-associated species. Almaco jack, amberjack, red snapper, gray snapper (mangrove snapper), and gray triggerfish dominate the large fish assemblage near the platforms in the GOM (Stanley and Wilson 1997). Fish density is elevated near the platforms but declines to background densities within 10–50 m (33–164 ft) of the structure (Stanley and Wilson 1997).

TABLE 3.8.4-1 The Ten Most Abundant Demersal Fish Species in Trawl Surveys of the Continental Shelf from Texas to Alabama

Species	Total number	% Frequency[a]
Summer		
Atlantic croaker (*Micropogonias undulates*)	119,000	52.0
Longspine porgy (*Stenotomus caprinus*)	77,667	69.9
Atlantic bumper (*Chloroscombrus chrysurus*)	44,374	48.9
Blackwing sea robin (*Prionotus rubio*)	10,610	37.8
Gulf butterfish (*Peprilus burti*)	9,531	46.0
Largescale lizard fish (*Saurida brasiliensis*)	8,989	40.6
Silver seatrout (*Cynoscion nothus*)	8,230	33.8
Striped anchovy (*Anchoa hepsetus*)	6,381	25.6
Atlantic cutlassfish (*Trichiurus lepturus*)	5,869	34.4
Blackear bass (*Serranus atrobranchus*)	5,219	28.7
Fall		
Atlantic croaker (*Micropogonias undulates*)	74,515	70.2
Longspine porgy (*Stenotomus caprinus*)	38,520	61.0
Atlantic bumper (*Chloroscombrus chrysurus*)	13,713	37.9
Silver seatrout (*Cynoscion nothus*)	99,881	50.6
Shoal flounder (*Syacium gunteri*)	9,874	53.7
Spot (*Leiostomus xanthurus*)	8,666	45.5
Blackear bass (*Serranus atrobranchus*)	7,328	27.0
Inshore lizardfish (*Synodus foetens*)	5,580	60.4
Star drum (*Stellifer lanceolatus*)	5,440	18.8
Bigeye searobin (*Prionotus longispinosus*)	4,510	31.2

[a] Percentage of all trawls in which the species was collected.

Source: SEAMAP 2010.

The deep-sea demersal fish fauna occur from the shelf-slope transition down to the abyssal plain in the GOM. Recent trawl studies sponsored by BOEM have investigated deep-sea demersal fish assemblages from the edge of the continental shelf to the abyssal regions (Rowe and Kennicutt 2009). Overall, 119 species were collected and distinct depth-species relationships were observed. The most diverse group are the cod-like fishes such as hakes and grenadiers (family Macrouridae), followed by cusk-eels (family Ophidiidae) and slickheads (Alepocephalidae). In general, water depth and proximity to canyons were the primary determinants of community structure. Fish species richness and abundance were highest in the upper and mid slope. Across the station transects, the abundance and diversity of fishes was greatest near the Mississippi Trough and the DeSoto Canyon and lowest at the stations to the west of the Mississippi River (Rowe and Kennicutt 2009).

There are many ongoing studies, but little data available, regarding impacts on fish from the DWH event. The spill has the potential to cause population-level impacts on fish species, particularly species that have already depressed populations or early life stages that rely heavily on marine and coastal habitats affected by the spill. However, The Atlantic Bluefin Tuna Status

TABLE 3.8.4-2 The Ten Most Abundant Reef Fish Species Collected in SEAMAP Trap Collections from South Texas to South Florida

Species	Total Number	% Frequency[a]
Vermillion snapper (*Rhomboplites aurorubens*)	210	1.5
Red snapper (*Lutjanus campechanus*)	139	2.3
Red porgy (*Pagrus pagrus*)	45	2.0
Red grouper (*Epinephelus morio*)	24	1.7
Gray triggerfish (*Balistes capriscus*)	6	0.6
Lane snapper (*Lutjanus synagris*)	6	0.3
Bank sea bass (*Centropristis ocyura*)	5	0.3
Greater amberjack (*Seriola dumerili*)	4	0.3
Whitebone porgy (*Calamus leucosteus*)	3	0.3
Scamp (*Mycteroperca phenax*)	3	0.3

[a] Percentage of all traps in which the species was collected.

Source: SEAMAP 2010.

Review Team estimated that the DWH event, under a worst-case scenario, would reduce the 2010 bluefin tuna year class by 20%, which would result in up to a 4% reduction in spawning biomass (Atlantic Bluefin Tuna Status Review Team 2011).

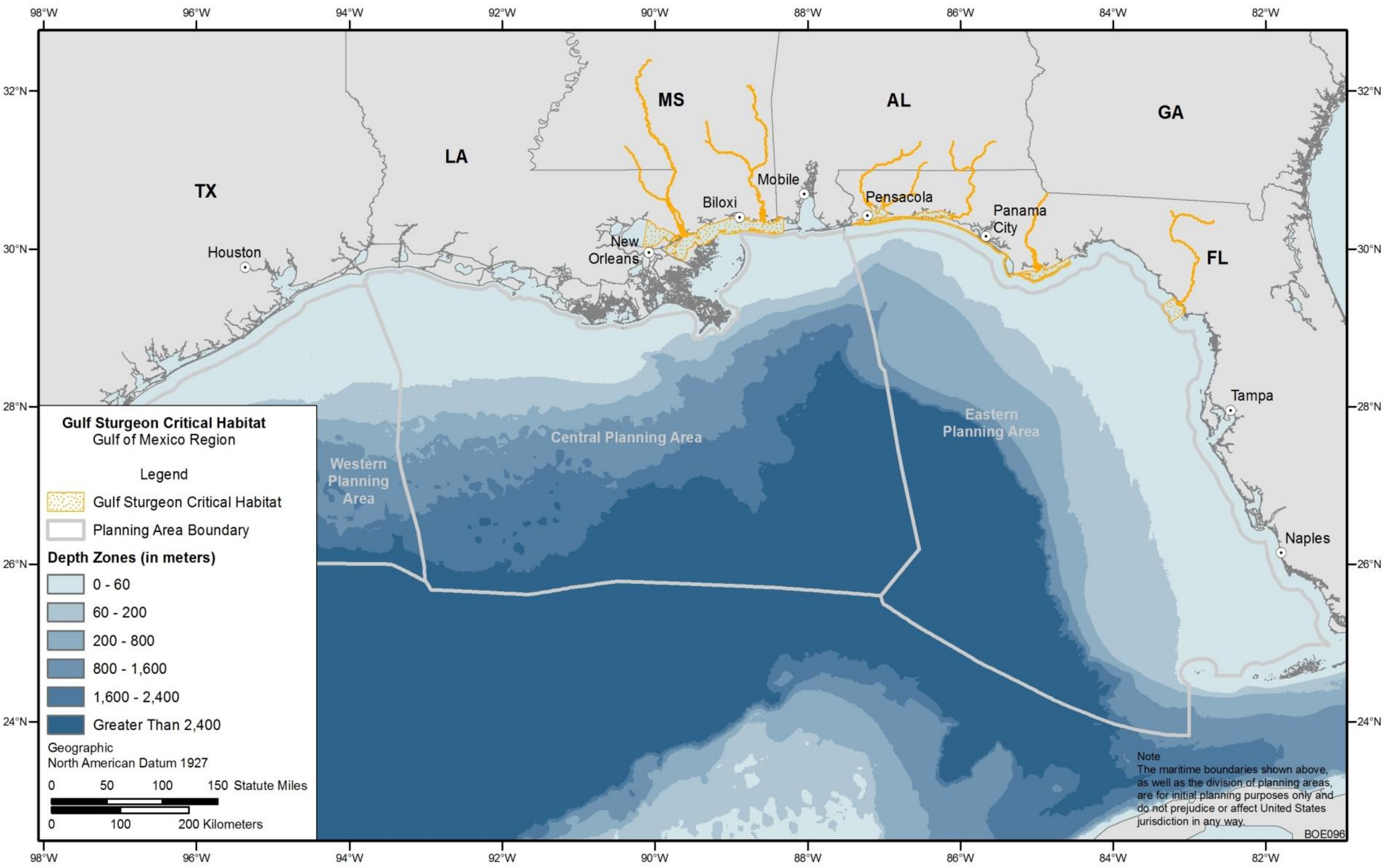
OSAT reported that less than 1% of sediment and water column samples from offshore and deepwater areas contained PAH concentrations exceeding the USEPA’s toxicity benchmarks for aquatic life (OSAT 2010), and extensive sampling of snappers, porgies, groupers, tuna, dolphin fish, wahoo, jack, and swordfish in Federal waters for PAHs and dispersants did not find evidence of contamination (Ylitalo et al. 2012). While these data suggest large-scale contamination is not an ongoing problem, localized impacts, particularly in heavily oiled marshes in Louisiana, may be significant. Whitehead et al. (2011) studied Gulf killifish (*Fundulus grandis*) from Louisiana marshes that were exposed to oil from the DWH event. He found killifish collected from oiled sites had higher expression of genes indicative of oil exposure, and hyperplasia of gill tissue (Whitehead et al. 2011). These effects were observed up to at least 2 months after exposure to oil. The long-term population-level effects are unclear. Several years may be required to fully assess the impacts of the DWH event on fish populations, given the lag between fish hatching and recruitment. This information, however, is not needed at the programmatic stage to make a reasoned choice among alternatives (see Section 1.4, Analytical Issues). The few initial studies suggest that, despite occurring during the spawning period for many GOM fishes, the DWH event did not have an immediate negative impact on fish populations (including juvenile age classes, although there remains the potential for long-term populations impacts from sublethal and chronic exposure (Fodrie and Heck 2011).

3.8.4.1.4 Species Listed under the Endangered Species Act.

Gulf Sturgeon. The Gulf sturgeon (*Acipenser oxyrinchus desotoi*) is a geographic subspecies of the Atlantic sturgeon. The Gulf sturgeon is an anadromous fish that migrates from the sea upstream into coastal rivers to spawn in freshwater. Historically, it ranged from the Mississippi River to Charlotte Harbor and Florida Bay; today, this range has contracted to encompass major rivers and inner shelf waters from the Mississippi River to the Suwannee River, Florida (USFWS and NMFS 2009). Populations have been depleted or driven to localized extirpation by fishing, boat collision, shoreline development, dredging, erosion, dam construction, declining water quality, and the species' low population growth rate (USFWS and NMFS 2009). These declines prompted the listing of the Gulf sturgeon as a threatened species in 1991 (56 FR 49653). Subsequently, a recovery plan was developed to ensure the preservation and protection of Gulf sturgeon spawning habitat (USFWS and Gulf States Marine Fisheries Commission 1995).

Females lay large numbers of eggs (>3 million) usually in deep areas or holes with hard bottoms and where some current is present (Sulak and Clugston 1998; Fox et al. 2000). The young fish remain in freshwater reaches of the rivers for about 2 yr, then begin to migrate back downstream to feed in estuarine and marine waters. The adults spend March through October in the rivers and November through February in estuarine or shelf waters. Near the river mouths and on the inner continental shelf, adults feed on clams, snails, crabs, shrimps, worms, brachiopods, amphipods, isopods, and small fishes (Gilbert 1992). Genetic studies show that the populations among different rivers are fairly distinct and that the Gulf sturgeon may even be river-specific (Stabile et al. 1996). In marine waters, however, Gulf sturgeon from different river systems were found to inhabit the same winter foraging grounds along the GOM barrier islands (Ross et al. 2009). In marine and estuarine habitats, Gulf sturgeon are found over coarse sand and shell substrates in clear and well oxygenated waters less than 7 m (23 ft) deep (Ross et al. 2009).

Currently, seven rivers are known to support reproducing populations of Gulf sturgeon (USFWS and NMFS 2009). After a review by NMFS in 2003, critical habitat for Gulf sturgeon was designated (68 FR 13370) and includes multiple areas of riverine, estuarine, and marine habitat from Louisiana to the Florida Panhandle (Figure 3.8.4-1). The 14 critical habitat units include the Pearl River Unit; the Pascagoula River Unit; the Escambia River Unit; the Yellow River Unit; the Choctawhatchee River Unit; the Apalachicola River Unit; the Suwannee River Unit; the Lake Pontchartrain, Lake St. Catherine, Rigolets, Little Lake, Lake Borgne, and Mississippi Sound Unit; the Pensacola Bay Unit; the Santa Rosa Sound Unit; the Florida Nearshore Unit; the Choctawhatchee Bay Unit; the Apalachicola Unit; and the Suwannee Sound Unit. Approximately 2,783 km (1,730 mi) of rivers and 6,042 km^2 (2,333 mi^2) are designated as critical habitat for the Gulf sturgeon. Detailed descriptions of these habitats can be found in 68 FR 13370–13495. Recent trends in abundance over the last decade indicate populations in Florida rivers are stable or increasing slightly. Populations in Mississippi and Louisiana Rivers are unknown due to the lack of recent comprehensive surveys (USFWS and NMFS 2009).



Note
The maritime boundaries shown above, as well as the division of planning areas, are for initial planning purposes only and do not prejudice or affect United States jurisdiction in any way.

FIGURE 3.8.4-1 Gulf Sturgeon Critical Habitat

Smalltooth Sawfish. The smalltooth sawfish (*Pristis pectinata*) was listed as federally endangered in 2003 (68 FR 15674). Smalltooth sawfish are usually found over muddy and sandy bottoms in sheltered bays, on nearshore shallow banks, and in estuaries or river mouths at all ages (NMFS 2009). Juveniles appear to prefer shallow mud or sand bottom (often less than 1 meter [3 ft]) as well as mangrove root habitat. As they grow, sawfish move to deeper water, and large adults can be found in marine waters in depths up to at least 122 m (400 ft). Smalltooth sawfish take more than 10 yr to reach maturity. They are livebearers, producing litters of 15 to 20 pups. Small fish and benthic invertebrates compose most of their diets. The decline in smalltooth sawfish abundance has been largely attributed to their capture as bycatch in various fisheries, loss and limited availability of appropriate habitat, and the species' low reproductive rate. Historically, smalltooth sawfish were common throughout the GOM from Texas to Florida. However, the current range of this species has contracted to peninsular Florida, and, although no accurate estimates of abundance are available, smalltooth sawfish are now relatively common only in the Everglades region at the southern tip of the State. In the Western and Central Planning Areas, smalltooth sawfish were relatively abundant as recently as the 1960s, but are now rare. Most recent records from Texas or the Florida Panhandle occur from April to August only, suggesting that most smalltooth sawfish are not resident, but rather seasonal migrants to the northern GOM from south Florida or Mexico (NMFS 2009). Critical habitat for the smalltooth sawfish was designated in October 2, 2009 (74 FR 45353), and consists of two units: the Charlotte Harbor Estuary Unit and the Ten Thousand Islands/Everglades Unit (TTI/E). The two units are located along the southwestern coast of Florida between Charlotte Harbor and Florida Bay, in the Eastern Planning Area. There is no critical habitat for smalltooth sawfish located in the Central or Western Planning Areas.

3.8.4.1.5 Climate Change. Climate change could affect fish communities through direct physiological action, through habitat loss, and by altering large-scale oceanographic and ecosystem processes (Twilley et al. 2001; Rosenzweig et al. 2007; Portner and Peck 2010). At the level of individual behavior and physiology, increasing water temperature could alter reproductive rates by speeding growth and altering the timing of migrations (including reproductive movements). Fish could also be forced to move to other areas if temperatures rise above their physiological tolerance. Higher temperatures may also increase the spread and virulence of new and existing pathogens. 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. In addition, aqueous concentrations of CO_2 projected to exist under certain climate change scenarios have been demonstrated to reduce the fitness of fish by reducing their ability to detect predators and adult habitat using olfactory and auditory cues (Munday et al. 2009, 2010).

In addition to direct physiological stress, climate change could reduce or eliminate critical fish habitats. Many fish in the GOM, including commercially important species, are estuarine-dependent, meaning they spend some portion of their life in estuarine waters. The predicted rise in sea level and increased storm frequency and severity could accelerate the loss of critical estuarine habitats such as salt marshes, lagoons, and barrier islands (Trenberth et al. 2007; CCSP 2009). In offshore areas, climate change may increase the size of the GOM "dead zone," reducing the amount of benthic habitat available to demersal fishes

(Rabalais et al. 2010). However, the extent and duration of hypoxia could also be decreased by the projected increase in tropical storms (Rabalais et al. 2010). Similarly, reef fish could suffer habitat loss if coral reefs decline as predicted by most climate change scenarios because of increased temperatures and/or ocean acidification (Hoegh-Guldberg et al. 2007).

Large-scale changes in oceanographic and ecosystem processes resulting from climate change could indirectly affect fish population in the GOM in several ways. For example, climate is a key determinant of fish abundance because climate influences critical recruitment processes such as the transport of larval fishes and the amount and seasonality of planktonic food resources. In addition, rising ocean temperatures could promote the expansion and establishment of tropical fish or allow the establishment of non-native fishes introduced by human activities. These species could in turn displace existing species and create changes in food web dynamics. Some have also speculated that climate change could increase the abundance of jellyfish, which prey heavily on fish larvae (Purcell et al. 2007). However, evidence for this hypothesis is limited (Purcell et al. 2007). Overall, predictions about the indirect effects of climate change on fish populations are subject to great uncertainty, given the complexity and compensatory mechanisms of the ecosystem (see Section 1.4.2, Incomplete and Unavailable Information).

3.8.4.2 Alaska – Cook Inlet

Waters of South Alaska support at least 314 fish species representing 72 families (Mecklenburg et al. 2002), and most of these species can be found in Cook Inlet. Fish species within Cook Inlet have a variety of habitat preferences and life history traits. Demersal fishes exist on the sea floor and near bottom waters and are distinct from pelagic fishes, which exist in the water column. In addition, there are anadromous fishes that that spend their adulthood in saltwater but spawn in freshwater.

3.8.4.2.1 Diadromous Fishes. Cook Inlet serves as a critical migratory corridor and early-life rearing area for several fish species, including all five species of Pacific salmon (Shields 2010a). Salmonids spawn in freshwater, where their eggs and juveniles develop and eventually migrate to the ocean as smolts. Salmon grow to maturity in the ocean and then return to their natal stream to spawn and die. Dolly Varden and steelhead trout also migrate through Cook Inlet; their life histories are similar to Pacific salmon, except that they are capable of spawning more than once and therefore make multiple migrations from freshwater to the ocean. The eulachon (*Thaleichthys pacificus*), known locally as hooligan, is a non-salmonid anadromous member of the smelt family that migrates through Cook Inlet. Both salmonids and eulachon provide critical food to marine mammals, predatory fish, and seabirds, and are important in recreational, commercial, and subsistence fisheries. Large schools of anadromous fish that seasonally enter freshwater habitat play an important role in the ecosystem; their carcasses provide food for terrestrial and stream consumers and release nutrients that are ultimately taken up by riparian forests and stream algae (Naiman et al. 2002).

The *Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes* and its associated Atlas (the Catalog and Atlas, respectively) specify which streams, rivers, and lakes within and adjacent to the Cook Inlet Planning Area are important to anadromous fish species and therefore are afforded protection under State law. Water bodies that are not "specified" within the Catalog and Atlas are not afforded that protection. The ADFG is solely responsible for maintaining anadromous waters data as well as revision to and publication of the Catalog and Atlas, which can be found at http://www.adfg.alaska.gov/sf/SARR/AWC/index.cfm?ADFG=maps.maps.

3.8.4.2.2 Pelagic Fishes. Pelagic species found in Cook Inlet waters include smelt (*Osmerus* spp.), Pacific herring (*Clupea pallasi*), Pacific sand lance, (*Ammodytes hexapterus*), eulachon, and capelin (*Mallotus villosus*). Walleye pollock, capelin, and eulachon made up 93% of all fish collected by mid-water trawls near Shelikof Strait (Wilson 2009). The Shelikof Strait has important spawning and juvenile nursery areas for pollock and herring (Nagorski et al. 2007). Pelagic species provide critical food to marine mammals, predatory fish, and seabirds, and are important in recreational, commercial, and subsistence fisheries. Forage fish are historically subject to large fluctuation in population size due to variation in environmental conditions (Robards et al. 1999; Robards et al. 2002; NMFS 2005). Populations of capelin, herring, and eulachon have been reported at historically low levels, possibly due to natural oscillations in sea temperatures (NMFS 2005; Litzow 2006; Arimitsu et al. 2008). In addition, sand lance, herring, and capelin spawn in nearshore and intertidal areas and are therefore extremely vulnerable to oil spills that contact the shoreline. For example, herring underwent a significant decline following the *Exxon Valdez* spill; while numbers have fluctuated since the spill, they remain at very low levels. However, there is still debate about whether the population crash was due to the *Exxon Valdez* spill, disease, climactic shifts, or a combination of these factors (*Exxon Valdez* Oil Spill Trustee Council 2009).

3.8.4.2.3 Demersal Fishes. Cook Inlet has a variety of substrates and shorelines, including a significant proportion of hard substrates. The resulting habitat complexity allows multiple species of demersal fish to inhabit Cook Inlet. These fish are collectively referred to as groundfish, because they have a common preference for seafloor habitat. Examples found in Cook Inlet include rockfish (*Sebastes* spp.), Pacific cod (*Gadus macrocephalus*), pollock (*Theragra chalcogramma*), lingcod (*Ophiodon elongates*), Pacific halibut (*Hippoglossus stenolepis*), sculpin (family Cottidae), and skates (Nagorski et al. 2007; Trowbridge et al. 2008). Many groundfish are of great commercial and recreational importance. Halibut are an important subsistence resource, and other groundfish are taken incidentally. The rockfish are particularly diverse, and at least 32 rockfish species have been reported to occur in the Gulf of Alaska (Eschmeyer et al. 1984). Groundfish can have distinct habitat preferences and may specialize in a particular sediment type. For example, species such as rockfish and lingcod prefer hard substrate and submerged vegetation, while cod prefer soft sediments. Groundfish typically use Cook Inlet as a seasonal feeding area, while spawning occurs offshore, often on the continental shelf edge of the GOA. However, some species, such as walleye pollock, spawn primarily in Shelikof Strait and the Shumagin Islands. Most groundfish deposit their eggs on the sea floor, but egg and larval development occur in the upper water column. Juveniles and adults ultimately transition to bottom habitat (NMFS 2005).

3.8.4.2.4 Protected Species. While Alaskan stocks of Pacific salmon are considered healthy, there are federally endangered stocks of Chinook salmon, sockeye salmon, and steelhead trout present in the GOA, and most have natal streams in Washington, California, and Oregon (NMFS 2005). The ESA-listed salmon are mixed with Alaskan and Asian salmon stocks and are not visually distinguishable from Alaskan salmon stocks (NMFS 2005). Critical habitat designations for stocks of Pacific salmon do not include any Alaskan waters.

3.8.4.2.5 Climate Change. Climate change may have a number of effects on fish communities, including direct effects on physiology and behavior and indirect effects caused by habitat loss and large-scale changes in ecological processes (Portner and Peck 2010). Under most climate change models, coastal fish habitats will be subject to hydrologic and thermal regimes that will be very different from present conditions. Hydrologic changes in Cook Inlet could result from changes in precipitation and increased glacial and snow pack melt in the mountains around Cook Inlet. The behavior and physiology of fish in river-influenced systems such as Cook Inlet would be particularly affected by changes in salinity, turbidity, and temperature linked to changes in hydrology. In addition, rising surface water temperature has the potential to affect all aspects of fish growth, feeding, and movement (Portner and Peck 2010). Similarly, aqueous concentrations of CO_2 projected to exist under certain climate change scenarios have been demonstrated to reduce the fitness of fish by reducing their ability to detect predators and adult habitat using olfactory and auditory cues (Munday et al. 2009, 2010; Simpson et al. 2011).

Climate change also has the potential to affect the large number of anadromous fishes that migrate through Cook Inlet. For example, the migratory behaviors of Pacific salmon at all life stages are adapted to existing hydrology (Bryant 2009). Current behaviors may be maladaptive if expected changes in sea level and the timing and intensity of rainfall occur, resulting in mismatches between salmon emergence and the availability of their food resources. In addition to habitat alteration, critical coastal habitats could be reduced or eliminated by rising sea levels and increased storm damage to nearshore areas. For species spawning in low-lying areas or the intertidal zone, or species using coastal estuaries as nursery grounds, rising sea levels could also eliminate spawning or juvenile habitat. Anadromous fish and species using nearshore marshes are likely to be most affected. Temperature monitoring in the Kenai watershed also suggests that salmon stream temperatures are increasing and often exceed water quality guidelines in the summer (Mauger 2005).

Climate change could potentially effect large-scale changes in ecological processes. In response, the distribution and species composition of fish communities in Cook Inlet may change. For example, temperature is a critical ecosystem control in the Gulf of Alaska; fish communities appear to undergo major shifts following natural oscillations in water temperature related to the Pacific Decodal Oscillation and the El Niño–Southern Oscillation (Anderson and Piatt 1999; Litzow 2006; NPFMC 2010). During periods of cold water temperatures, benthic crustaceans and pelagic forage fish such as capelin and herring dominate the ecosystem biomass. After the climate cycles to warmer water temperatures, the biomass of forage species declines and the biomass of higher trophic level fish such as groundfish and salmon increases. These cycles occur naturally on multi-decadal scales. 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 fish populations are subject to great uncertainty (see Section 1.4.2, Incomplete and Unavailable Information).

3.8.4.3 Alaska – Arctic

Aquatic systems of the Arctic undergo extended seasonal periods of frigid and harsh environmental conditions. Important environmental factors that Arctic fishes must contend with include reduced light, seasonal darkness, prolonged low temperatures and ice cover and low seasonal productivity (McAllister 1975; Craig 1984, 1989). The lack of sunlight and the extensive ice cover in Arctic latitudes during winter months affect primary and secondary productivity, making food resources very scarce during this time, so most of a fish’s yearly food supply must be acquired during the brief Arctic summer. In addition, most fish species inhabiting the frigid polar waters are thought to grow slowly relative to individuals or species inhabiting boreal, temperate, or tropical systems. Because of the harsh conditions, many species found in the Beaufort and Chukchi Seas are at the northern limits of their range.

Fishes of the Arctic may use one or more aquatic habitats to carry out their respective life cycles. Such habitats may include, but are not limited to bays; ice; reefs such as the Boulder Patch; and nearshore, coastal, continental shelf, oceanic, and bathypelagic waters and/or substrates. The Beaufort and Chukchi Seas support at least 98 fish species from 23 families (Mecklenburg et al. 2002). The greatest number of species is found in the Chukchi Sea (Hopcroft et al. 2008). Other species are likely to be found in the Arctic when deeper marine waters are more thoroughly surveyed. Additional information concerning the biology, ecology, and behavior of the fish species of Arctic Alaska is in Moulton and George (2000), Fechhelm and Griffiths (2001), Mecklenburg et al. (2002), and Childs (2004). More recent assessments of fish populations in the Chukchi Sea can be found in Norcross et al. (2009) and Mecklenburg et al. (2007, 2011). Recent fish surveys for the Beaufort Sea can be found in NMFS (2010e) and Logerwell et al. (2011).

Subsistence fishing has long been an integral part of Native life in the U.S. Arctic, and abundant local fisheries knowledge exists among these people (see Section 3.15.2.1 and Section 3.14.3.2). Commercial fishing, which occurred only infrequently and on a very small scale in the past, does not currently occur in the region, and therefore the typically published stock assessments and monitoring data do not exist. Because of the logistical difficulties of research and the lack of commercial fishing data, the published information on fish in the U.S. Arctic seas is relatively small compared to published information on fish in seas bordering other areas of the State of Alaska and the United States.

3.8.4.3.1 Diadromous Fishes. Common diadromous fishes found in the Beaufort and Chukchi Seas are salmonids and include Arctic cisco (*Coregonus autumnalis*), least cisco (*Coregonus sardinella*), humpback whitefish (*Coregonus pidschian*), broad whitefish (*Coregonus nasus*), and Dolly Varden (*Salvelinus malma*) (Craig 1989). The Colville River Delta and the Sagavanirktok River Delta have a particularly high abundance and diversity of diadromous fishes. Spawning occurs in the warmer months of the year. Life history traits of individual fish species in the Beaufort/Chukchi region are not well understood (DeGange and Thorsteinson 2011). Although present in Arctic waters, all five Pacific salmon species significantly decrease in abundance north of the Bering Strait (Craig and Haldorson 1986; Babaluk et al. 2000) and from west to east along the Beaufort and Chukchi Seas. Pink salmon and chum salmon are the most common Pacific salmon in Arctic waters (Augerot 2005; Stephenson 2005). Salmon appear to be rare in the Beaufort Sea and extremely rare in the eastern Beaufort Sea, although chum salmon are natal to the Mackenzie River and are consistently found there in low numbers (Irvine et al. 2009). Chum and pink salmon may be natal to other rivers on the North Slope, but this is unconfirmed (Irvine et al. 2009). Recent studies indicate that most of the juvenile chum salmon caught in the Chukchi Sea site were genetically related to populations in northwestern Alaska (Kondzela et al. 2009).

3.8.4.3.2 Pelagic Fishes. Common pelagic fish in the Beaufort Sea and Chukchi Sea include pacific sand lance (*Ammodytes hexapterus*), pacific herring (*Clupea pallasii*), Arctic cod (*Boreogadus saida*), capelin (*Mallotus villosus*), snailfish (Liparidae), and lanternfish (*Benthosema glaciale*). Anadromous species of salmonids are found in shallow nearshore waters. Mid-water trawl sampling in the Beaufort Sea indicated that young-of-the-year fish Arctic cod, sculpin (Cottidae), snailfish, poacher (Agonidae), and capelin dominated the pelagic biomass and the distribution of fish was related to depth, salinity, water temperature, and proximity to the Chukchi Sea (NMFS 2010e). Pelagic fishes can occupy benthic habitats as well at certain life stages. For example, Arctic cod are often demersal as adults, but young Arctic cod are closely associated with the underside of sea ice. Arctic cod are an ecologically important species because of their numerical dominance (Logerwell et al. 2011) and their role in linking zooplankton and sea ice invertebrates to higher trophic levels such as marine mammals and seabirds (Gradinger and Bluhm 2004).

3.8.4.3.3 Demersal Fishes. Most fish in the Beaufort Sea and Chukchi Sea are demersal species living on or near the bottom. Demersal fish in Arctic waters are often migratory species that originate from the Bering Sea or North Atlantic waters. In recent bottom trawl surveys in the Chukchi Sea, a total of 33 species were collected and 79% of all fishes caught were Arctic staghorn sculpin (*Gymnocanthus tricuspis*), shorthorn sculpin (*Myoxocephalus scorpius*), Bering flounder, or Arctic cod (Mecklenburg et al. 2007). Other recent surveys of the Chukchi Sea indicated cod (family Gadidae), poachers (family Agonidae), Bering flounder (*Hippoglossoides robustus*), and sculpins (family Cottidae) are the most abundant demersal fishes in the Chukchi Sea (Barber et al. 1997; Norcross et al. 2009). Greenlings (family Hexagrammidae), eelpouts (family Zoarcidae), smelts (family Osmeridae), wolfish (family Anarhichadidae) and snailfish (*Lycodes* spp.) are also present in Arctic waters (Barber et al. 1997; Norcross et al. 2009).

NOAA and BOEM have sponsored recent surveys of benthic fishes in the Beaufort Sea. In the Beaufort Sea, Arctic cod, eelpouts, and walleye pollock (*Theragra chalcogramma*) comprised the majority of the catch in benthic trawl surveys (NMFS 2010e) (Table 3.8.4-3). With the exception of Arctic cod, fish catch per unit effort (CPUE) is much lower in the Beaufort Sea compared to trawl CPUEs in the Chukchi and Bearing Seas (NMFS 2010e). Species distributions were primarily influenced by depth, temperature, and salinity (Logerwell et al. 2011). Sculpins were more strongly associated with relatively warm, low-salinity water, while polar cod and eelpouts were associated with cold, high-salinity bottom water. Depth was also significant (Logerwell et al. 2011). Sculpin were generally found in waters less than 100 m (328 ft) deep, in contrast to eelpouts, walleye pollock, and Arctic cod, which were most abundant in waters greater than 100 m (328 ft).

Rocky substrate is uncommon in subtidal areas of the Beaufort and Chukchi Seas and occurs primarily in the form of scattered boulders (Figure 3.7.2-4). Data on fish communities inhabiting these boulder patches are limited. Clingfish (*Liparis herschelinus*), four-horned sculpin (*Myoxocephalus quadricornis*), and the eelpout (*Gymnelis viridis*) have been observed in boulder patch habitat, and fish have been observed to lay eggs on boulders or associated vegetation (Dunton et al. 1982).

3.8.4.3.4 Climate Change. Climate change may have a number of effects on fish communities, including direct effects on physiology and behavior and indirect effects caused by habitat loss and large-scale changes in ecological processes. Changes in the magnitude or seasonality of water temperatures could affect growth rate, food demand, and reproductive behavior because water temperature is an important trigger for the seasonal fish migrations. Hydrologic changes in rivers flowing into the Beaufort and Chukchi Seas could result from changes in precipitation and ice melt. The behavior and physiology of fish in river-influenced systems such as the Beaufort and Chukchi Seas would be particularly affected by the alteration of salinity, turbidity, and temperature linked to changes in hydrology. In addition, rising surface water temperature has the potential to affect all aspects of fish growth, feeding, and movement

TABLE 3.8.4-3 The Five Most Abundant Fish Taxa Collected during 2008 Bottom Trawls in the Beaufort Sea

Common Name	Total Number	Total Weight (kg)
Arctic cod (*Boreogadus saida*)	66,278	1,242
Marbled eelpout (*Lycodes raridens*)	1,642	142
Walleye pollock (*Theragra chalcogramma*)	1,082	34
Canadian eelpout (*Lycodes polaris*)	772	38
Bering flounder (*Hippoglossoides robustus*)	231	35
Greenland turbot (*Reinhardtius hippoglossoides*)	221	16

Source: NMFS 2010e.

(Portner and Peck 2010). Similarly, aqueous concentrations of CO_2 projected to exist under certain climate change scenarios have been demonstrated to reduce the fitness of fish by reducing their ability to detect predators and adult habitat using olfactory and auditory cues (Munday et al. 2009; Simpson et al. 2011).

In addition to habitat alteration, critical coastal habitats could be reduced or eliminated by rising sea levels and increased storm damage to nearshore areas as the amount of open water increases. Anadromous fish and species that use coastal habitats are likely to be most affected. In addition, species such as the Arctic cod that depend on sea ice will lose habitat with the reduction in seasonal ice. However, Arctic cod may gain from the increase in open water plankton productivity. The impacts of climate change on Arctic habitat in the Beaufort and Chukchi Seas is discussed in Sections 3.7.2.3 and 3.7.3.3.

Climate change is also likely to change fish community composition. For example, the cold temperatures in Alaska are a critical ecosystem feature that limits species distribution. Historical records suggest that rising seawater temperatures could allow the establishment of sub-Arctic species in Arctic waters (reviewed in Loeng 2005). As a consequence of the range expansions of subArctic species, true Arctic species such as Arctic cod and capelin may be pushed northward (Loeng 2005). In offshore waters, NMFS (2010e) noted that comparison of their recent fish collections with earlier trawl data suggested that pollock and Pacific cod (*Gadus macrocephalus*) may have expanded northward into the Beaufort Sea as a result of rising surface water temperatures. There is also speculation that increasing water temperatures could allow Pacific salmon to expand their range and numbers into Arctic waters (Irvine et al. 2009). However, recent reviews (Stephenson 2005; Irvine et al. 2009) found there was no evidence of increased catches of most salmon species, and there is not enough information to state definitively that salmon are increasing in frequency in the Arctic due to climate change.

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, climate change could alter ocean currents that govern the transport of larval fish. Temperature is another climate variable that is a critical feature in Arctic ecosystems that influences the amount and seasonal availability of planktonic food resources. 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). Ultimately, however, predictions about the indirect and cascading ecological impacts of climate change on fish populations are subject to great uncertainty, given the complexity of the ecosystem (see Section 1.4.2, Incomplete and Unavailable Information).

3.8.5 Invertebrates and Lower Trophic Levels

Invertebrates (animals without a backbone) occupy multiple habitat types from the intertidal zone to the deep sea. Invertebrates can occupy benthic (bottom) or pelagic (water column) habitats, depending on their life histories. Invertebrates that occupy the benthos can be categorized by their size, location in the substrate, and feeding guild. Benthic invertebrates that burrow into the sediment are called infauna, and invertebrates that move on the sediment surface are called epifauna. Size classifications for benthic infauna are mieofauna (typically 43–500 µm), which are dominated by copepods and nematodes, and macroinfauna (>500 µm), which are usually dominated by polychaete worms, amphipods, and bivalves. Benthic invertebrates can be further classified into several trophic guilds, including (1) predators and scavengers, which feed on live animals or carrion; (2) scrapers, which remove biofilms from hard substrate; (3) suspension (filter) feeders, which filter food from the water; and (4) deposit feeders, which consume surface or subsurface sediment organic matter. Invertebrates in the various feeding guilds often occupy specific sediment types. For example, suspension feeders prefer clean sandy sediment or hard surfaces where they can avoid fine sediments that tend to clog their filtering organs. In contrast, deposit feeders prefer silty sediments that are rich in organic matter.

Pelagic invertebrates may drift with the current (zooplankton) or actively swim (nekton). Pelagic invertebrates can range in size from microscopic protozoans to large megafauna, such as squid and jellyfish. They play a critical role in the recycling of nutrients and organic matter in the water column and in the amount of and timing at which these food resources reach benthic consumers.

3.8.5.1 Gulf of Mexico

Following are brief descriptions of the classes of prokaryotes, viruses, and eukaryotic invertebrates common in marine environments, including the Northern GOM Shelf and Slope Marine Ecoregions:

- *Prokaryotes*. Prokaryotes are distinguished from invertebrates by not having a nucleus. Based on their genetics and cell membranes, prokaryotes are divided into Eubacteria and Archaea. Eubacteria are dominant in the benthos and the water column and are key drivers in a number of ecosystem processes. One primary function of bacteria is the break down and recycling of organic matter. In addition, bacteria are critical in nutrient (e.g., nitrogen, phosphorous, and sulfur) transformation in both the sediment and water column. Bacteria are heterotrophic and subsist on dissolved and particulate organic matter. They are consumed by protists and a variety of zooplankton and macroinvertebrates in the sediment. Although bacterial consumption of organic matter is an important ecological process, it facilitates the development of seasonal bottom-water hypoxia on the shallow continental shelf of the GOM. Archaea are prokaryotes found throughout the ocean but are strongly associated with extreme environments. Prokaryotes are the key biological components of cold seeps communities in the GOM, where methanogenesis (archaea) and coupled sulfate reduction (eubacteria) and methane oxidation (archaea) provide the substrates that support the cold seeps macroinvertebrate communities and their bacterial symbionts. Prokaryotic communities in the sediment and water column also play a critical role in the breakdown of hydrocarbons released by natural processes and human activities. These activities prevent the accumulation of hydrocarbons to toxic levels in the environment. Studies following the DWH event demonstrated that the amount of menthanotropic and oil-eating bacteria increased greatly after the DWH event (Camilli et al. 2010; Kessler et al. 2011).

- Viruses are simple life forms consisting of DNA and RNA in a protein covering. They reproduce by injecting their genetic material into the cells of other organisms and replicate their DNA using the cellular machinery of the host cell after which the host cell lyses and releases the replicated viruses. Viruses serve as a significant population control on bacteria in the ocean.

- *Protozoans*. Protozoans are a broad and diverse group of microorganisms that include foraminifierans, ciliates, radiolarians, and flagellates. They can occupy both benthic and pelagic habitats, where they act as parasites or free-living consumers of phytoplankton, bacteria, or other zooplankton. Protozoans with carbonate or silicate shells create oozes of relict shells on the seafloor of the deep ocean. Protozoans are abundant in the water column and sediments, and they are often dominant planktonic consumers in pelagic food webs in areas where biological productivity is low and nutrients and carbon are tightly cycled between small phytoplankton, microplankton, and bacteria.

- *Porifera*. Poriferans (sponges) are primitive sessile animals consisting of cellular aggregations held in a flexible protein/carbonate housing. Poriferans are suspension feeders that consume phytoplankton and particulates from the water column. They are found in all sediment types from the Northern GOM Shelf to the Slope Ecoregions. They may reproduce sexually or asexually.

- *Cnidarians and Ctenophores*. Cnidarians (jellyfish, hydrozoans, sea anemones, corals) are defined by their radial symmetry and the use of nematocysts (stinging cells) to capture prey. Comb jellies (Ctenophora) are similar to cnidarians but lack nematocysts. Cnidarians can reproduce sexually and asexually; they typically produce free-floating planktonic larvae that eventually settle to the seafloor. Ctenophores are pelagic throughout their life cycle. Cnidarians can be found across the shelf and slope of the GOM in both benthic habitats and water column habitats. Corals form ecologically significant benthic habitat (see Section 3.7.2.1.2). Jellyfish appear to be increasing in abundance in the GOM (Graham 2001), possibly because of higher water temperatures, lack of predators, and their hypoxia tolerance. The increase in jellyfish abundance could have negative consequences on the eggs and larvae of fish and invertebrates that they prey upon.

- *Worms*. Worms cover a wide range of taxa that have soft, elongated bodies and bilateral symmetry in common. As adults, most worms are sediment dwellers, but some species are pelagic (arrow worms [Chaetognatha]). Although benthic as adults, many worms produce free-living planktonic larvae. The GOM supports a diverse array of worms, such as peanut worms (Sipunculans), flatworms (Platyhelminthes), ribbonworms (Nemertea), nematodes (Nematoda), and segmented worms (Annelida; including polychaetes and oligochaetes). Nematodes and polychaetes are particularly abundant in sediments and are important food sources for higher trophic levels. In addition to their role as food sources, polychaetes continually displace and mix the sediments, thereby promoting biogeochemical cycling. Polychaetes can also significantly modify their environment by forming tubes from sediment particles; thus, they create microhabitats for other benthic organisms. Worms have a range of diets and feeding strategies; for example, they may be suspension feeders, predators, or deposit feeders. Worms show a range of tolerance to contaminants and therefore are important ecological indicators for assessments of human disturbance.

- *Mollusks*. Mollusks (bivalves, gastropods, and cephalopods) are characterized by having a muscular foot and mantle tissue that in most species produces a calcium carbonate shell. Bivalves, which have two shells joined by a hinge, can be found across coastal and marine sediments from estuaries to the deep sea. Bivalves reproduce by releasing sperm and eggs into the water column, where fertilization occurs. Their larvae undergo a temporary planktonic period before settling to the bottom and developing into adults. The common bivalves present in the GOM are clams, oysters (*Crassostrea virginica*), scallops, and mussels. Clams burrow into the sediments, where they deposit or suspension feed on small organisms or organic particles. Oysters are common in estuarine habitats, where they attach to hard substrates and feed by filtering plankton and particulate organic matter from the water column. Oysters are ecosystem engineers that provide critical reef habitat in estuaries. Mussels are relatively rare in marine waters but are common in estuaries and in deepwater methane seep communities. Bivalves can perform several ecological functions. Filter-feeding species have historically increased light penetration by removing particulates and phytoplankton from the water column. Also, because they produce feces that are consumed by other sediment biota, they can be an important link in the transfer of water column production to benthic consumers.

  Gastropods (snails and slugs) typically have a single whorled shell. Most species are sediment-dwelling, but species with reduced shells or no shell can also occupy the water column. Soft-sediment marine gastropods typical of the central and western portions of the Northern GOM Ecoregions are usually carnivores or scavengers. Most marine gastropods fertilize internally and lay eggs in the sediment. After larvae hatch, they may undergo a planktonic stage.

  Cephalopod mollusks are the octopi and squid, which are characterized by a pronounced head and complex eye development. Cephalopods like the octopus are benthic, while the squid may be found from relatively shallow to very deep portions of the water column. Cephalopods are carnivorous and, in turn, are important food sources for fish and marine mammals.

- *Crustaceans*. Crustaceans possess an exoskeleton and can be found as free-swimming water column forms, bottom-dwelling mobile forms, and attached forms. Copepod crustaceans are important phytoplankton grazers; in turn, they are often the primary food source for fish during their early life stages, and they represent a key link in transferring energy from primary producers to predatory consumers at higher trophic levels. Barnacles are examples of crustaceans that attach to hard substrate (including oil and gas platforms), where they filter food from the water column. Common epifaunal (on the sediment surface) crustaceans are the decapods, which include portunid crabs, stone crabs, and penaeid shrimp, many of which are commercially important. Decapods are found from the estuarine to the deep sea over soft and hard substrates and are key food resources for demersal fishes. Decapods usually have a pelagic larval life stage but are benthic as adults. Many decapods are estuarine-dependent (reside in an estuary during some period of their life cycle), and, given their abundance and high biomass, they are important in transferring nutrients and organic matter between estuarine and marine habitats.

- *Echinoderms*. Echinoderms are defined by their radial symmetry, tube feet, and an endoskeleton. Common examples in the Northern GOM Marine Ecoregions include sea stars (Asteroidea), brittle stars (Ophiuroidea), sea urchins (Echinoidea), and sea cucumbers (Holothuroidea). Sea stars, brittle stars, and sea cucumbers, in particular, are common throughout the marine environment — on soft and hard substrates from coastal waters to the deep sea. Echinoderms can be grazers (sea urchins), deposit feeders (sea cucumbers), or predators (sea stars). Echinoderms usually produce planktonic larvae that settle to the seafloor after some period of time in the water column.

- *Chordates*. Chordates have a primitive spinal cord at some point in their development, yet they are classified as invertebrates because they lack a backbone. In the GOM, the most common chordates are the filter-feeding tunicates (sea squirts, salps, and larvaceans). The most important chordate grazer in the northern GOM is the planktonic larvacean *Oikopleura dioica*, which filters bacteria and small phytoplankton out of the water column. Larvaceans have been reported to consume an average of 20% of the particles from the upper 5 m (16.4 ft) of the Mississippi River plume each day. Their abundance is so great that the deposition of their fecal pellets and discarded gelatinous houses may be great enough to contribute significantly to the bottom-water hypoxia that occurs seasonally in the GOM (Dagg et al. 2007).

There are few completed, peer-reviewed studies of the impacts of the DWH event on invertebrate communities in the GOM. However, 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. A description of these studies can be found at http://www.gulfspillrestoration.noaa.gov/oil-spill/gulf-spill-data. Samples of commercially harvested invertebrates in Federal waters from Louisiana to Florida found evidence of PAH contamination in only a few areas off the Louisiana coast (Ylitalo et al. 2012). Coastal sediment porewater samples collected from Florida to Louisiana were tested for toxicity to benthic invertebrates using sea urchin fertilization and embryological development as test endpoints (Biedenbach and Carr 2011). Porewater was found to be toxic at multiple locations along the Louisiana coast, but only one site in Mississippi, and no sites in Texas, Florida, or Alabama. Toxicity appeared to result primarily from the high concentrations of ammonia in the porewater.

In offshore areas, impacts from the DWH event appear to be localized. Some researchers have reported seeing dead and dying benthic animals, as well as what appear to be thick deposits of an unidentified brown substance on the seafloor (BOEMRE 2010b). Follow-up studies provide evidence that the flocculent contained oil from the DWH event (White et al. 2012). In addition, approximately half of the deepwater corals and brittle stars at the site showed signs of stress such as mucus secretion, bleaching, and abnormal color and/or attachment posture. However, evidence of DWH impacts was found at only 1 of the 11 deepwater coral reefs surveyed. In another study, remotely operated vehicle (ROV) surveys of benthic epifaunal invertebrates were conducted 500 m (1,640 ft) and 2000 m (6,562 ft) from the Macondo well from August to September 2010. Species richness and abundance were lower at the site located 500 m (1,640 ft) from the well compared to the more sites more distant from the well (Benfield 2011; Putt 2011). The surveys did not indicate an obvious change in species composition, although pre-spill data was qualitative and therefore statistical comparisons could not be made.

Several studies of areas affected by the DWH event indicated that oil dramatically altered the sediment (Hamdan and Fulmer 2011; Kostka et al. 2011) and water column (Hazen et al. 2010; Kessler et al. 2011; Lu et al. 2011) bacterial communities by increasing the relative abundance of oil-consuming microbes. These microbial communities were critical in the rapid disappearance of much of the oil. However, studies of microbial communities on oiled beaches in Louisiana also suggested 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 genera with comparatively less capacity to degrade hydrocarbons (Hamdan and Fulmer 2011). Patchy areas of hydrocarbon contamination were detected in zooplankton samples collected in the vicinity of the Macondo well and up to 20 km (12.5 mi) southwest of the well (Mitra et al. 2012). In coastal areas, the hydrocarbons appeared to be assimilated by bacteria and transferred up through the zooplankton food web (Graham et al. 2010). The carbon derived from the DWH event appeared to be processed and was no longer detectable in plankton samples after a few weeks (Graham et al. 2010).

Overall, several years may be required to fully assess the impacts of the DWH event on invertebrate populations. This information, however, is not needed at the programmatic stage to make a reasoned choice among alternatives (see Section 1.5, Analytical Issues).

3.8.5.1.1 Species Listed Under the Endangered Species Act.

Elkhorn Coral. Elkhorn coral (*Acropora palmata*) is a branching, reef-building, scleractinian coral. Like other species of coral, elkhorn coral derives energy from symbiotic algae (zooxanthellae) and filter feeding. Reproduction occurs sexually or by asexual fragmentation. This species is found in south Florida, the Caribbean, Central America, and South America, in waters typically less than 30 m (100 ft) in depth. The preferred temperature of Acropoird corals is 66°F to 88°F (see http://sero.nmfs.noaa.gov/pr/esa/acropora.htm). They were historically one of the most abundant and ecologically important coral species. However, since the 1970s Elkhorn coral abundance has declined by 95% within its historical range (Zimmer et al. 2010; see http://www.nmfs.noaa.gov/pr/species/invertebrates/staghorncoral.htm). White band and white pox disease were directly responsible for the decline, although other stressors on corals, such as climate change, sewage discharge, and coastal eutrophication, may have ultimately contributed to their decline and lack of subsequent recovery (Aronson and Precht 2001; Muller et al. 2008; Sutherland et al. 2011). In response to the steep population decline, elkhorn coral were listed as threatened under the Endangered Species Act (71 FR 26852) in 2006. In 2008, the NMFS designated marine areas of Palm Beach County, Florida, to the Tortugas and various areas in Puerto Rico and the Caribbean as critical habitat for elkhorn coral (73 FR 72210).

Two elkhorn colonies have been discovered in the northern GOM, one in the West Flower Gardens Bank in 2003 and one in the East Flower Gardens in 2005 (Zimmer et al. 2010). The East Flower Garden colony is 0.5 m (2 ft) in width and 1 m (3 ft) in height and is located on the southeast corner of the bank in approximately 24 m (77 ft) of water. Both colonies are still present, although Hurricane Ike appears to have broken off branches of the colony (Zimmer et al. 2010). The northward range expansion of elkhorn coral is likely due to increasing water temperatures in the northern GOM (Precht and Aronson 2004). In the West Flower Gardens Bank, the elkhorn colony was found at a depth of 22 m (71 ft) and as of May 2005, the colony measured less than 1 m (2 ft) wide by 0.5 m (2 ft) high, with a maximum branch length of 9 cm (4 in; Zimmer et al. 2010). The Flower Gardens Bank is not considered critical habitat for this species (73 FR 72210).

Candidate Species. There are currently 82 “candidate species” of coral that are under review for listing under the Endangered Species Act (75 FR 6616). Only eight of the species occur in the U.S. waters, and only a portion of these are found in the GOM; these include *Montastraea annularis*, *Montastraea faveolata*, and *Montastraea franksi*. Once NOAA Fisheries has reviewed the candidate species, a decision will be made as to whether each species will receive protection under the ESA.

3.8.5.1.2 Climate Change. Several major classes of invertebrates could be affected by the environmental changes predicted to result from climate change. A significant loss of corals could result from increased water temperature and ocean acidification. The impacts of climate change on habitat-forming invertebrates, such as corals, are discussed in detail in Section 3.7.2.1. As described in Sections 3.7.4.1 and 3.7.3.1, climate change might increase the range and temporal variability of a water column’s oxygen, salinity, and temperature, all of which are critical determinants of invertebrate community distribution, density, and species composition. Such large-scale changes in benthic and pelagic habitats could significantly alter the existing invertebrate community structure and ecosystem services. In particular, invertebrates in nearshore areas would be likely to experience more differences in the physical and chemical variables brought about by the change in the hydrologic regime. Invertebrates have specific physiological tolerances; thus, more fluctuations in environmental variables, especially salinity (Attrill 2002), would probably reduce their abundance and diversity as the more-tolerant species replaced the less-tolerant ones. Nonmobile or slow-moving benthic invertebrates, such as echinoderms, mollusks, and macroinfauna, would be most vulnerable to physiological stress. Invertebrate communities in the Mississippi Estuarine Area Ecoregion would be especially likely to undergo significant changes, because of the strong influence of Mississippi River discharge on biological communities. The rise in temperatures could also alter species compositions as more tropical species expanded north, potentially replacing existing fauna.

With the expected increase in water column stratification and nutrient delivery to the GOM, the extent and duration of hypoxia might increase (Section 3.7.3.1). Mortality to adult stages of larger mobile invertebrates might be limited because of their ability to avoid hypoxic waters; however, smaller zooplankton could be affected by hypoxia in several ways. First, more sensitive species, like copepods, might be replaced by smaller more tolerant species (Marcus 2001). Hypoxia might also increase the abundance of jellies, which can tolerate low-oxygen areas (Purcell et al. 2001). In addition, it has been found that hypoxia can disrupt daily zooplankton migrations from the lower to the upper water column, which could affect food intake of zooplankton and their predators (Qureshi and Rabalais 2001).

The increasing inputs of CO_2 into the ocean are expected to reduce oceanic pH and, with it, the availability of calcite and aragonite. Calcifying marine organisms — such as shallow and deepwater corals, echinoderms, foraminiferans, and mollusks — might decline in abundance because they require calcite or aragonite to lend structural support to their exoskeletons (Royal Society 2005).

3.8.5.2 Alaska – Cook Inlet

See Section 3.8.5.1 for a general description of invertebrate groups and their ecological roles, and see MMS (1996b, 2003a) for a comprehensive description of the invertebrate zooplankton community of Cook Inlet. The water column invertebrates in Cook Inlet are similar to those in other subarctic waters (Speckman et al. 2005) and are composed of a mix of oceanic and coastal species (MMS 1996b). Several species of copepods dominate the macrozooplankton assemblage. Measurements of zooplankton productivity indicate a peak in late spring and summer (MMS 1996b). Lower Cook Inlet has a complicated physical and chemical environment as a result of the mixing of fresh and marine water, and the zooplankton community appears to be primarily structured by temperature, salinity, bottom depth, and turbidity (Speckman et al. 2005).

Benthic invertebrates are important trophic links connecting primary producers to higher-trophic-level organisms found in Cook Inlet and the Gulf of Alaska, such as crabs, flatfishes, and cod. In Lower Cook Inlet, there are spatial differences in the compositions of the benthic invertebrate communities related to differences in ice formation, with Arctic species being more common on the western side of Cook Inlet and the temperate species being more common in the eastern portion of Cook Inlet (MMS 1996b, 2003a). In addition, benthic invertebrate species differ by substrate type and tidal zone. The lower rocky intertidal zone contains a diverse mix of echinoderms (sea urchins and sea stars), mollusks (bivaves, limpets, and snails), polychaete worms, and crustaceans (barnacles and crabs). Sandy intertidal sediments are dominated by polychaetes and amphipods, with clams increasing in abundance in deeper waters. Several distinct subtidal communities have been identified on substrates of rock, sand, silt, and/or shell debris (Feder and Jewett 1986). Clams were dominant in sandy subtidal sediment, and clams and polychaetes dominated in muddy sediment. Substrates consisting of shell debris generally have the most diverse communities and are dominated by mollusks and bryozoans (Feder and Jewett 1986). Epifauna (invertebrates on the sediment surface) in the region are primarily crustaceans (tanner crabs, king crabs, pandalid and cragonid shrimp) and echinoderms (sea cucumbers and sea urchins). Studies in the western side of Shelik of Strait indicated that limpets, snails, crabs, chitons, barnacles, and mussels dominated the lower and mid rocky intertidal. Several clam species are found in intertidal and subtidal soft substrates (Nagorski et al. 2007).

3.8.5.2.1 Climate Change. It is predicted that physical and chemical changes to subarctic invertebrate habitat would result from climate change. These changes 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 will facilitate a northward expansion of subarctic and temperate invertebrate species. Rising sea water 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. Also, 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. Changes in the magnitude, frequency, and timing of river discharge are expected to result from climate change (Arctic Council 2005). Thus, invertebrates in the Cook Inlet Ecoregion where there are strong riverine inputs would likely be affected by alterations in the salinity, temperature, and sediment delivery regime.

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. 2009). The loss of shelled invertebrates could affect higher trophic levels, including benthic mollusks and pelagic pteropods, that are critical food sources for birds, fish, and marine mammals. Snow crab and Tanner crab could also be affected as oceanic pH decreases, reducing the availability of the $CaCO_3$ they require for shell formation. The physiological stress and reduction in shell strength associated with ocean acidification could reduce the population of these commercially important invertebrates.

3.8.5.3 Alaska – Arctic

See Section 3.8.5.1 for a general description of invertebrate groups and their ecological roles. At the lowest invertebrate trophic levels, microbes such as bacteria and protists are known to be important in Arctic waters for breaking down and recycling nutrients and organic matter (Hopcroft et al. 2008). Cilliates and dinoflagellates dominate the microzooplankton biomass in the Chukchi Sea, but their role in the Beaufort and Chukchi Seas is not well studied (Hopcroft et al. 2008). The most common water column macroinvertebrates in the Arctic are the copepods (typically *Pseudocalanus* spp.). In the Chukchi Sea, much of the copepod biomass originates in the Bering Sea, while true Arctic species are most common in the Beaufort Sea (Hopcroft et al. 2008). Riverine inputs also create an estuarine zone with a distinct zooplankton assemblage. Other common zooplankton include larvaceans, jellies, euphausiid shrimp, amphipods, pteropod mollusks, and arrow worms. In the Beaufort and Chukchi Seas, invertebrate zooplankton productivity is highly seasonal as a result of the extremely cold winter temperatures. Many invertebrates (i.e., copepods) have adapted by storing lipids for the winter and undergoing a winter dormant period during which they rest in the sediment or lower water column.

Across the Beaufort and Chukchi shelf, the benthic infaunal community is dominated primarily by echinoderms, polychates, sponges, anemones, bivalves, gastropods, and bryozoans (Grebmeier and Dunton 2000; Dunton et al. 2005). Studies in the Beaufort Sea indicated brittle stars, snow crabs (*Chionoectes opilio*), ascidians, mussels, sea anemones, and echinoderms dominated the epifaunal assemblage (NMFS 2010e). Snow crabs are found in across the Beaufort and Chukchi shelf. Logerwell et al. (2011) reported that they were most densely distributed between 100 and 500 m (328 and 1,640 ft) in the Beaufort Sea. Overall, however, larger invertebrate infauna are relatively sparse in much of the Beaufort Sea when compared to their presence in the Chukchi Sea, where echinoderms, crabs, and shrimp are more abundant (Hopcroft et al. 2008).

There are several strong spatial gradients in benthic invertebrate biomass and species composition across the Beaufort/Chukchi shelf. Benthic biomass is higher in Chukchi Sea compared to the Beaufort Sea (Grebmeier et al. 2006). Within the Beaufort Sea, benthic biomass is slightly lower in the eastern and deepwater portions of the Beaufort Sea and slightly higher to the west, adjacent to the Chukchi Sea. South of the Chukchi Sea Planning Area, the Chukchi Sea contains some of the highest benthic biomass in the Arctic (Grebmeier et al. 2006; Hopcroft 2008). The high benthic biomass and richness in the Chukchi Sea have been attributed to currents that move nutrients onto the shallow Chukchi shelf from the Bering Sea, the resulting sudden and intense springtime phytoplankton bloom during a period of relative inactivity for zooplankton, and the subsequent deposition of large amounts of phytoplankton food on the seafloor (Hopcroft et al. 2008). Nearshore infauna diversity and abundance can be low because of ice scour and freshwater inputs. Invertebrate biomass also decreases from the mid-shelf to the slope. For example, trawls in the western Beaufort Sea indicated that invertebrate biomass was dramatically higher between 100 and 500 m (328 and 1,640 ft) than between 40 and 100 m (131 and 328 ft) (NMFS 2010e).

Invertebrate species associated with boulder habitats are located primarily on the Beaufort shelf. These habitats vary according to their post-disturbance successional stage. Pioneer colonizing invertebrates include polychaetes, followed by encrusting bryozoans and hydroids, and ultimately a diverse community of kelp, soft coral, tubeworms, and sponges. Multiple studies have demonstrated that if significantly physically disturbed, communities associated with boulders are slow (2 or more years) to begin recovery and that full recovery of boulder invertebrate communities may take 10 or more years (MMS 2002b; Konar 2007 and references therein).

Sea ice invertebrates include microbes, polychaetes, copepods, nematodes, and amphipods. Like zooplankton, sea ice invertebrates are important in connecting the water column to the benthos by depositing food on the seafloor and by providing habitat for benthic invertebrates in their early life stages (Gradinger and Bluhm 2005). Sea ice invertebrates are also an important food source to certain pelagic fish like Arctic cod.

3.8.5.3.1 Climate Change. It is predicted that physical and chemical changes to Arctic and subarctic invertebrate habitat would result from climate change (Section 3.3). Any of 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. For example, the movement of large decapod crabs into the Arctic may dramatically alter existing food webs (Weslawski et al. 2011). The change in species composition may be greatest in the eastern Beaufort Sea where Arctic species currently predominate. The timing and duration of copepod recruitment as well as copepod biomass are also likely to be affected by the rise in surface water temperatures.

It is predicted that a decrease in sea ice habitat would result from increasing water temperature. Consequently, the distribution of invertebrates specialized to inhabit sea ice will contract if they are unable to occupy new habitats. Also, the seasonal deposition of food from melting sea ice may be reduced, but settled phytoplankton may make up for the loss as the productivity of open water increases. Overall, an increase in the productivity of water column invertebrates is expected (Hopcroft et al. 2008). The abundance of benthic invertebrates may also increase in nearshore areas with the reduction in ice scour extent and duration and the consequent increase in the area of the seafloor available for colonization by invertebrates (Weslawski et al. 2011). However, loss of sea ice could also increase 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 and Chukchi Seas are expected to result from climate change (Arctic Council 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. 2011).

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). The loss of shelled invertebrates could affect higher trophic levels. For example, benthic mollusks are critical food sources for birds and marine mammals, and pteropods (pelagic snails) are abundant in Arctic waters and are an important food resource for salmon (Groot and Margolis 1991).

3.9 AREAS OF SPECIAL CONCERN

3.9.1 Gulf of Mexico

Areas of special concern include federally managed areas (e.g., Marine Protected Areas [MPAs], National Marine Sanctuaries, National Parks, National Wildlife Refuges), all of which are discussed in the following sections. In addition, a number of locations that have been given special designations by Federal and State agencies (e.g., National Estuarine Research Reserves, National Estuary Program Sites, and Military and National Aeronautics and Space Administration [NASA] Use Areas) are also included as areas of special concern. Critical habitat for endangered species is discussed in biota-specific sections.

3.9.1.1 Coastal Areas of Special Concern

3.9.1.1.1 Marine Protected Areas. Executive Order 13158 on Marine Protected Areas defines a MPAs as “any area of the marine environment that has been reserved by Federal, State, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein.” Thus MPAs have greater protection than the surrounding waters and can also vary widely in purpose, legal authorities, agencies, management approaches, level of protection, and restrictions on human uses (National Marine Protected Areas Center 2008).

To strengthen and enhance the nation’s system of MPAs, Executive Order 13158 directed the U.S. Department of Commerce and U.S. Department of the Interior, in consultation with other departments, to create a National System of MPAs. Section 5 of the Order calls for Federal agencies to “avoid harm” to National System MPAs and identify any actions that do harm to National System sites. Each Federal agency is responsible for its own implementation of its responsibilities under Section 5. As directed by the Order, the National Marine Protected Areas

Center (http://www.mpa.gov), directed by NOAA, has developed a planning and coordination process for adding existing MPAs into the National System. As described in *Framework for the National System of Marine Protected Areas of the United States of America* (National Marine Protected Areas Center 2008a), to be eligible for National System membership, an MPA must:

1. Meet the definitional criteria of an MPA, including each of its key terms — area, marine environment, reserved, lasting, and protection;

2. Have a management plan;

3. Support at least one priority goal and conservation objective of the national system; and

4. Cultural heritage MPAs also must conform to criteria for including sites on the *National Register of Historic Places*.

The *Framework for the National System of Marine Protected Areas of the United States of America* outlines the working relationship for building National System MPA sites, networks, and systems for areas managed by Federal, State, tribal, or local governments. No existing Federal, State, local, or tribal MPA laws or programs are altered by the National System or the Order, and no new legal authorities were established to designate, manage, or change MPAs.

Most National System MPAs encompass the National Marine Sanctuaries, National Parks, and National Wildlife Refuges, and are therefore managed by existing authorities.

At present, 14 National System MPAs have been designated in the Western and Central GOM Planning Areas, and 7 National System MPAs have been designated in the Eastern Planning Area from the Florida/Alabama border to Tampa Bay (Table 3.9.1-1; Figure 3.9.1-1). Most National System MPAs are National Wildlife Refuges and are described in Section 3.9.1.1.3.

In addition to the National System MPA member sites in Table 3.9.1-1, there are several State-designated and State-managed MPAs, federally managed areas, and partnership areas under State and Federal management that may or may not be eligible for membership in the National System MPA program. A complete listing and descriptions of the locations of these areas can be obtained from the lists on the Marine Protected Areas of the United States website at http://www.mpa.gov/helpful_resources/inventoryfiles/gulf_june_2010.pdf. Florida has 87 State-designated MPAs from the Panhandle to Tampa Bay. The vast majority are Outstanding Florida Waters, although many are also State Parks and aquatic preserves. Louisiana and Mississippi have 26 and 10 State-designated MPAs, respectively, most of which are coastal preserves and wildlife management areas. Texas has nine State-designated MPAs, most of which are State Parks or Wildlife Management Areas. Texas has a large coastline containing numerous and ecologically important bird rookeries, migratory bird stopover sites, unique vegetative communities, and protected species, all of which are found near the Texas coastline.

TABLE 3.9.1-1 National System Marine Protected Area Member Sites in the Western and Central GOM Planning Area and the Eastern GOM Planning Area from Alabama to Tampa, Florida

Site Name[a]	State	Managing Agency[b]
Bon Secour National Wildlife Refuge	AL	USFWS
Jean Lafitte National Historical Park and Preserve, Barataria Preserve	LA	NPS
Flower Garden Banks National Marine Sanctuary	LA	NOAA
Big Branch Marsh National Wildlife Refuge	LA	USFWS
Breton National Wildlife Refuge	LA	USFWS
Delta National Wildlife Refuge	LA	USFWS
Sabine National Wildlife Refuge	LA	USFWS
Shell Keys National Wildlife Refuge	LA	USFWS
Grand Bay National Wildlife Refuge	MS/AL	USFWS
Cedar Keys National Wildlife Refuge	FL	USFWS
Chassahowitzka National Wildlife Refuge	FL	USFWS
Crystal River National Wildlife Refuge	FL	USFWS
Lower Suwannee National Wildlife Refuge	FL	USFWS
Pinellas National Wildlife Refuge	FL	USFWS
St. Marks National Wildlife Refuge	FL	USFWS
St. Vincent National Wildlife Refuge	FL	USFWS
Anahuac National Wildlife Refuge	TX	USFWS
Aransas National Wildlife Refuge	TX	USFWS
Big Boggy National Wildlife Refuge	TX	USFWS
Brazoria National Wildlife Refuge	TX	USFWS
San Bernard National Wildlife Refuge	TX	USFWS

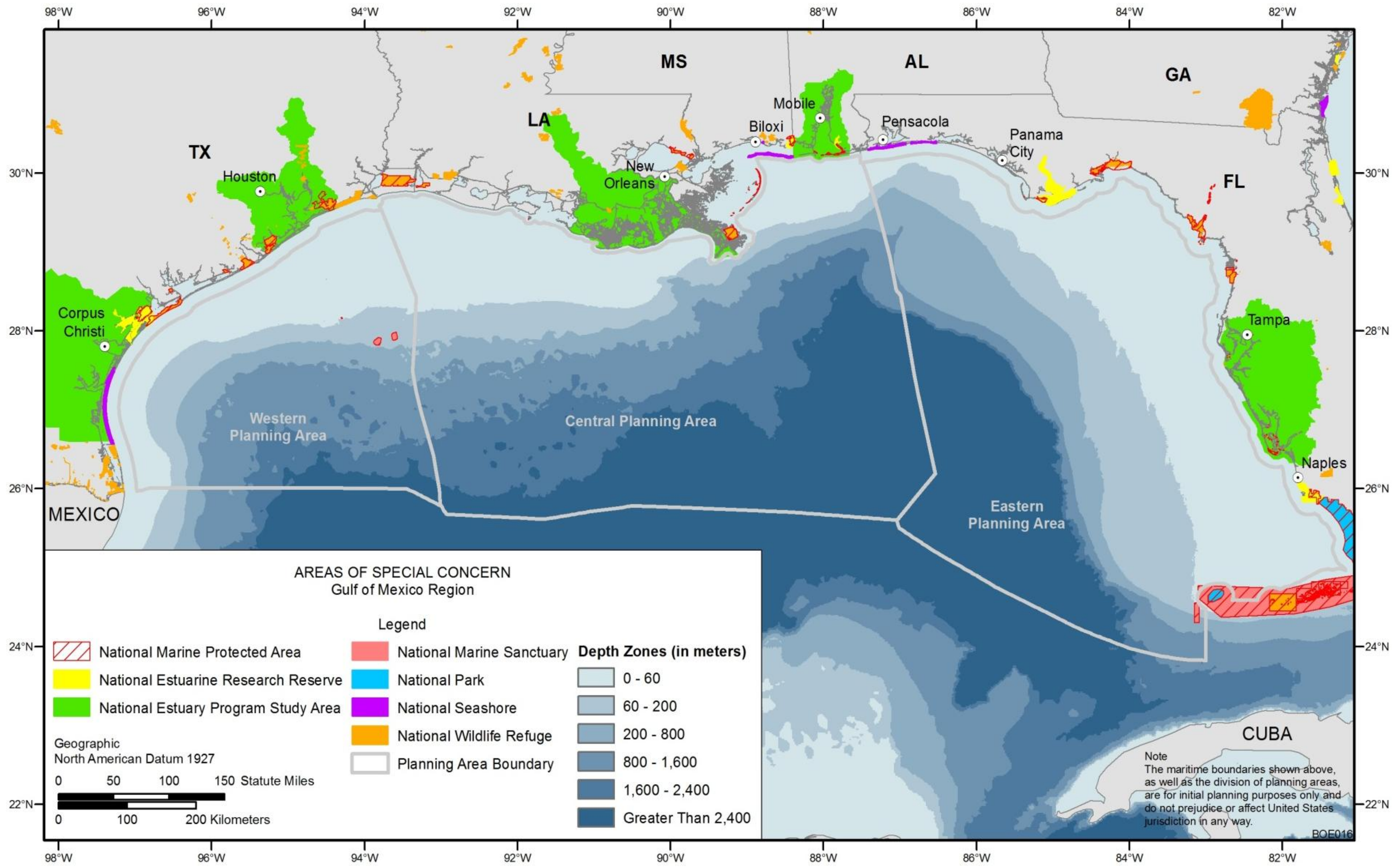
[a] Includes sites designated by the USDOI and NOAA. Sites designated by State, Territory, and Commonwealth agencies are not included but can be obtained from the lists on the Marine Protected Areas of the United States website at http://www.mpa.gov/helpful_resources/inventoryfiles/gulf_may_2011.pdf.

[b] NPS = National Park Service, NOAA = National Oceanic and Atmospheric Administration, USFWS = U.S. Fish and Wildlife Service.

Source: NOAA 2010c.

Federally managed areas that are eligible for MPA status but are not members of the National System MPA consist of Habitat Areas of Particular Concern (see Section 3.7.4.1), offshore banks, chemosynthetic communities, and deepwater corals (see Section 3.7.2.1). National Estuarine Research Reserves are partnership-managed areas under Federal and State management and are described below.

3.9.1.1.2 National Park System. The National Park System ensures the protection and interpretation of the country's natural, cultural, and recreational resources. Descriptions of National Parks given below are based on information for individual parks on the National Park Service (NPS) website (http://www.nps.gov). NPS lands along the coast or in coastal areas of the GOM include the Padre Island National Seashore (Texas), Jean Lafitte National Historic Park



Note
The maritime boundaries shown above, as well as the division of planning areas, are for initial planning purposes only and do not prejudice or affect United States jurisdiction in any way.

FIGURE 3.9.1-1 Map Showing the Location of Areas of Special Concern in the Western, Central, and Eastern Planning Areas

(Louisiana), Gulf Islands National Seashore (Mississippi and Florida), and DeSoto National Memorial (Florida). More than 177 km (110 mi) of coastal beaches and barrier islands in Texas, Mississippi, and Florida are used by millions of visitors each year at Padre Island National Seashore and Gulf Islands National Seashore. In addition to being a popular tourist destination, Padre Island National Seashore protects the largest portion of undeveloped barrier island in the world, supports a wide variety of flora and fauna, and is the most important nesting site for the Kemp's ridley sea turtle in the United States. Padre Island National Seashore also includes approximately 8,094 ha (20,000 ac) of the Laguna Madre, which is one of only five hypersaline lagoons in the world. Outside of the Central and Western Planning Areas, the Dry Tortugas National Monument is located offshore of the southern tip of Florida in the Eastern Planning Area.

The Gulf Islands National Seashore includes major portions of the barrier islands off the coasts of Florida and Mississippi, including beaches, coastal marshes, maritime forests, and offshore areas. The park also contains historic sites dating to 16th century European exploration and occupation. DeSoto National Memorial contains information on Hernando DeSoto's exploration of Florida in the 16th century and on Florida's history from the Civil War to the present. Oil from the DWH event reached the shoreline of the Gulf Island National Seashore. Cleanup efforts continue and the Seashore remains open. Monitoring efforts are ongoing (http://www.nps.gov/aboutus/oil-spill-response.htm).

The Jean Lafitte National Historic Park comprises six sites located in southern Louisiana: Acadian Cultural Center in Lafayette, Prairie Acadian Cultural Center in Eunice, Wetlands Acadian Cultural Center in Thibodaux, Barataria Preserve in Marrero, Chalmette Battlefield and National Cemetery in Chalmette, and French Quarter Visitor Center in New Orleans. Barataria Preserve covers more than 9,308 ha (23,000 ac) and contains bayous, swamps, marshes, forests, alligators, nutrias, and more than 300 species of birds. The other five sites are dedicated to the history and cultural preservation of southern Louisiana.

3.9.1.1.3 National Wildlife Refuges. The National Wildlife Refuge System is a network of U.S. lands and waters managed by the USFWS specifically for the enhancement of wildlife. There are 27 National Wildlife Refuges located along the coastline or within the coastal areas of the Western and Central GOM Planning Areas and the Eastern Planning Area from the Florida/Alabama border to Tampa Bay (Figure 3.9.1-1 and Table 3.9.1-2). Information on individual refuges can be found at http://www.fws.gov/refuges/refugeLocatorMaps. Most refuges along the GOM coastline were established to provide wintering areas for ducks, geese, coots, and other migratory waterfowl and shorebirds. Threatened and endangered species, including the American alligator and manatee, also use the refuges along the GOM.

Delta NWR, Breton NWR, Grand Bay NWR, and Bon Secour NWR were all contacted by oil from the DWH event (http://www.fws.gov/refuges/RefugeUpdate/MarchApril_2011/oneyear.html). Breton NWR and Bon Secour NWR appear to have been the most affected. Breton NWR was closed immediately following the spill but has since reopened (http://www.fws.gov/home/dhoilspill/pdfs/Breton2010OilSpillFactSheet.pdf). Monitoring efforts at Breton NWR are ongoing. Bon Secour NWR was heavily oiled and samples collected

TABLE 3.9.1-2 National Wildlife Refuges along the GOM Coast from Texas through Tampa Bay, Florida

National Wildlife Refuge	Total Area (ha)[a]
Texas	**141,498**
Anahuac	13,880
Aransas	46,296
Big Boggy	2,023
Brazoria	17,767
Laguna Atascosa	23,402
McFadden	22,258
San Bernard	12,249
Texas Point	3,623
Louisiana	**34,422**
Shell Keys	3
Bayou Sauvage	9,009
Delta	19,749
Breton	3,661
Mississippi	**2,072**
Grand Bay	2,072
Alabama	**3,713**
Grand Bay	1,010
Bon Secour	2,703
Florida (Panhandle to Tampa Bay)	**45,400**
St. Vincent	5,055
St. Marks	27,164
Cedar Keys	361
Chassahowitzka	12,482
Crystal River	19
Pinellas	160
Egmont Key	133
Passage Key	26
Matlacha Pass	159

[a] To convert hectares to acres, multiply by 2.47.

in winter 2010–2011 indicated elevated PAHs in beach sediments (OSAT-2 2011). The models of oil degradation for beaches at Bon Secour suggest alkanes and PAHs would degrade to approximately 15–20% of their current concentration within 2.5 to 5 yr (OSAT-2 2011).

3.9.1.1.4 National Estuarine Research Reserves. The National Estuarine Research Reserve Program was established by the Coastal Zone Management Act of 1972 and is administered by NOAA. One of the primary objectives for establishing this program was to provide research information that could be used by coastal managers and the fishing industry to help assure the continued productivity of estuarine ecosystems. Four estuarine research reserves have been established in the GOM area from Texas to Tampa Bay, as detailed below (Figure 3.9.1-1). Summary descriptions of the reserves described below were gathered through the National Estuarine Research Reserve website (http://nerrs.noaa.gov/ReservesMap.aspx). Detailed site profiles are available at http://nerrs.noaa.gov/BGDefault.aspx?ID=602.

1. Weeks Bay National Estuarine Research Reserve in coastal Alabama includes a small estuary covering about 2,641 ha (6,525 ac). The reserve is composed of open shallow waters, with an average depth of less than 1.5 m (5 ft) and extensive vegetated wetland areas. Freshwater enters from the Fish and Magnolia Rivers, and the reserve connects with Mobile Bay through a narrow opening.

2. The Apalachicola National Estuarine Research Reserve, southeast of Panama City, Florida, covers about 99,553 ha (246,000 ac). It consists of forested flood plains, saltwater and freshwater marshes, barrier islands, and open bays. A Federal Refuge and a State Park are within the reserve boundaries. A commercially important oyster fishery is located in the Apalachicola area.

3. The Grand Bay National Estuarine Research Reserve supports several rare or endangered plant and animal species, numerous important marine fishery resources, diverse habitat types, and important archaeological sites. It contains a diverse range of habitats, including coastal bays, saltwater marshes, maritime pine forests, pine savannas, and pitcher plant bogs. It supports extensive and productive oyster reefs and seagrass habitats, and it serves as a nursery area for many important recreational and commercial marine species, such as shrimp, blue crab, speckled trout, and red drum. Grand Bay NERR received oil from the DWH event. Baseline mapping of sensitive resources such as seagrasses and oyster beds was conducted to determine any long-term impacts from the spill (htpp://grandbaynerr.org/archives/13).

4. The Mission Aransas National Estuarine Research Reserve is located in Aransas and Refugio Counties, Texas, about 48 km (30 mi) northeast of Corpus Christi. It covers about 75,153 ha (185,708 ac) and was designated a reserve in 2006. Habitats present on the site include coastal prairies, coastal and freshwater marshes, ponds, bays, seagrass beds, oyster reefs, mangrove forests, and tidal flats. The University of Texas' Marine Science Institute is

the lead State agency overseeing the site. The site is home to wintering populations of the federally endangered whooping crane (*Grus americana*).

3.9.1.1.5 National Estuary Program. In 1987, an amendment to the Clean Water Act, known as the Water Quality Act (P.L. 100-4), established the National Estuary Program. The purposes of the program are to (1) identify nationally significant estuaries, (2) protect and improve their water quality, and (3) enhance their living resources. Under the administration of the USEPA, comprehensive administration plans are generated to protect and enhance the environmental resources of estuaries designated to be of national importance. The governor of a State may nominate an estuary for the program and may request that a comprehensive conservation and management plan be developed. Over a 5-yr period, representatives from Federal, State, and interstate agencies; academic and scientific institutions; and industry and citizens groups work to define objectives for protecting the estuary, select the chief problems to be addressed in the plan, and ratify a pollution-control and resource-management strategy to meet each objective. The GOM estuaries currently falling within the National Estuary Program include: Coastal Bend Bays and Estuaries, Corpus Christi Bay, Galveston Bay, Barataria-Terrebonne Estuarine Complex, Mobile Bay, Tampa Bay, Sarasota Bay, and Charlotte Harbor (USEPA 2011d; Figure 3.9.1-1).

3.9.1.2 Marine Areas of Special Concern

3.9.1.2.1 Marine Protected Areas. The only National System MPA in the Western and Central GOM Planning Areas located in marine waters is the FGBNMS. The FGBNMS is described below. In addition, there are *de facto* MPAs that are waters where access or activities are restricted by law for reasons other than conservation or natural resource management, such as to protect public health and safety, and public and private infrastructure, as well as those that provide training areas for the military (National Marine Protected Areas Center 2008). Military installations, anchoring sites, navigational channels, oil and gas transfer areas, and safety, security, and restricted areas (e.g., power plants) are all examples of *de facto* MPAs in the northern GOM. Almost 25% of the GOM regional waters (approximately 200,000 km^2 [7,7220 mi^2]) can be considered *de facto* MPAs. The GOM has 217 individual *de facto* MPAs and 64% of the nation's total *de facto* MPA area. Most of these sites are military use areas (Section 3.9.1.2.3) and areas restricted to protect the oil and shipping industries of the region. Most *de facto* MPAs allow multiple commercial and recreational uses with some periodic activity restriction. Fewer than 1% (approximately 100 km^2 [39 mi^2]) of *de facto* MPAs (primarily oil platforms and certain military use areas) are permanent no-access areas (National Marine Protected Areas Center 2008). Military use areas are discussed in more detail below. Maps and additional information on *de facto* MPAs can be found at http://www.mpa.gov/helpful_resources/inventoryfiles/defacto_mpa_report_0608.pdf.

3.9.1.2.2 Marine Sanctuaries. The only National Marine Sanctuary in the Western and Central GOM Planning Areas is the FGBNMS. The FGBNMS is located about 175 km (109 mi) southeast of Galveston, Texas (Figure 3.9.1-1). The area containing both the East and West Banks covers 143 km^2 (55 mi^2) and has 142 ha (351 ac) of reef crest (Gardner et al. 1998). In October 1996, Congress expanded the sanctuary by adding a small third bank, Stetson Bank, which is located about 113 km (70 mi) south of Galveston. The FGBNMS represents the northernmost coral reef system in the United States (Figure 3.9.1-1) and is described in detail in Section 3.7.2.1.2.

The most recent FGBNMS management plan (NOAA 2010d) suggests expanding the current FGBNMS boundary to include banks and topographic features that currently exist outside it but that may be vulnerable to anthropogenic impacts.

BOEM has protected the biological resources of the FGBNMS from potential damage due to oil and gas exploration by establishing a No Activity Zone and other operational restrictions in the vicinity of the banks. BOEM management and protection of the FGB and other topographic features began in 1973 prior to the establishment of the Sanctuary in 1992. Designating the area as a National Marine Sanctuary has provided other protective measures by regulating the following (available at http://flowergarden.noaa.gov/about/regulations.html):

- Injuring, removing, possessing, or attempting to injure or remove a living or nonliving sanctuary resource;

- Feeding fish and certain methods of taking fish;

- The speed, anchoring, and mooring of vessels;

- Destroying sanctuary property, or discharging or depositing outside the sanctuary boundaries polluting materials that could subsequently enter the sanctuary and injure a sanctuary resource or worsen its quality; and

- Altering the seabed or constructing, placing, or abandoning any structure or material on the seabed.

Recent surveys indicate that the FGBNMS appears to be healthy, with a coral cover of 50 to 70% on both the east and west banks and a low incidence of bleaching or other coral disease (Precht et al. 2008; Robbart et al. 2009). Data collected from the east and west banks from 1978 to 2006 do not indicate any long-term trends in the percentage of coral cover (Hickerson et al. 2008; Robbart et al. 2009). Ongoing stressors on the FGBNMS include mechanical disturbance from anchors and discarded fishing gear, coastal runoff, and disease (Hickerson et al. 2008).

3.9.1.2.3 Military and NASA Use Areas. Military Use Areas, established off all U.S. coastlines, are required by the U.S. Air Force, 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 (Figure 3.9.1-2).

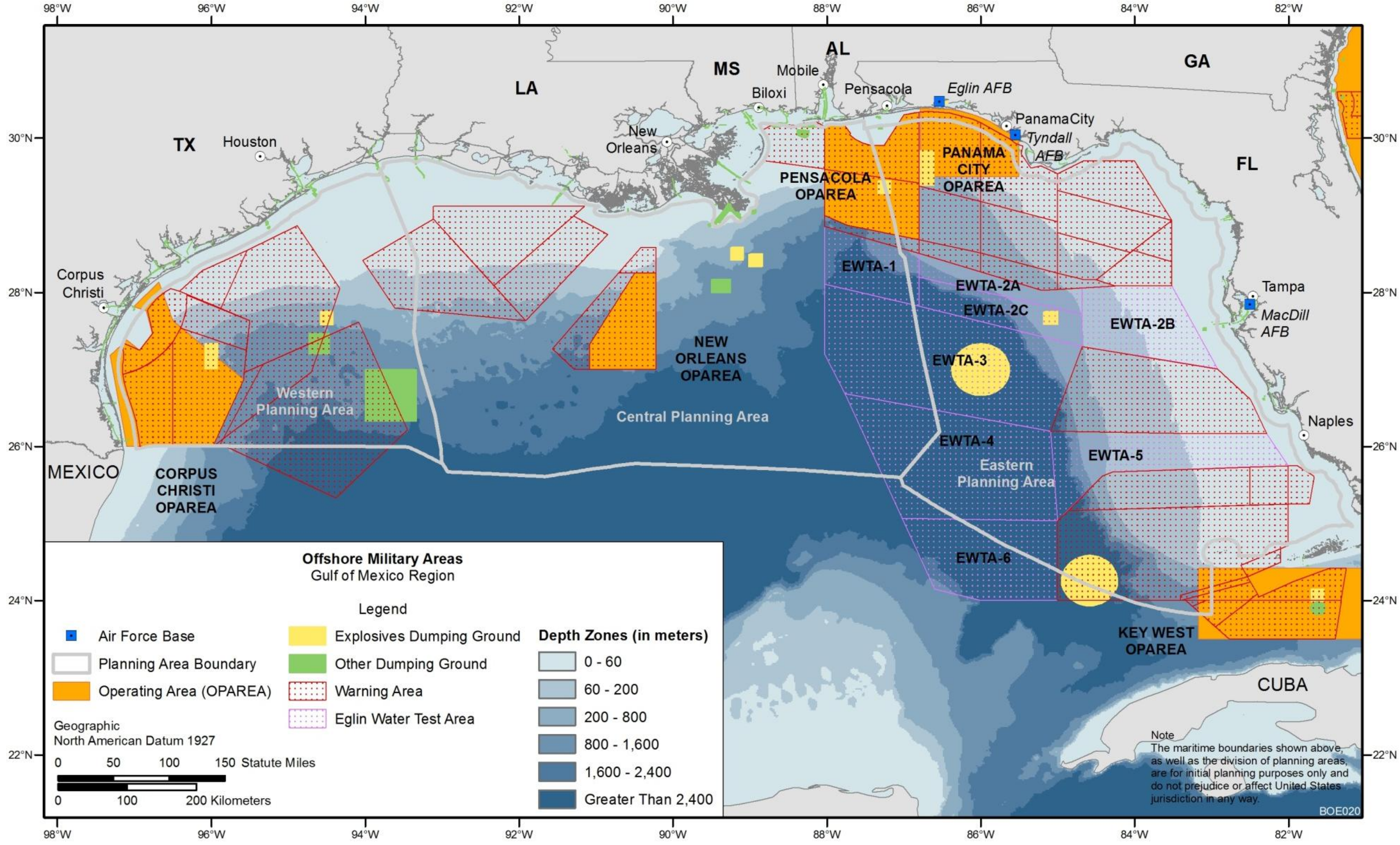


FIGURE 3.9.1-2 Location of Military Use Areas in the GOM

Military dumping areas are also shown in Figure 3.9.1-2. Dumping areas can be classified according to whether spoil, ordinance, chemical waste, or vessel waste is deposited in the area.

The U.S. Air Force has established multiple surface danger zones and restricted areas. Danger zones are defined as water areas used for a variety of hazardous operations (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. The regulations pertaining to the identification and use of these areas are found in 33 CFR Part 334. Units of the U.S. Department of Defense (USDOD) and NASA use surface danger zones and restricted areas in coastal and offshore waters for rocket launching, weapons testing, and conducting a variety of training and readiness operations. Most danger zones and restricted areas in the northern GOM are associated with Elgin Air Force Base (AFB) and Tyndall AFB, both of which are located in the Florida Panhandle. The danger zones extend from nearshore areas to hundreds of kilometers off the coast of Florida. There is also a danger zone associated with MacDill AFB in Tampa Bay.

The GOM Range Complex is a combined air, land, and sea space that provides realistic training areas for Navy personnel. In coastal and marine areas, the GOM Range Complex includes military operating areas (OPAREAs) and overlying Special Use Airspaces (SUAs), the Naval Support Activity Panama City Demolition Pond, security group training areas, and supporting infrastructure (U.S. Fleet Forces 2010). Four offshore OPAREAs are located in the northern GOM: Corpus Christi, New Orleans, Pensacola, and Panama City (Figure 3.9.1-2). These offshore surface and subsurface areas total 59,817 km^2 (17,440 NM^2) and include 41,406 km^2 (12,072 NM^2) of shallow ocean area less than 185 m (590 ft) deep (U.S. Fleet Forces 2010). OPAREAs define where the U.S. Navy conducts surface and subsurface training and operations. The Navy conducts various training activities at sea (e.g., surface target sinking exercises and mine warfare exercises) and shakedown cruises for newly built ships.

Aircraft operated by all USDOD units train within SUAs that overlie the OPAREAs, as designated by the Federal Aviation Administration (U.S. Fleet Forces 2010). SUAs, also called warning areas, 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. These areas are designated as airspace for military activities, but because they occur over international waters, there are no restrictions on nonmilitary aircraft. The purpose of designating such areas is to warn nonparticipating pilots of potential danger. When they are being used for military exercises, the controlling agency notifies civil, general, and other military aviation organizations of the current and scheduled status of the area (U.S. Department of the Navy 2004). Aircraft operations conducted in warning areas primarily involve air-to-air combat training maneuvers and air intercepts, which are rarely conducted at altitudes below 1,524 m (5,000 ft) (U.S. Department of the Navy 2002).

Security group training areas are also located in marine waters of the GOM Range Complex. There are two group training areas: one is located 13 km (8 mi) off the coast of

Panama City, Florida; the other is 13 km (8 mi) off the coast of Corpus Christi, Texas. These areas are used for machine gun and explosives training (U.S. Fleet Forces 2010).

3.9.2 Alaska – Cook Inlet

The Alaska National Interest Lands Conservation Act of 1980 designated certain public lands in Alaska as units of the NPS, NWR, Wild and Scenic Rivers, National Wilderness Preservation, and National Forest systems. This section describes Alaskan lands managed by the NPS, USFWS, and USFS. It also describes MPAs, National Estuarine Research Reserves, National Estuary Program areas, MUAs, and NOAA-designated HCAs.

3.9.2.1 National Park Service Lands

Lands managed by the NPS include National Parks, National Monuments and Preserves, National Historic Areas, and designated Wild and Scenic Rivers. Onshore oil facilities are permissible only on private land holdings within NPS-managed lands. Even in some of these units, development of onshore oil-support facilities is unlikely because of the associated logistical difficulties that are perceived. Subsistence harvesting is allowed in some NPS units and may be affected by offshore oil and gas development.

There are three National Parks and one National Monument that could be affected by OCS oil and gas activities, including accidental spills. The information on each park provided below was gathered from NPS websites for individual parks. More information can be found at http://www.nps.gov/state/ak/index.htm.

The Katmai National Park and Preserve (which, for management purposes, includes the Alagnak Wild River and Aniakchak National Monument and Preserve) encompasses 1.9 million ha (4.7 million ac) (Figure 3.9.2-1). Katmai National Park is located in the Cook Inlet Planning Area on the western shore of Shelikof Strait, about 300 km (186 mi) southwest of Anchorage.

The Aniakchak National Monument and Preserve is located on the Alaskan peninsula about 161 km (100 mi) south of the Cook Inlet Planning Area (Figure 3.9.2-1). The park contains Aniakchak caldera and the Aniakchak River, which flows 43 km (27 mi) from Surprise Lake (inside the Aniakchak caldera) to the Pacific Ocean. Sockeye salmon make spawning runs up the Aniakchak River. The park is relatively pristine because of its remote location and harsh weather, both of which limit the number of visits by humans.

The Lake Clark National Park and Preserve, which borders Cook Inlet, spans 1.6 million ha (4 million ac) and extends roughly 150 km (93 mi) inland. It is a composite of ecosystems representative of many regions of Alaska, including lakes, rivers, and streams. The park receives more than 4,000 visitors annually.

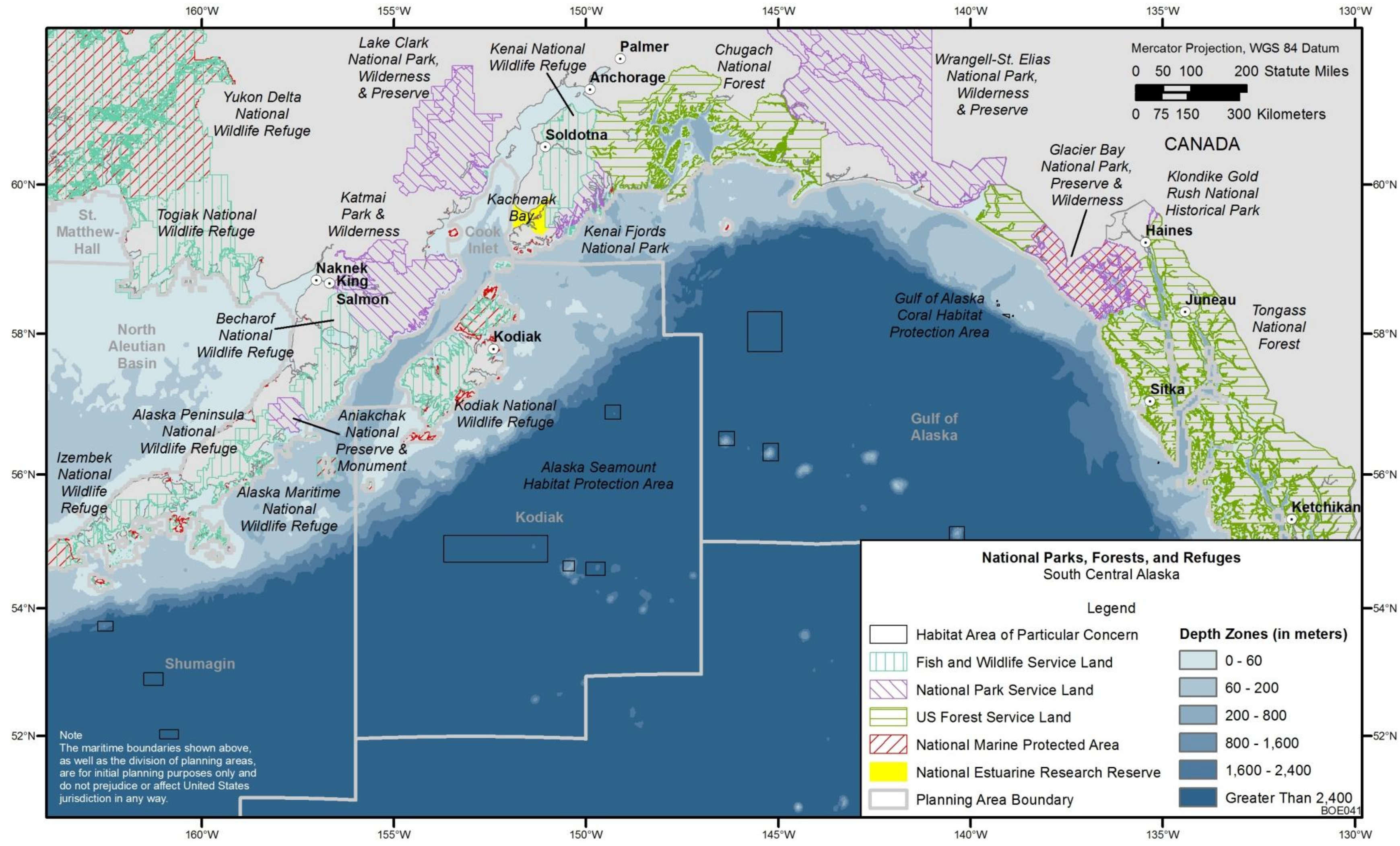


FIGURE 3.9.2-1 Map Showing the Location of Areas of Special Concern in the Cook Inlet Planning Area

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. This park contains the Harding Icefield and 38 glaciers.

3.9.2.2 Fish and Wildlife Service Lands

The USFWS has jurisdiction over NWRs for carrying out the responsibilities of Federal laws. Oil facility development is discretionary on NWRs in Alaska. Potential use of USFWS lands as bases for offshore oil and gas exploration as well as onshore oil and gas development will be determined in part by Title XI (see also Title III) of the Alaska National Interest Lands Conservation Act (ANILCA). Title XI ROWs are issued according to both ANILCA and the NWR System Administration Act of 1966 (16 USC 668dd), as amended by the NWR System Improvement Act of 1997 (P.L. 105-57). Title XI provides a procedural framework for permitting the use of USFWS lands and access to these lands for transportation and utility systems, which includes an application and extensive review process.

Information on each refuge provided below was gathered from NWR websites for individual refuges. More information can be found at http://www.fws.gov/refuges. There are six NWRs in Cook Inlet and the Kenai Peninsula. These include two units of the Alaska Maritime NWR: (1) the GOA Unit, which includes 1,287 km (800 mi) of coast from southeast Alaska’s rainforests across the arc of Prince William Sound to Kodiak Island, and (2) the Alaska Peninsula Unit, which extends west more than 644 km (400 mi) from Kodiak Island to the southern tip of the peninsula (Figure 3.9.2-1).

The Alaska Peninsula NWR (managed jointly with the Becharof NWR) encompasses 1.5 million ha (3.7 million ac) and contains a variety of habitats, including mountains, rivers, lakes, volcanoes, and fjords.

The Becharof NWR encompasses roughly 485,623 ha (1.2 million ac), of which 202,343 ha (500,000 ac) is designated wilderness. The Becharof NWR is located south of Katmai National Park and Preserve and contains Becharof Lake. Sockeye spawn in Becharof’s rivers, and Becharof Lake serves as a nursery for the world’s second-largest run of sockeye salmon. The refuge includes vast areas of pristine wildlife and fish habitat and includes a diversity of mammalian, avian, and fish species.

The Izembek NWR encompasses 121,406 ha (300,000 ac), most of which is forest land containing critical streams and land for salmon, waterfowl, seabirds, and mammalian predators and herbivores. The refuge is located on the Alaska Peninsula near Cold Bay, Alaska, more than 322 km (200 mi) from the Cook Inlet Planning Area. Within the refuge is the Izembek Lagoon, which contains extensive eelgrass beds used by fish and birds as feeding and resting areas. The American Bird Conservancy designated the Izembek Refuge as a Globally Important Bird Area in 2001. Marine mammals, including steller sea lions and gray, minke, killer, and humpback whales, also inhabit or pass through the refuge.

The Kenai NWR encompasses roughly 809,371 ha (2 million ac). The refuge is located on the Kenai Peninsula on the eastern side of upper Cook Inlet. The Kenai NWR attracts many visitors because of its closeness to Anchorage and general accessibility. The area contains important moose habitat and also a rich array of habitats for an estimated 200 different vertebrate species. The refuge, including the rivers (Russian and Kenai), streams, and lakes within its borders, provides important spawning and rearing habitat for trout and all five species of Pacific salmon. The Harding Icefield lies partially within the refuge boundaries and nearby Kenai Fjords National Park. The Chickaloon watershed and estuary is a major waterfowl and shorebird staging area and is the only such area on the refuge. Oil and gas development activities occur on roughly 89,000 ha (220,000 ac).

The Kodiak NWR, encompassing about 768,903 ha (1.9 million ac), covers roughly two thirds of Kodiak Island, Uganik Island, the Red Peaks area on northwestern Afognak Island, and all of Ban Island. Biologists have identified 250 species of fish, mammals, and birds (including both residents and migrants) on the refuge. About 1.5 million marine birds overwinter in nearshore habitats surrounding Kodiak Island. There are 117 salmon streams on Kodiak Island that provide spawning and rearing habitat for all five species of Pacific salmon.

3.9.2.3 Forest Service Lands

Coastal lands managed by the USFS are at risk from potential impacts from outer continental shelf oil and gas development. The U.S. Bureau of Land Management (BLM), in cooperation with the USFS, manages oil/gas lease operations. The USFS has approval authority for the surface-use portion of the Federal oil/gas operation (36 CFR Part 228, Subpart E – Oil & Gas Resources). The USFS will carry out its statutory responsibilities when issuing Federal oil and gas leases and managing subsequent oil and gas operations on National Forest system lands.

The Chugach National Forest borders Prince William Sound and Turnagian Arm and is the closest National Forest (300 km [186 mi]) to the Cook Inlet Planning Area (Figure 3.9.2-1). It encompasses 2.2 million ha (5.5 million ac), of which 567,000 ha (1.4 million ac) have been proposed and are currently managed as wilderness. Though a variety of land uses are permitted on USFS lands (including timber harvest and mining activities), wilderness areas generally are exempt from such “multiple-use” activities. The Chugach Forest Management Plan identifies lands that are open or closed to leasing. Currently, the plan provides for oil and gas exploration and development in the Katalla area.

3.9.2.4 Marine Protected Areas

The Alaska Peninsula Unit and GOA Unit of the Alaska Maritime NWR are the only National System MPAs in the vicinity of the Cook Inlet Planning Area and are described in Section 3.9.2.2. The Alaska Maritime MPA is categorized as a Natural and Cultural Heritage Conservation Area and a Sustainable Production Conservation Area. Commercial fishing and recreational fishing are restricted.

Although not National System MPAs, there are several State and Federal MPAs present in Cook Inlet. Cook Inlet itself is eligible for National System membership, and fishing within Cook Inlet is restricted. There are also several NOAA-designated HCAs and Habitat Protection Areas (HPAs) in the Gulf of Alaska, including three federally managed steller sea lion protection areas: the Gulf of Alaska HCA located near Prince William Sound, the Aleutian Islands Coral HPA, and the Aleutian Islands Habitat HCA located to the west of Cook Inlet. These areas have prohibitions against specific fishing activities or that target certain species. In addition, Cook Inlet and the waters around Kodiak Island contain State marine protected areas that are eligible for MPA membership and that contain shrimp and scallop fishing closure areas and restrictions on types of commercial fishing gear. A detailed map of State and federally eligible MPAs can be found at http://www.mpa.gov/helpful_resources/inventoryfiles/AK_Map_090831_final.pdf.

There are no de facto MPAs (waters whose use is restricted to protect military property, public health, and private and public infrastructure) within Cook Inlet (National Marine Protected Areas Center 2008). However, to the east, there are several de facto MPAs within Prince William Sound. Most are administered by the U.S. Coast Guard to protect shipping. Maps and additional information on de facto MPAs can be found at http://www.mpa.gov/helpful_resources/inventoryfiles/defacto_mpa_report_0608.pdf.

3.9.2.5 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.

Kachemak Bay, Alaska, is a National Estuarine Research Reserve located in Cook Inlet on the southern end of the Kenai Peninsula. The reserve covers 149,734 ha (370,000 ac), and the bay itself has more than 515 km (320 mi) of shoreline. There is a variety of marine and estuarine habitat in the reserve, including mudflats, rock shore, beaches, open water, and submerged aquatic vegetation. Marine mammals use the bay heavily, as do commercially important fish and shellfish. More information on the Kachemak Bay NERR can be found at http://nerrs.noaa.gov/Reserve.aspx?ResID=KBA.

There are no military use restrictions (i.e., danger zones and restricted areas) in the waters of the Cook Inlet Planning Area (National Marine Protected Areas Center 2008). 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.

3.9.3 Alaska – Arctic

The Alaska National Interest Lands Conservation Act of 1980 designated certain public lands in Alaska as units of the National Park, NWR, Wild and Scenic Rivers, National Wilderness Preservation, and National Forest systems. This section describes Alaskan lands managed by the NPS and USFWS. There are no USFS lands adjacent to the Beaufort or Chukchi Sea Planning Areas. Also described are MPAs, National Estuarine Research Reserves, National Estuary Program Areas, Military Use Areas, and NOAA-designated HCAs.

3.9.3.1 National Park Service Lands

The Iñupiat Heritage Center in Barrow, Alaska, is the only NPS-managed area along the coast of the Beaufort and Chukchi Planning Areas (Figure 3.9.3-1). The Iñupiat Heritage Center uses exhibits, classes, performances, and educational activities to promote and protect Iñupiaq culture, history, and language. More information on the Iñupiat Heritage Center is available at http://www.nps.gov/inup/index.htm. The Cape Krusenstern National Monument is located along the northern shore of Hope Basin, about 150 km (93 mi) south of the Chukchi Planning Area. The Bering Land Bridge National Preserve is located along the southern shore of Hope Basin, about 300 km (186 mi) south of the Chukchi Sea Planning Area (Figure 3.9.3-1). Also located in Hope Basin are the deltas of Noatak and Kobuk National Park Units. More information on these parks is available at http://www.nps.gov.

Onshore oil facilities are permissible only on private land holdings within NPS-managed lands. In some of these units, development of onshore oil-support facilities is unlikely because of the logistical difficulties perceived. In addition, subsistence harvesting is allowed in some NPS units.

3.9.3.2 Fish and Wildlife Service Lands

The Arctic NWR and the Chukchi Sea Unit of the Alaska Maritime NWR are the closest NWRs to the Beaufort and Chukchi Sea Planning Areas. The Arctic NWR consists of about 7.65 million ha (18.9 million ac) of land in northeastern Alaska along the Beaufort Sea coast (Figure 3.9.3-1). An additional 277,000 ha (684,000 ac) are either selected for conveyance or have been conveyed, under the terms of the Alaska Native Claims Settlement Act of 1971 (ANCSA), to the State or to Native corporations. All federally owned land within the refuge is currently designated as wild rivers, or minimal or wilderness management status. Under the ANILCA, production of oil and gas from the Arctic NWR is prohibited, and no leasing or other development leading to production of oil and gas can be undertaken until authorized by an Act of Congress. However, under the same Act, 607,028 ha (1.5 million ac) along the northern coast, known as the 1002 Area, has been set aside for further study and possible oil development, per ANILCA (ANILCA Sec. 1002). More information on the Arctic NWR is available at http://arctic.fws.gov.

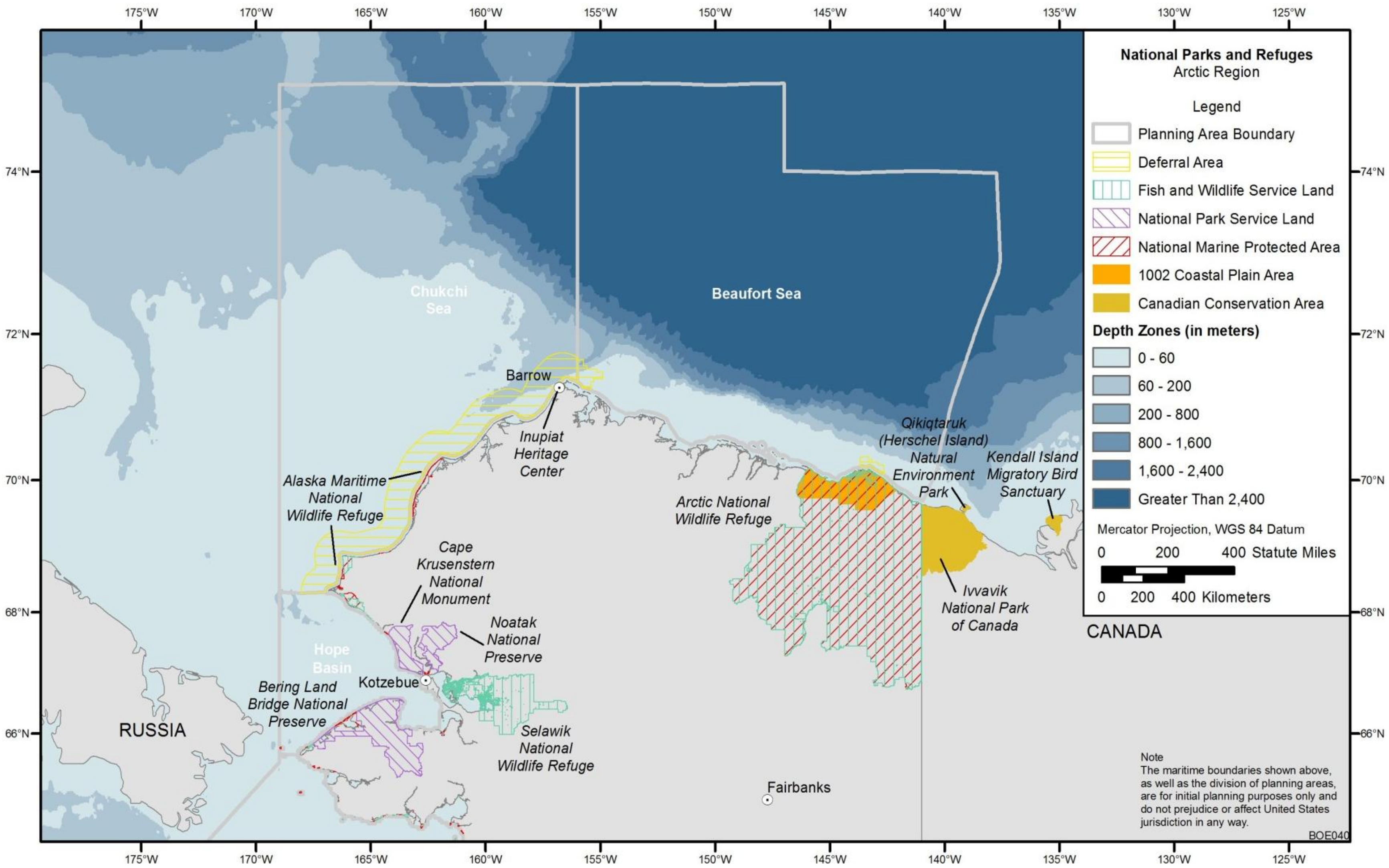


FIGURE 3.9.3-1 Map Showing the Locations of Areas of Special Concern in the Beaufort and Chukchi Sea Planning Areas

The Chukchi Sea Unit of the Alaska Maritime NWR includes coastal and offshore islands and extends 805 km (500 mi) from south of Barrow to south of Cape Thompson (Figure 3.9.3-1). The Chukchi Sea Unit contains several islands and coastal habitats important to marine birds. More information on the Chukchi Sea Unit of the Alaska Maritime NWR is available at http://alaskamaritime.fws.gov.

3.9.3.3 Marine Protected Areas

The Arctic NWR and the Chukchi Sea Unit of the Alaska Maritime NWR are the two National System MPAs in or near the Beaufort and Chukchi Sea Planning Areas and are described in Section 3.9.3.2 (Figure 3.9.3-1). Both NWRs are classified as Natural and Cultural Heritage Conservation Areas and Sustainable Production Conservation Areas. Commercial fishing is prohibited in the Arctic NWR and is restricted in the Chukchi Sea Unit of the Alaska Maritime NWR. There are no State MPAs or *de facto* MPAs in the Beaufort and Chukchi Planning Areas (http://www.mpa.gov/helpful_resources/inventoryfiles/AK_Map_090831_final.pdf).

3.9.3.4 Other Areas of Special Concern

There are no National Estuarine Research Reserves, National Estuary Program Areas, or Habitat Conservation Areas in or adjacent to the Beaufort and Chukchi Planning Areas. There are four active U.S. Air Force radar sites located on the coast bordering the Beaufort and Chukchi Sea Planning Areas. They are all Long-Range Radar Sites (LRRSs): Cape Lisburne LRRS, Point Barrow LRRS, Oliktok LRRS, and Barter Island LRRS. 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.

A pipeline linking the Chukchi Sea Planning Area to the North Slope will likely cross the Bureau of Land Management NPR-A. Oil and gas leasing in the NPR-A is authorized under the Naval Petroleum Reserves Production Act of 1976 (42 USC 6501 *et seq.*), as amended, including the Department of the Interior and Related Agencies Appropriation Act of 1981 (94 Stat. 2964). Several lease tracts of NPR-A lands have been sold by BLM for oil and gas development (http://www.blm.gov/ak/st/en/prog/energy/oil_gas/npra.html).

Other areas of special concern include Ivvavik National Park, Herschel Island Territorial Park, and Kendall Island Bird Sanctuary, all of which are located in Canada on the eastern side the Beaufort Sea Planning Area.

3.10 POPULATION, EMPLOYMENT, AND INCOME

Offshore waters of the Western, Central, and Eastern GOM Planning Areas lie adjacent to coastal Texas, Louisiana, Mississippi, Alabama, and Florida. Although economic and demographic impacts of OCS oil and gas activity occur in other States in the U.S., the majority of impacts occur in the coastal States adjacent to the GOM. For the purposes of this analysis, the GOM coastal region consists of counties (and parishes in Louisiana) in each of the five States whose social and economic well-being is directly or indirectly affected by the OCS oil and gas industry. In this analysis, these counties (and parishes in Louisiana) have been grouped into labor market areas (LMAs), defined on the basis of inter-county commuting patterns using a method suggested by Tolbert and Sizer (1996). There are 129 counties in the 23 Labor Market Areas in the five States located along the GOM coast (MMS 2006b). Counties in the LMAs adjacent to the Western GOM Planning Area are all within Texas and include the cities of Brownsville, Corpus Christi, Victoria, Brazoria, Houston-Galveston, and Beaumont-Port Arthur. Counties in the LMAs adjacent to the Central GOM Planning Area include Lake Charles, Lafayette, Baton Rouge, Houma, and New Orleans, Louisiana; Biloxi-Gulfport, Mississippi; and Mobile, Alabama. Counties in the LMAs adjacent to the Eastern Planning Area are all within Florida and include Pensacola, Panama City, Tallahassee, Lake City, Gainesville, Ocala, Tampa-St. Petersburg, Sarasota, Ft. Myers, and Miami.

The south central Alaska region (which corresponds with the Cook Inlet Planning Area) is the most densely populated part of Alaska and includes Anchorage Municipality and the entirety of the Kenai Peninsula, Kodiak Island, and Matanuska-Susitna Boroughs. The area corresponds to the area where many workers on offshore oil and gas platforms would live, at least temporarily if they live permanently outside Alaska, and spend their wages and salaries when they are in residence, and the area in which much of the oil and gas infrastructure associated with development in Cook Inlet and many of the supporting industries would be located. The Arctic region (Beaufort and Chukchi Sea Planning Areas) consists of the North Slope Borough and the Northwest Arctic Borough. The area corresponds to the area where some of the workers on the offshore oil and gas platforms would live, at least temporarily if they live permanently elsewhere in Alaska or the U.S., and spend their wages and salaries when they are in residence, and the area in which much of the oil and gas infrastructure associated with development would be located.

3.10.1 Population

3.10.1.1 Gulf of Mexico

Population in the counties in the GOM coast region 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 (Table 3.10.1-1). Total population in 2009 was 23.2 million. Within the region, recent annual population growth has been higher in the Texas counties, with growth of 2% between 1990 and 2000 and 2.1% between 2000 and 2009. Population in the Mississippi counties grew annually at 1.7% between 1990 and 2000, slowing to 0.2% between 2000 and 2009, while growth rates in the Florida counties have been higher between 2000 and 2009 compared to the previous period; population growth was negative in the Alabama counties between 1990 and 2000.

As is the case for the U.S. population as a whole, there is a relative decline in lower age cohorts over time (Table 3.10.1-2), while the region has shown a steady improvement in the level

TABLE 3.10.1-1 Gulf of Mexico Coastal Region Population (thousands)

State	1980	1990	Average Annual Percent Change (1980–1990)	2000	Average Annual Percent Change (1990–2000)	2009	Average Annual Percent Change (2000–2009)
Texas	4,931.67	5,726.76	1.5	6,969.83	2.0	8,376.1	2.1
Louisiana	3,021.66	3,056.77	0.1	3,343.69	0.9	3,354.07	0.0
Mississippi	370.07	389.02	0.5	458.67	1.7	466.59	0.2
Alabama	581.23	609.33	0.5	599.4	–0.2	647.09	0.9
Florida	6,424.37	8,178.85	2.4	8,955.93	0.9	10,320.23	1.6
Total region	15,329.00	17,960.74	1.6	20,327.54	1.2	23,164.08	1.5

Source: USCB 2011d.

TABLE 3.10.1-2 Gulf of Mexico Coastal Region Population Composition

Population Segment	1980	1990	2000
Total Population	15,329,000	17,960,740	20,327,536
Age Structure (%)			
Under 5	7.4	7.6	7.0
5 to 14	15.4	14.5	14.7
15 to 24	18.1	14.2	13.7
25 to 34	16.3	16.9	13.8
35 to 44	11.1	14.6	15.6
45 to 54	9.7	9.8	13.0
55 to 64	9.5	8.6	8.8
65+	12.6	13.8	13.5
Education of Persons Age 25+ (%)			
0 to 8 yr schooling	20.5	12.6	9.6
9 to 11 yr schooling	15.8	15.9	14.1
High school graduates	32.1	28.6	27.8
13 to 15 yr schooling	15.9	24.4	26.9
College graduates	15.6	18.4	21.6

Source: MMS 2006b.

of educational attainment; the percentage of persons having attended or graduated from college increased from 31% in 1980 to 48% in 2000.

3.10.1.2 Alaska – Cook Inlet

Population in the south central Alaska region increased at an average annual rate of 3.5% between 1980 and 1990, 1.8% between 1990 and 2000, and 1.5% between 2000 and 2009 (Table 3.10.1-3). Total population in Alaska in 2009 was 698,473. Within the region, recent annual population growth has been higher in the Matanuska-Susitna Borough, with growth of 8.3% between 1980 and 1990 and 4.1% between 1990 and 2000, and 4.1% between 2000 and 2009. Population in Kenai Peninsula grew annually at 4.9% between 1980 and 1990, slowing to 2.0% between 1990 and 2000. Recent growth rates in Anchorage have also declined, from 2.6% between 1980 and 1990 to 1.4% between 1990 and 2000. Growth rates in Anchorage and Kenai Peninsula between 2000 and 2009 are similar to those experienced in the State as a whole.

3.10.1.3 Alaska – Arctic

Population in the Arctic region increased at an average annual rate of 3.0% between 1980 and 1990, 1.9% between 1990 and 2000, and –0.3% between 2000 and 2009 (Table 3.10.1-3). Total population in the Northwest Arctic Borough was 7,444 in 2009, with 6,752 residents in the North Slope Borough.

TABLE 3.10.1-3 Alaska Regional Population (thousands)

Borough, Region, and State	1980	1990	Average Annual Percent Change (1980–1990)	2000	Average Annual Percent Change (1990–2000)	2009	Average Annual Percent Change (2000–2009)
Anchorage	174,431	226,338	2.6	260,283	1.4	286,174	1.0
Kenai Peninsula	25,282	40,802	4.9	49,691	2.0	54,665	1.0
Kodiak Island	9,939	13,309	3.0	13,913	0.4	13,946	–0.4
Matanuska-Susitna	17,816	39,683	8.3	59,322	4.1	88,379	4.1
Total region	**227,468**	**320,132**	**3.5**	**383,209**	**1.8**	**442,564**	**1.5**
North Slope	4,199	5,979	3.6	7,385	2.1	6,752	–1.0
Northwest Arctic	4,831	6,113	2.4	7,208	1.7	7,444	0.3
Total region	**9,030**	**12,092**	**3.0**	**14,593**	**1.9**	**14,196**	**–0.3**
Alaska	**401,851**	**550,043**	**3.2**	**626,932**	**1.3**	**698,473**	**1.2**

Sources: Department of Labor and Workforce Development 2011; USCB 2011d.

3.10.2 Community Population and Income

3.10.2.1 Alaska – Cook Inlet

Anchorage Municipality had 280,389 residents over the period 2005–2009, almost 45% of the total population of Alaska (Table 3.10.2-1). Median household income in Anchorage was $70,151 over the period 2005–2009, per capita income stood at $33,436 over the same period. Only 7.8% of individuals in the borough were living in poverty, and 5.6% of the population classified themselves as American Indian or Alaska Native.

Although Kenai Peninsula Borough had 53,052 residents, of the 22 communities in the borough, only three had more than 3,000 residents over the period 2005 to 2009 (Kenai, 7,661; Kalifornsky, 7,020; Homer, 5,667; Nikiski 4,683; Soldotna 4,266, and Seward 3,083), constituting 37% of the population of the Borough (Table 3.10.2-1). While five communities had median household incomes of more than $60,000 over the period 2005–2009 (Halibut Cove, $127,010; Kasilof, $77,188; Salamatof, $72,958; Nikiski, $70,000; and Kalifornsky, $66,652), there were nine communities with median household income of less than $40,000. Six communities in the borough had per capita incomes higher than the borough community average over the period 2005–2009 ($26,940), while 15 communities had per capita incomes less than the borough average over the same period; per capita incomes in three communities stood at half the borough average.

The percentage of individuals living in poverty was greater than the borough average in 11 communities, with a higher number of individuals in two communities (Clam Gulch, 45.1%, and Port Graham, 40.5%). Two of the larger communities in the borough, Nikiski and Seward, had higher than average poverty levels. Three communities in the borough (Tyonek, 100%; Nanwalek, 97.2%; and Port Graham, 82.4%) had a high percentage of American Indian or Alaska Natives, with higher than average percentages in six other communities.

Population in the Kodiak Island Borough is concentrated in Kodiak, with 6,291 residents between 2005 and 2009 constituting more than 48% of the population of the borough. Two communities had median household incomes of more than $50,000 over the period 2005–2009 (Kodiak, $57,930, and Larsen Bay, $54,375), while two communities had median household incomes of less than $10,000. Two communities in the borough had per capita incomes higher than the borough community average over the period 2005–2009 ($26,862), while five communities had per capita incomes less than the borough average over the same period, and per capita incomes in one community stood at less than half the borough average.

The percentage of individuals living in poverty was higher than the borough average in six communities, with a high number of individuals in two communities (Karluk, 71.7%; Old Harbor, 39.9%). Two communities in the borough, Karluk (100%) and Akhiok (90.1%), had a high percentage of American Indian or Alaska Natives, with higher than average percentages in four other communities.

TABLE 3.10.2-1 South Central Alaska Region Community Population, Income, and Poverty Status (2005–2009 Average)

Community	Total Residents	Median Household Income (2009 $)	Per Capita Income (2009 $)	Percent of Individuals Living in Poverty	Percent American Indian/ Alaska Native
State of Alaska	683,142	64,635	29,382	9.6	13.5
Anchorage					
Anchorage	280,389	70,151	33,436	7.8	5.6
Kenai Peninsula Borough	53,052	55,966	26,940	9.7	6.9
Anchor Point	1,743	50,710	25,615	7.0	2.5
Clam Gulch	104	32,639	25,075	45.1	0.0
Cohoe	808	52,125	29,090	9.3	5.3
Fox River	559	51,750	12,735	18.6	0.0
Fritz Creek	1,865	44,773	20,694	7.9	1.9
Halibut Cove	60[a]	127,010[a]	89,895[a]	0.0[a]	0.0[a]
Happy Valley	498	51,875	25,191	16.4	2.2
Homer	5,667	54,730	30,317	8.2	3.0
Kalifornsky	7,020	66,652	29,789	11.3	8.5
Kasilof	370	77,188	36,044	7.0	5.4
Kenai	7,661	51,875	27,597	8.1	4.5
Nanwalek	179	29,306	7,731	29.1	97.2
Nikiski	4,683	70,000	25,713	14.8	8.7
Nikolaevsk	332	44,333	17,797	9.0	5.1
Ninilchik	490	42,917	26,121	12.0	5.9
Port Graham	153	26,875	11,939	40.5	82.4
Salamatof	969	72,958	19,158	8.1	12.4
Seldovia City	326	51,111	28,378	7.7	17.5
Seldovia Village	109	50,417	20,939	12.8	32.2
Seward	3,083	44,457	18,189	13.5	17.6
Soldotna	4,266	47,031	26,686	9.1	9.1
Tyonek	164	22,813	14,149	28.7	100.0
Kodiak Island Borough	13,147	59,655	26,862	10.6	15.4
Akhiok	101	9,107	10,556	23.8	90.1
Karluk	53	6,250	7,502	71.7	100.0
Kodiak	6,291	57,930	24,058	10.8	10.9
Larsen Bay	79	54,375	43,038	1.3	69.6
Old Harbor	233	22,813	10,910	39.9	68.7
Ouzinkie	214	48,333	23,698	13.1	50.5
Port Lions	153	38,750	29,271	6.5	79.1
Matanuska-Susitna Borough	82,099	66,052	24,906	10.3	4.0
Houston	1,628	43,750	20,957	15.0	1.7
Palmer	7,696	60,000	21,105	14.4	7.8
Wasilla	9,616	53,977	24,221	14.2	3.4

[a] 2000 data.

Source: USCB 2011e.

Population in the Matanuska-Susitna Borough is dispersed among a large number of small, unincorporated communities. The largest incorporated community, Wasilla, had 9,616 residents between 2005 and 2009, and Palmer had 7,696 residents. The population in these communities constituted 21% of the population of the borough. Two communities had median household incomes of more than $50,000 over the period 2005–2009 (Palmer, $60,000; Wasilla, $53,977).

The percentage of individuals living in poverty was slightly higher than the borough average in each incorporated community. Palmer (7.8%) had a higher than average percentage of American Indian or Alaska Natives.

3.10.2.2 Alaska – Arctic

Population in the North Slope Borough is concentrated in Barrow, with 4,078 residents between 2005 and 2009 constituting 61% the population of the borough (Table 3.10.2-2). Two communities had median household incomes of more than $70,000 over the period 2005–2009 (Nuiqsut, $85,156; Point Hope, $73,438), while two communities had median household incomes of less than $50,000. One community in the borough had per capita incomes higher than the borough average over the period 2005–2009 ($24,125), while five communities had per capita incomes less than the borough average over the same period. In the Northwest Arctic Borough, population is concentrated in Kotzebue, with 3,152 residents between 2005 and 2009, constituting 42% of the Borough population. Three communities had median household incomes of more than $60,000 over the period 2005–2009 (Kobuk, $88,333; Kotzebue, $69,306; and Noatak, $63,125), while one community (Deering, $21,653) had a median household income of less than $30,000. One community in the borough had per capita incomes higher than the borough average over the period 2005–2009 ($20,001), while ten communities had per capita incomes less than the borough average over the same period.

The percentage of individuals living in poverty in the North Slope Borough was higher than the borough average in two communities. All but one of communities in the borough had a high percentage of American Indian or Alaska Natives, with a lower than average percentage in Barrow. In the Northwest Arctic Borough, the percentage of individuals living in poverty was higher than the borough average in six communities. All but three of communities in the borough had a high percentage of American Indian or Alaska Natives.

3.10.3 Employment, Unemployment, and Earnings

3.10.3.1 Gulf of Mexico

Employment in the GOM coast region in 2009 was concentrated in Florida (4.5 million employed in 2009) and Texas (3.6 million); together these States provide more than 81% of employment in the region (10.1 million) (Table 3.10.3-1). Unemployment rates for 2009 vary across the GOM coast region; the highest rates were 10.3% in Alabama and Florida, with rates

TABLE 3.10.2-2 Arctic Region Community Population, Income, and Poverty Status (2005–2009 Average)

Community	Total Residents	Median Household Income ($)	Per Capita Income ($)	Percent of Individuals Living in Poverty	Percent American Indian/Alaska Native
State of Alaska	683,142	64,635	29,382	9.6	13.5
North Slope Borough	6,716	66,556	24,125	14.8	67.5
Barrow	4,078	67,411	27,786	17.9	54.9
Kaktovik	260	44,375	19,022	10.4	87.3
Nuiqsut	366	85,156	17,849	0.6	94.3
Point Hope	875	73,438	18,825	8.0	80.7
Point Lay	194	46,875	14,067	16.8	99.0
Wainwright	534	68,750	20,063	12.7	94.2
Northwest Arctic Borough	7,430	57,885	20,001	19.2	80.6
Ambler	279	41,406	14,741	40.5	82.4
Buckland	491	44,688	10,478	19.4	98.4
Deering	78	21,563	14,565	10.3	75.6
Kiana	344	35,000	15,581	32.3	92.2
Kivalina	446	59,821	13,727	12.3	96.7
Kobuk	90	88,333	16,130	16.7	82.2
Kotzbue	3,152	69,306	22,535	15.5	70.8
Noatak	506	63,125	15,365	9.3	78.7
Noorvik	676	46,042	13,766	22.1	90.7
Selawik	801	36,563	10,633	33.0	91.3
Shungnak	303	36,875	9,090	26.1	98.7

Source: USCB 2011e.

between 8.1% and 8.2% in Texas and Mississippi, and a lower rate of 6.5% in Louisiana. The average for the region as a whole was 8.9%.

The distribution of earnings in the GOM coast region reflects the concentration of employment across the five States, the $433.1 billion in combined compensation in Florida ($218.6 billion) and Texas ($214.5 billion) representing more than 80% of earnings in the region as a whole in 2009 ($537.7 billion).

3.10.3.2 Alaska – Cook Inlet

Employment in the south central Alaska region in 2009 was concentrated in Anchorage (144,403 employed in 2009), which provides almost 83% of employment in the region (188,218) (Table 3.10.3-2). Unemployment rates for 2009 vary across the south central Alaska region; the

TABLE 3.10.3-1 Gulf of Mexico Coastal Region Labor Force, Unemployment, Earnings, and Employment Composition

Employment	Alabama	Florida	Louisiana	Mississippi	Texas	Total
Labor Force (2009)						
Total	283,507	5,073,188	1,554,441	210,766	3,964,812	11,086,714
Employed	254,298	4,553,309	1,453,757	193,507	3,644,160	10,099,031
Unemployment rate	10.3%	10.3%	6.5%	8.2%	8.1%	8.9%
Earnings ($billion)	12.2	218.6	82.1	10.2	214.5	537.7
Employment by Industrial Sector (2008)						
Farm employment[a]	6,875	79,691	31,553	6,085	86,928	211,132
Non-farm proprietors	75,417	1,306,323	395,915	47,781	1,019,572	2,845,008
Forestry and fishing	1,936	26,788	11,600	2,326	18,126	60,777
Mining	1,483	8,609	54,474	1,577	142,824	209,267
Utilities	1,633	14,275	5,954	1,809	22,060	45,731
Construction	32,661	395,711	165,576	23,982	398,417	1,016,348
Manufacturing	26,469	195,115	121,830	24,228	329,400	697,042
Wholesale and retail trade	55,713	864,588	268,537	30,277	668,588	1,887,704
Transportation and warehousing	12,958	189,625	81,448	6,093	200,447	490,571
Finance, insurance, and real estate	31,960	644,080	151,177	15,803	403,318	1,246,339
Services	145,577	2,631,238	818,446	93,704	1,933,388	5,622,353
Federal civilian government	3,054	75,075	22,278	9,515	46,285	156,207
Federal military government	3,935	63,428	26,600	13,196	26,275	133,434
State and local government	39,067	595,626	241,896	30,478	493,954	1,401,021

[a] Farm employment includes farm proprietors and agricultural services employment.

Sources: USDOL 2011; USDOC 2011a,b.

highest rate was 10.1% in Anchorage, with rates between 6.6% and 7.3% in Anchorage and Kodiak Island. The average for the region as a whole was 7.2%.

The distribution of earnings in the south central Alaska region reflects the concentration of employment across the four boroughs, the $11.2 billion in compensation in Anchorage representing almost 82% of earnings in the region as a whole in 2009 ($13.6 billion).

Personal incomes in Alaskan Native villages are lower than in the State as a whole, and unemployment, especially in smaller villages, is high, particularly during the winter when there is little alternate market-based activity. Because of the key role of subsistence in many village economies, economic data that is collected for these communities may not fully represent their economic well-being. For example, many transactions between individuals involving the exchange of subsistence products that would otherwise provide income if they took place in the marketplace are not reflected in personal income statistics. Similarly, unemployment data may not reflect the extent to which additional economic activity may be required if subsistence activities provide a sufficient alternative to participation in the marketplace. In addition, the

TABLE 3.10.3-2 South Central Alaska Region Labor Force, Unemployment, Earnings, and Employment Composition

Employment	Anchorage	Kenai Peninsula	Kodiak Island	Matanuska-Susitna	South Central Alaska Region Total
Labor Force (2009)					
Total	154,562	27,045	6,611	42,425	230,643
Employed	144,303	24,326	6,127	38,497	213,253
Unemployment rate	6.6	10.1	7.3	9.3	8.3
Earnings ($b)	11.2	1.0	0.4	1.0	13.6
Employment by Industrial Sector, 2008					
Farm employment[a]	0	225	0	574	799
Non-farm proprietors	37,222	11,742	2,613	12,001	63,578
Forestry and fishing	1,232	2,095	976	832	5,135
Mining	3,811	1,489	24	345	5,669
Utilities	557	263	42	143	1,006
Construction	12,393	2,366	349	3,630	18,738
Manufacturing	2,750	1,035	1,616	658	6,059
Wholesale and retail trade	26,606	3,610	885	5,291	36,392
Transportation and warehousing	12,404	1,233	316	1,360	15,313
Finance, insurance & real estate	15,768	2,139	329	2,484	20,720
Services	85,191	11,782	2,869	13,653	113,496
Federal civilian government	9,464	405	345	207	10,421
Federal military government	13,425	462	1,049	595	15,531
State and local government	20,302	4,655	1,108	3,630	29,695

[a] Farm employment includes farm proprietors and agricultural services employment.

Sources: USDOL 2011; USDOC 2011a, b.

large differences in prices between urban and rural Alaska may exaggerate the corresponding differences in economic well-being depending on the extent to which local community members in rural areas have to participate in the local market economy for key consumer items, such as food, clothing, and energy, and the extent to which these items can be obtained through participation in subsistence activities.

A significant portion of income for lower-income Alaskans is the Alaska Permanent Fund Dividend, an annual per capita payment from a savings account established in 1976 using a portion of royalties paid to the State from oil production on State land. Although the fund principal is constitutionally protected from being spent, the majority of the earnings from the fund are distributed to every State resident as an annual cash payment. Dividends were first paid in 1982, and the annual payment has become a growing portion of per capita personal income in the State (USDOI 2002).

3.10.3.3 Alaska – Arctic

Employment by place of residence in the North Slope Borough in 2009 was 5,140 (Table 3.10.3-3); in the Northwest Arctic Borough employment stood at 2,623 (Table 3.10.3-3). The unemployment rate for the North Slope Borough 2009 was 4.7%, and earnings were $1.4 billion; the unemployment rate for the Northwest Arctic Borough in 2009 was 12.0%, and earnings were $0.2 billion.

Personal incomes in Alaskan Native villages are lower than in the State as a whole, and unemployment, especially in smaller villages, is high, particularly during the winter when there is little alternate market-based activity (see Section 3.10.3.2). A significant portion of income for many Alaskans is the Alaska Permanent Fund Dividend, an annual per capita payment from a savings account established in 1976 using a portion of royalties paid to the State from oil production on State land (see Section 3.10.3.2).

3.10.4 Employment by Industry

3.10.4.1 Gulf of Mexico

The largest employing sectors in the GOM coast region in 2008 were services (43.1% of total employment), retail and wholesale trade (14.5%), and State and local government (10.7%) (Table 3.10.3-1). The share of total State employment in services — wholesale and retail trade and finance and insurance and real estate — was slightly higher than the GOM coast average in Florida, and the share of employment in State and local government was slightly higher in Louisiana and Mississippi.

In addition to sectoral employment distributions, counties on the GOM coast can be classified into economic types indicating primary land use patterns. Using this approach, only 5 of the 129 counties in the GOM coast region are classified as farming-dependent; 9 counties are defined as mining-dependent, suggesting the importance of oil and gas development to these local economies (MMS 2005b). Manufacturing dependence is noted for another 27 of the counties. Local school districts and public facilities, such as hospitals and prisons, are often the largest employers in sparsely populated rural areas; 16 rural counties and 14 metropolitan counties are classified as government employment centers. Another 21 counties have economies tied to service employment. Thirty-nine of the 132 counties are considered major retirement destinations, and 7 of the rural counties are classified as recreation-dependent.

3.10.4.2 Alaska – Cook Inlet

The largest employing sectors in the south central Alaska region in 2008 were services (41.0% of total employment), with retail and wholesale trade at 13.1% and State and local government at 10.7% (Table 3.10.3-2). Of the share of total State employment in services, wholesale and retail trade was slightly higher than the south central Alaska region average in

TABLE 3.10.3-3 Arctic Region Labor Force, Unemployment, Earnings, and Employment Composition

Employment	North Slope Borough	Northwest Arctic Borough	Arctic Region Total
Labor Force (2009)			
Total	5,394	2,980	8,374
Employed	5,140	2,623	7,763
Unemployment rate	4.7	12.0	7.3
Earnings ($b)	1.4	0.2	1.6
Employment by Industrial Sector, 2008[a]			
Farm employment[b]	0	0	0
Forestry and fishing	25	68	93
Mining	8,342	135	8,477
Utilities	61	15	76
Construction	272	201	473
Manufacturing	12	10	22
Wholesale and retail trade	498	241	740
Transportation and warehousing	207	197	404
Finance, insurance and real estate	890	217	1,107
Services	5,043	983	6,025
Federal civilian government	24	47	71
Federal military government	46	52	98
State and local government	1,757	1,102	2,859

[a] As labor force data is by place of residence, and employment by sector is by place of work, not all individuals working in the North Slope Borough are included in the labor force statistics, with many employees commuting to the Borough from other parts of Alaska and the United States.

[b] Farm employment includes farm proprietors and agricultural services employment.

Sources: USDOL 2011; USDOC 2011a, b.

Anchorage, and the share of employment in State and local government was slightly higher in the Kenai Peninsula Borough and in the Kodiak Island Borough. Employment in manufacturing and military employment was more important in the Kodiak Island Borough than elsewhere in the region.

3.10.4.3 Alaska – Arctic

The largest employing sectors by place of work in the Arctic region in 2008 were mining (including oil and gas) with 8,477 people employed (49.3% of total employment), services with 6,025 employees (35.0%), and State and local government with 2,859 employees (16.6%) (Table 3.10.3-3). Between 2001 and 2007, approximately 70% of North Slope workers in the oil and gas industry in 2001 and 2006 commuted to and from permanent residences elsewhere in Alaska, primarily in south central Alaska and Fairbanks (MMS 2008b).

The North Slope Borough itself is the largest employer of the resident workforce through government positions, primarily in Barrow; Borough-provided services; and Capital Improvement Program construction projects (MMS 2006b). The regional and village corporations established by the ANCSA also provide local employment.

3.10.5 Oil and Gas Employment

3.10.5.1 Gulf of Mexico

Oil and gas employment in the GOM coast States is concentrated in Texas, with 1,639 establishments employing roughly 38,549 people in 2008, representing nearly 62% of oil and gas industry employment in the GOM States (62,314) (USCB 2011f). Louisiana is second most important State, with 767 establishments employing 23,061 people. The Houston LMA had the largest oil and gas sector employment in the GOM coast in 2004, with 564 establishments employing roughly 11,882 people, followed by the New Orleans LMA, where 70 establishments employed 3,578 people (MMS 2006b).

3.10.5.2 Alaska – Cook Inlet

Oil and gas employment in the south central region in 2007 stood at 8,636, with 3,418 employed directly in oil and gas extraction activities, pipeline and refinery activities, and 5,218 in support activities (AOGA 2011). Oil and gas employment was concentrated in Anchorage, where there were 5,192 total employees, with 1,649 direct and 3,543 support workers. Kenai Peninsula (2,213) and Matanuska-Susitna (1,231) supported lower levels of oil and gas employment.

3.10.5.3 Alaska – Arctic

Large numbers of Arctic region oil and gas workers reside in other parts of Alaska and the U.S., relocating temporarily to work locations in the Arctic region as required. Employment statistics are typically presented by place of residence, meaning that oil and gas employment for the Arctic region on this basis would be relatively small. Employment by place of work data show that there were 7,540 oil and gas workers in the Arctic region in 2007, all of whom were located in the North Slope Borough (AOGA 2011). Of these workers, 1,741 were employed directly in oil and gas extraction activities, pipeline and refinery activities, and 5,799 in support activities.

3.10.6 Population, Labor Force, and Income Projections

3.10.6.1 Gulf of Mexico

Projections of demographic and economic data assume the continuation of existing social, economic, and technological trends at the time of the forecast, including employment associated with the continuation of current OCS leasing activity, as well as the continuation of trends in other industries important to the region. Projections in this section are based on growth rates provided in MMS (2006b) and the most recent population employment and earnings data.

The GOM coast region is projected to experience average annual increases in population of 1.3% between 2010 and 2020, with slightly lower average annual rate of 1.2% over the period 2020 to 2030 (Table 3.10.6-1). Differences in age structure, as well as net migration, among the coastal commuting zone areas could create variations in population growth within the GOM coast region. Southern Florida and western Texas areas are projected to have the highest growth rates, exceeding those expected for Louisiana and Mississippi.

Average annual growth in employment of 1.5% between 2010 and 2030 is primarily driven by growth in services, and while the farming labor force is not expected to experience a high growth rate over the period, related activities in agricultural services are projected to realize rapid growth rates over the 25-yr period (MMS 2006b).

Earnings in the GOM coast region (in 2009 dollars) are projected to grow at an average annual rate of 2.4% between 2005 and 2025, and 2.5% between 2025 and 2030. Earnings in services are projected to increase rapidly during this period, contributing more to this increase than any other industry. In other industries, such as manufacturing, rapid growth in projected average wages compensate for moderate employment growth, making these industries strong contributors to overall regional income (MMS 2006b).

3.10.6.2 Alaska – Cook Inlet

Projections of demographic and economic data assume the continuation of existing social, economic, and technological trends at the time of the forecast, including employment associated with the continuation of current OCS leasing activity, as well as the continuation of trends in other industries important to the region. Projections in this section are based on population forecasts provided by the State of Alaska (Alaska Department of Labor and Workforce Development 2007) and employment and earnings data for 2009.

The south central Alaska region is projected to experience average annual increases in population of 1.27% between 2010 and 2020, with a slightly lower average annual rate of 1.07% over the period 2020 to 2030 (Table 3.10.6-2). Differences in age structure, as well as net migration, could create variations in population growth within the south central Alaska region. Between 2010 and 2020, Matanuska-Susitna (2.83%) and Anchorage (0.94%) are projected to have higher growth rates in the region, with lower rates in the Kenai Peninsula (0.77%). Rates in

TABLE 3.10.6-1 Gulf of Mexico Coastal Region Projections

Regional Characteristics	2010	2015	2020	2025	2030
Population	23,478,203	25,067,221	26,702,229	28,398,512	30,19 5,698
Employment	10,253,294	11,049,871	11,907,349	12,835,229	13,842,305
Earnings ($billion 2009)	550.8	620.9	700.0	789.7	891.7

Sources: MMS 2005b, 2006b.

TABLE 3.10.6-2 South Central Alaska Region Projections

Regional Characteristics	2010	2015	2020	2025	2030
Population	444,735	473,994	504,529	534,084	561,076
Employment	214,416	228,115	242,476	256,434	269,103
Earnings ($billion 2009)	13.8	14.5	15.3	16.1	16.7

Sources: MMS 2006b; Department of Labor and Workforce Development 2007.

Kodiak Island are expected to decline, by 0.32% between 2010 and 2020 and by 0.63% between 2020 and 2030.

Based on unemployment and labor force participation rates from 2009, employment in the south central Alaska region is expected to grow from 214,416 in 2010 to 269,103 in 2030, with the majority of employment growth occurring in Anchorage during this period. Growth rates over the 25-yr period will be driven primarily by growth in mining (including oil and gas), fisheries, and services (MMS 2006b). Earnings in the south central Alaska region (in 2009 dollars) are projected to grow from $13.8 billion in 2010 to $16.7 billion in 2030, with earnings growth concentrated in Anchorage.

3.10.6.3 Alaska – Arctic

Projections of demographic and economic data assume the continuation of existing social, economic, and technological trends at the time of the forecast, including employment associated with the continuation of current OCS leasing activity, as well as the continuation of trends in other industries important to the region. Projections in this section are based on population forecasts provided by the State of Alaska (Alaska Department of Labor and Workforce Development 2007) and employment and earnings data for 2009.

The Arctic region is projected to experience average annual increases in population of 1.08% between 2010 and 2020, with a slightly lower average annual rates of 0.95% over the period 2020 to 2030 (Table 3.10.6-3). Differences in age structure, as well as net migration, could create variations in population growth within the Arctic region.

Based on unemployment and labor force participation rates from 2009, employment in the Arctic region is expected to grow from 5,550 in 2010 to 10,091 in 2030. Growth rates over the 25-yr period are driven primarily by growth in mining (including oil and gas), fisheries, and services (MMS 2006b). Earnings in the Arctic region (in 2009 dollars) are projected to grow from $1.7 billion in 2010 to $2.1 billion in 2030.

3.10.7 Economic Impacts of the Deepwater Horizon Event

The DWH event has produced significant economic impacts throughout the GOM region, affecting population, employment, and regional earnings and incomes. Impacts coming as a result of lost production will have indirect impacts in the various industries serving oil and gas production and providing retail and other services to oil and gas workers. The 6-month moratorium imposed in May 2010 on all deepwater drilling projects is projected to reduce GOM production by roughly 31,000 bbl per day in the fourth quarter of 2010 and 82,000 bbl per day in 2011 (EIA 2010b), and could lead to the loss of 8,200 jobs in oil and gas and associated sectors in the GOM coast region, $487 million in lost wages, and $98 million in State and local tax revenues (Mason 2011). Short-term losses to the tourism and recreation industry are also expected (see Section 3.13.6).

The relative decline in the housing market in the GOM coastal States, in part a result of the 2008 U.S. housing crisis, may have been further compounded by the event, although the impact of the event is still being investigated. In some coastal communities in Louisiana, for example, stigmatization and uncertainty surrounding coastal housing markets as a result of the spill may have contributed to a reported 5–15% decrease in housing value in Louisiana in 2010, with losses of 14% reported for 2011 (Housing Predictor 2012). Immediately after the event, losses of at least 35% were projected for Louisiana and Mississippi (Housing Predictor 2010). The loss of beach amenities associated with the event could result in property value loss of between $648 and $3 billion in Florida, Alabama, and Mississippi (CoreLogic 2010). In addition, jurisdictions in coastal communities may have experienced a decline in property taxes

TABLE 3.10.6-3 Arctic Region Projections

Regional Characteristics	2010	2015	2020	2025	2030
Population	15,002	15,887	16,699	17,449	18,348
Employment	8,267	8,755	9,194	9,597	10,091
Earnings ($billion 2009)	1.7	1.8	1.9	2.0	2.1

Sources: MMS 2006b; Alaska Department of Labor and Workforce Development 2007.

as a result of the spill, in addition to the negative impact of the housing market crisis on property taxes in these areas, which could mean a reduction in services or a necessary increase in revenue to maintain current levels of public service provision. States that are more dependent on sales taxes from tourist activity (e.g., Florida) may experience more of an impact than other States.

The long-term economic and financial impact in the GOM coast States may be offset to some extent by the short-term economic boom associated with oil spill cleanup efforts. In some communities, cleanup crews have replaced oil field workers and fishermen in some hotels and restaurants, and some fishermen have used their boats to assist cleanup activities. Companies that specialize in booms, chemical dispersant, hazardous materials training, and other spill-related services have experienced a significant boom in business. In communities where cleanup operations are based, such as Louisiana’s Plaquemines Parish, State revenue increased by 80% as rental properties, hotels, restaurants, and other facilities were besieged by cleanup personnel (Associated Press 2010). For the 20,000 workers hired by BP in response to the oil spill, many have taken up staging areas along the coast in Florida, Alabama, Mississippi, and Louisiana (Seaford 2011).

Timely payment of damage claims may also mitigate some of the impacts in smaller fishing communities where property damage has occurred. To assist those affected by the event, BP established a $20 billion compensation fund, and by September 2010, the fund had already paid more than $240 million to 19,000 claimants (Kollewe 2010).

The full extent, magnitude, and duration of spill-related socioeconomic impacts on the GOM will continue to be evaluated. BOEM will continue to update baseline population, employment, and regional income numbers in future documents as new information becomes available from Woods & Poole Economics, Inc., the U.S. Department of Labor’s Bureau of Labor Statistics, individual State data, and published reports. This information, however, is not needed at the programmatic stage to make a reasoned choice among alternatives (see Section 1.4, Analytical Issues).

3.11 LAND USE AND INFRASTRUCTURE

3.11.1 Gulf of Mexico

There are five coastal States within the GOM region containing approximately 2,600 km (1,600 mi) of coastline. Land use is a heterogeneous mix of urban areas; manufacturing, marine, shipping, agricultural, and oil and gas activities; recreational areas; and tourist attractions. There are numerous urban areas in the region, and a complexity of land uses associated with urbanization can be found there. The area is composed of 67 metropolitan and 65 rural counties. The GOM coastal region contains one of the United States’ ten most populous cities (Houston) (as of 2010; Mackum and Wilson 2011), approximately16% of the nation’s coastal population (as of 2008; Wilson and Fischetti 2010), and 12 of the nation’s 20 largest ports (USACE 2010).

The GOM region contains a mix of bays, estuaries, wetlands, barrier islands, and beaches of great environmental and economic value. Some of these areas support fishing, shrimping, and related economic activities, and although accessibility is sometimes limited, many of these areas are very popular for recreation and tourism. Along the GOM coast are numerous State Parks and beaches as well as units of both the NPS and the USFWS. For a listing and discussion of many of these areas, see Section 3.9 (Areas of Special Concern). Notable features in the area include Padre Island National Seashore, the Atchafalaya Basin, the Mississippi Delta, Mobile Bay, and Everglades National Park.

All of the States in the GOM region participate in the National Coastal Zone Management (CZM) Program and have taken various approaches to managing their coastal lands. The National CZM Program is a voluntary partnership between the Federal Government and U.S. coastal and Great Lakes States and territories (States) authorized by the Coastal Zone Management Act of 1972 (CZMA) to address national coastal issues. Key elements of the National CZM Program include the following:

- Protecting natural resources;
- Managing development in high hazard areas;
- Giving development priority to coastal-dependent uses;
- Providing public access for recreation; and
- Coordinating State and Federal actions.

The coastal area of the States in the GOM region is very diverse. Military facilities and training areas in this region are discussed in Section 3.9.2.3. Areas of Special Concern, including the National Marine Sanctuaries, National Parks, National Wildlife Refuges, and National Marine Protected Areas, are discussed in Section 3.9. The States along the GOM coast have authority over submerged lands out to approximately 5.6 km (3 NM [3.5 statute mi]) with the exception of Texas and Florida, which have jurisdiction out to approximately 14.5 km (3 leagues [9 statute mi]).

The U.S. Department of Agriculture's Economic Research Service (ERS) classifies nonmetropolitan counties into economic types that indicate primary land use patterns (ERS 2011). Land use patterns for counties near the GOM (as of 2004, the latest year for which figures are available) are shown in Figure 3.11.1-1. Five of the 90 nonmetropolitan counties are classified by ERS as farming-dependent. Eight counties are defined as mining-dependent, suggesting the importance of oil and gas activities to these local economies. Manufacturing dependence is noted for another 25 of the nonmetropolitan counties; while 30 of the 90 nonmetropolitan counties are classified by ERS as government employment centers, and 18 of the nonmetropolitan counties have economies tied to service employment. The ERS also classifies counties in terms of their status as a retirement destination. Thirty-eight of the 90 nonmetropolitan counties are considered major retirement destinations by ERS. Of these,

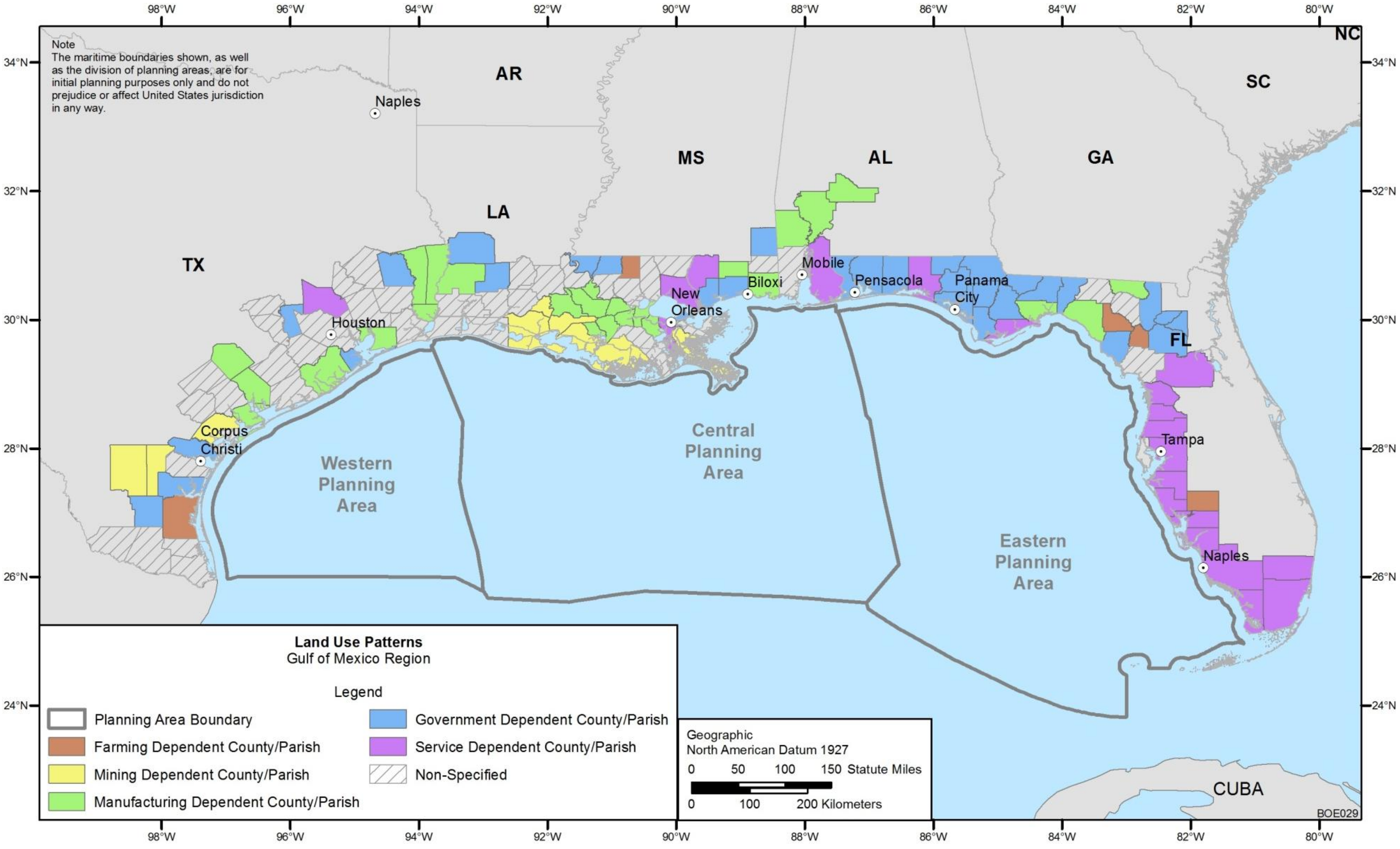


FIGURE 3.11.1-1 Land Use Patterns for Coastal Counties in the GOM Region

ten are inshore of the Eastern GOM Planning Area where little offshore development has taken place (see Figure 3.11.1-2).

Oil and gas development and production play an important role in determining land uses in many communities surrounding the GOM. These are the 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 OCS in the GOM originate (Louis Berger Group, Inc. 2004). The use of these facilities and trends in new facility development closely follow the level of activity in offshore drilling, with increased deepwater drilling having provided an important stimulus for increased facility use and development in recent decades. Because of the large size of the structures involved, construction and servicing of remote deepwater facilities require deeper ports than nearshore operations. There are several ports with deepwater access along the GOM coast, with deepwater development activities occurring around these ports. With the expansion of deepwater activities, some onshore facilities have migrated to these ports and nearby areas that have capabilities for handling deepwater vessels, which require more draft (see Figure 3.11.1-3). As previously indicated, the GOM contains 12 of the nation’s 20 largest ports (USACE 2010).

The western and central portions of the GOM region (offshore Texas, Louisiana, Mississippi, and Alabama) are major offshore oil and gas areas, and most of the equipment and facilities supporting offshore GOM oil and gas operations are located in these areas. Only limited offshore activities (i.e., exploratory activities, a single major project) have occurred in the eastern portion of the region, and there is very little infrastructure in place to support exploration and development of offshore oil and gas off the GOM coast of Florida. Current data indicate there are more than 3,900 fixed structures located in the GOM at depths up to 518 m (1,700 ft) (Dismukes 2011).

Oil and gas activities on the OCS are supported by onshore infrastructure industries consisting of thousands of contractors responsible for virtually every facet of the activity, including supply, maintenance, and crew bases. These contractors are hired to service production areas, provide material and manpower support, and repair and maintain facilities along the coasts. Nearly all of these support industries are found near ports.

There are hundreds of onshore facilities in the GOM region that support the offshore industry. Platform fabrication facilities are located along the GOM from the Texas-Mexico border to the Florida Panhandle, and employ large numbers of workers during periods of active development. Shipbuilding and repair facilities are located in key ports along the GOM coast.

Other offshore support industries are responsible for such products and services as engine and turbine construction and repair, electric generators, chains, gears, tools, pumps, compressors, and a variety of other tools. In addition, drilling muds, chemicals, and fluids are produced and transported from onshore support facilities, and these materials and other equipment are stored in warehouses near GOM ports. Many types of transportation vessels and helicopters are used to transport workers and materials to and from OCS platforms. Crew quarters and bases are also near ports, but some helicopter facilities are located farther inland.

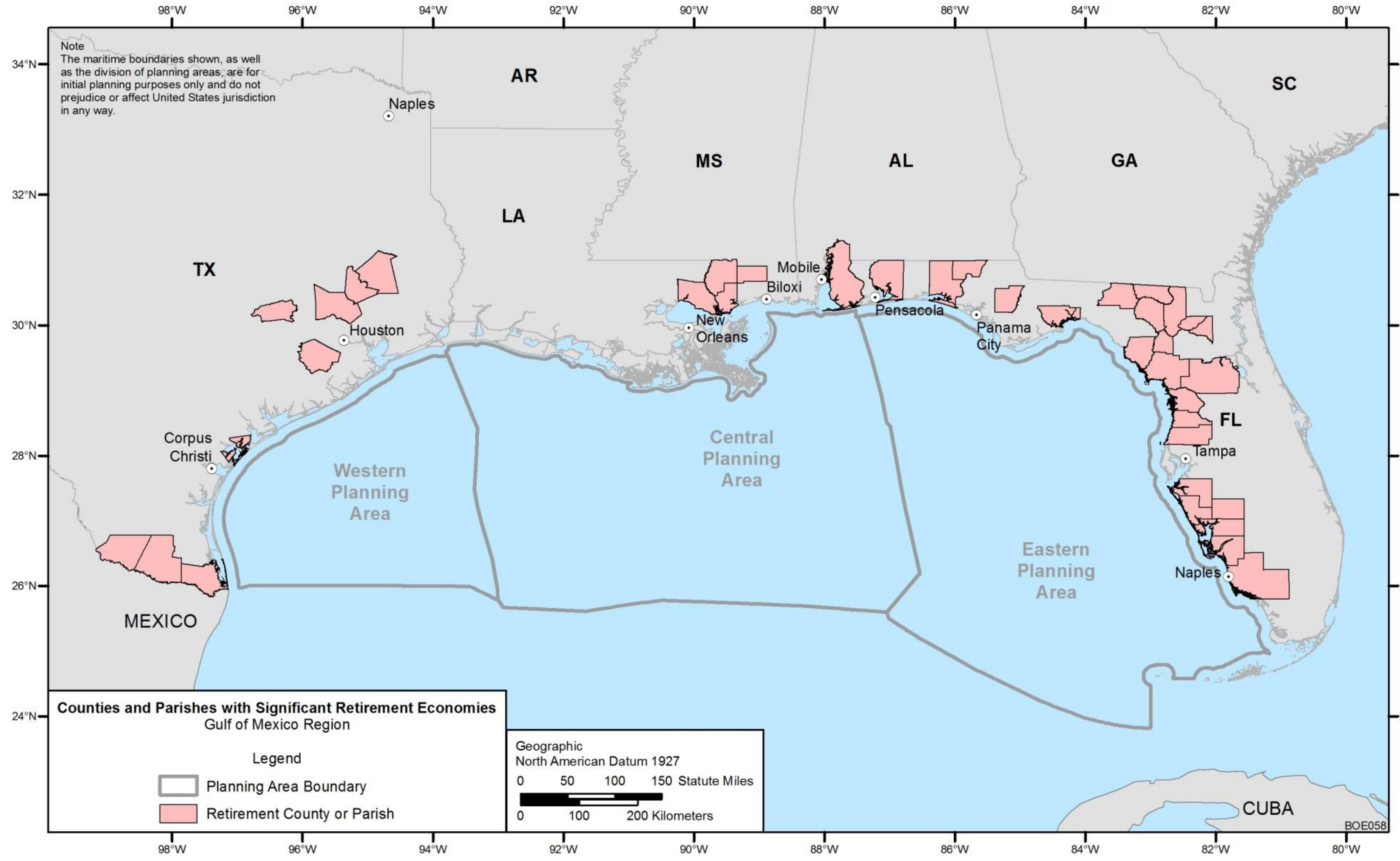


FIGURE 3.11.1-2 Counties with Significant Retirement Economies in the GOM Region

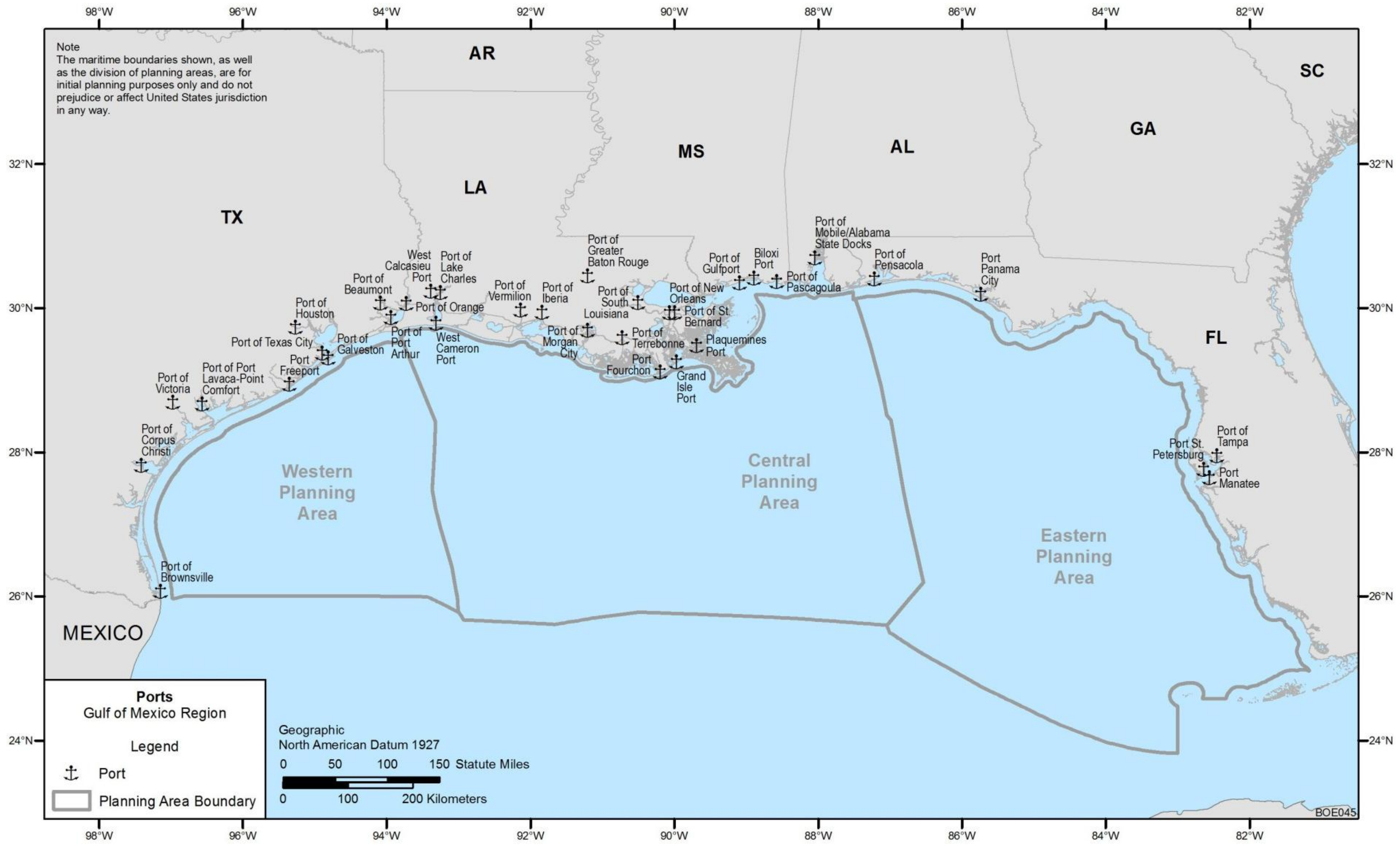


FIGURE 3.11.1-3 GOM Port Facilities

Existing OCS-related infrastructure in the region includes:

- *Port Facilities.* Major maritime staging areas for movement between onshore industries and infrastructure and offshore leases.

- *Platform Fabrication Yards.* Facilities in which platforms are constructed and assembled for transportation to offshore areas. Facilities can also be used for maintenance and storage.

- *Shipyards and Shipbuilding Yards.* Facilities in which ships, drilling platforms, and crew boats are constructed and maintained.

- *Support and Transport Facilities.* Facilities and services that support the offshore activities. This includes repair and maintenance yards, supply bases, crew services, and heliports.

- *Pipelines.* Infrastructure that is used to transport oil and gas from offshore facilities to onshore processing sites and ultimately to end users.

- *Pipe Coating Yards.* Sites that condition and coat pipelines used to transport oil and gas from offshore production locations.

- *Natural Gas Processing Facilities and Storage Facilities.* Sites that process natural gas and separate its component parts for the market, or that store processed natural gas for use during peak periods.

- *Refineries.* Industrial facilities that process crude oil into numerous end-use and intermediate-use products.

- *Petrochemical Plants*. Industrial facilities that intensively use oil and natural gas and their associated byproducts for fuel and feedstock purposes.

- *Waste Management Facilities*. Sites that process drilling and production wastes associated with offshore oil and gas activities (Dismukes 2011).

Figures 3.11.1-4 and 3.11.1-5 show key onshore infrastructure including ports, supply bases, shipyards, platform fabrication yards, pipe yards, oil refineries, gas processing facilities, helicopter pads, pipelines, and other infrastructure.

A short description of each type of infrastructure facility can be found below. Unless otherwise indicated, the following information is from the MMS study, *Deepwater Program: OCS-Related Infrastructure in the Gulf of Mexico Fact Book* (Louis Berger Group, Inc. 2004) and its update, *Infrastructure Fact Book, Volume I: OCS-Related Energy Infrastructure and Post-Hurricane Impact Assessment* (Dismukes 2011); more detailed information can be found in these two reports.

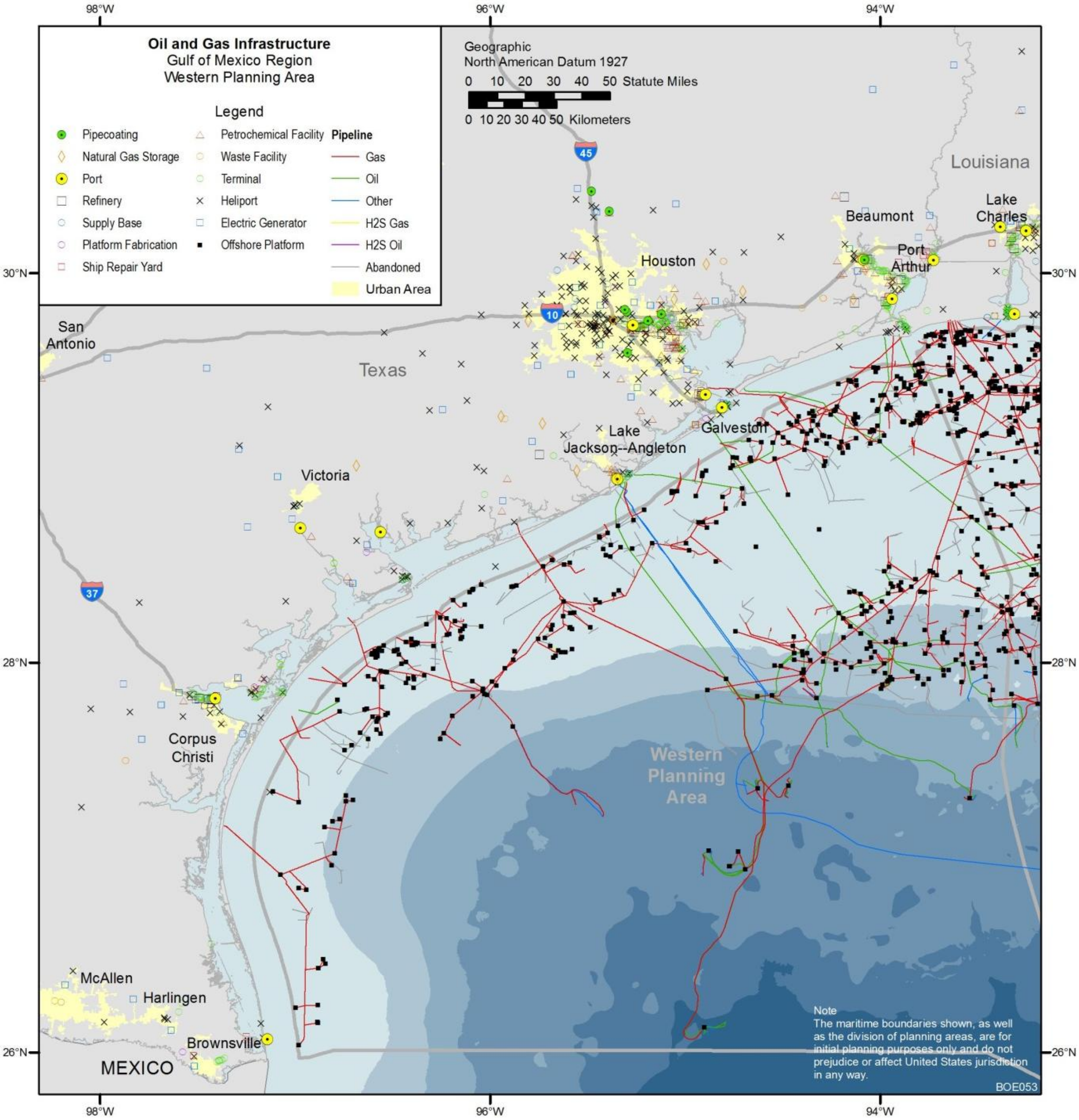
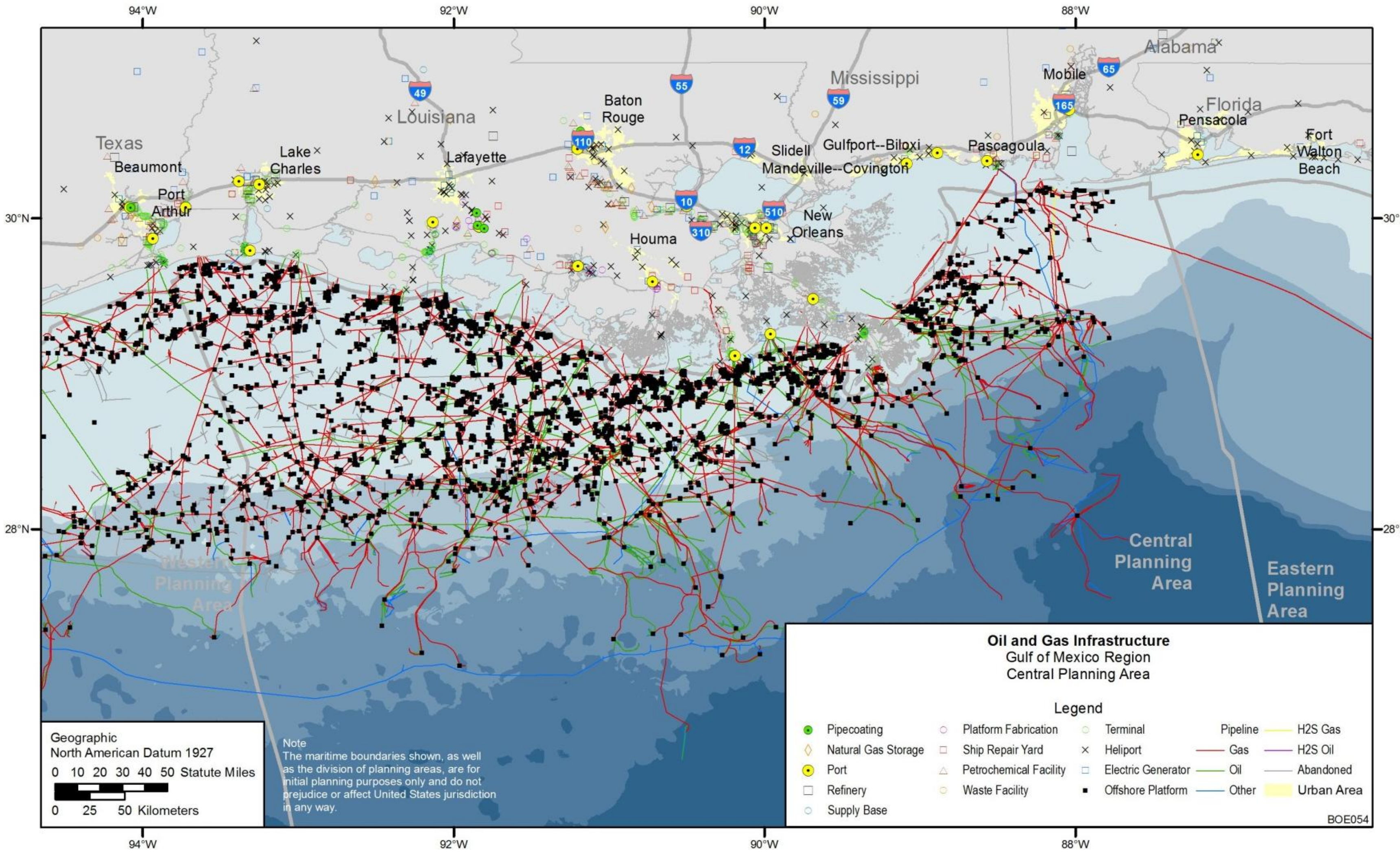


FIGURE 3.11.1-4 Oil and Gas Infrastructure Locations in the GOM Region Western Planning Area



Note
The maritime boundaries shown, as well as the division of planning areas, are for initial planning purposes only and do not prejudice or affect United States jurisdiction in any way.

FIGURE 3.11.1-5 Oil and Gas Infrastructure Locations in the GOM Region Central Planning Area

3.11.1.1 Ports

States along the GOM provide substantial amounts of support to service the OCS oil and gas industry. Service bases and other industries at many ports offer a variety of services and support activities to assist the industry. Personnel, supplies, and equipment must come from the land-based support industry and pass through a port to reach drilling sites. In addition to servicing the offshore oil and gas industry, a number of GOM ports also are commercial ports, such as those in: Mobile, Alabama; Pascagoula, Mississippi; Lake Charles, Morgan City, Plaquemines and Venice, Louisiana; and Corpus Christi, Freeport, Galveston, and Port Arthur, Texas. Other ports include a combination of local recreation and offshore service activity.

GOM ports include a wide variety of shore-side operations from intermodal transfer to manufacturing. The ports vary widely in size, ownership, and functional characteristics. Private ports operate as dedicated terminals to support the operation of an individual company. They often integrate both fabrication and offshore transport into their activities. Public ports lease space to individual business ventures and derive benefit through leases, fees charged, and jobs created. GOM ports, including deepwater ports, are shown in Figures 3.11.1-3.

3.11.1.2 Platform Fabrication Yards

Offshore drilling and production platforms are fabricated onshore at platform-fabrication yards and then towed to an offshore location for installation. Production operations at fabrication yards include cutting and welding of steel components, construction of living quarters and other structures, and assembly of platform components. According to the Atlantic Communications 2006 Gulf Coast Oil Directory, there are more than 80 platform fabrication yards located in the GOM region, with the concentration in Louisiana and Texas (as cited in Dismukes 2011). The distribution of fabrication yards within the region is shown in Figures 3.11.1-4 and 3.11.1-5.

Because platform fabrication yards must be located on navigable channels large enough to allow for towing of bulky and long structures such as offshore drilling and production platforms, most fabrication yards in the region are located along the Intracoastal Waterway and within easy access of the GOM. A number of these plants have deep channel access to their facilities, which allows them to handle the deeper draft vessels used for deepwater operations.

Because of the size of the fabricated product and the need to store a large quantity of materials such as metal pipes and beams, fabrication yards typically occupy large areas, ranging from just a few acres to several hundred acres. Typical fabrication yard equipment include lifts and cranes, various types of welding equipment, rolling mills, and sandblasting machinery. Besides large open spaces required for jacket assembly, fabrication yards also have covered warehouses and shops.

Fabrication yards typically specialize in the production of one type of platform or one type of platform component. Few facilities have complete capabilities for all facets of offshore projects, and yards may cooperate in the development of platforms. Despite the large number of platform fabrication facilities in the GOM region, only a few facilities can handle large-scale fabrication. Recently, in an attempt to diversify their activities, many fabrication yards have expanded their operations into areas such as maintenance and renovations of drilling rigs, fabrication of barges and other marine vessels, drydocking, and surveying of equipment.

3.11.1.3 Shipyards

A 2007 report from USDOT indicated that only 28 private shipyards with major shipbuilding and repair bases were present within the GOM. This figure represented active shipbuilding yards, other shipyards with building positions, repair yards with dry dock facilities, and topside repair yards (USDOT 2007). A private count of shipyards dated August 2011 indicated that there were 80 shipyards[14] located on the GOM coast (MarineLog 2011).

In addition to the major shipyards, there are about 2,600 other companies that build or repair other craft such as tugboats, supply boats, ferries, fishing vessels, barges, and pleasure boats. Major shipyards in the GOM region are located primarily in Texas and Louisiana; however, several are located in Pascagoula, Mississippi, and other locations east of the Mississippi River (USDOT 2004). Recent high demand, driven in part by the expansion of deepwater oil and gas operations, has led to the expansion of capacity by smaller shipyards, which are building more and larger vessels that are technologically more sophisticated. This expansion has been accompanied by development of new pipe and fabrication shops, drydock extensions, military work enhancement programs, automated steel process buildings, and expanded design programs. The distribution of shipyards within the region is shown in Figures 3.11.1-4 and 3.11.1-5.

3.11.1.4 Support and Transport Facilities

A variety of facilities and services support offshore activities by providing supplies, equipment repair and maintenance services, services for crews, and transportation, including boats and heliports. Figures 3.11.1-4 and 3.11.1-5 show the distribution of various support and transport facilities in the GOM region.

The main types of vessels used in the GOM offshore industry include anchor handling towing supply (AHTS), offshore supply vessels (OSVs), and crewboats. There is a large fleet of offshore tugs (AHTS vessels) whose sole job is to tow rigs from one location to another and to position the rig’s anchors. Offshore supply vessels deliver drilling supplies such as liquid mud, dry bulk cement, fuel, drinking water, drill pipe, casing, and a variety of other supplies to drilling rigs and platforms. Crewboats transport personnel to, from, and between offshore rigs and

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[14] Shipyards consist of builders of large oceangoing naval and/or commercial ships; builders of mid-sized oceangoing ships, rigs, oceangoing barges; and builders of small ships, boats, and barges for coastal or inland service. It does not include repairers, builders of aluminum boats, or builders of yachts. The number was determined by hand counting the individual addresses listed for each of the facilities (MarineLog 2011).

platforms. There are a variety of other types of vessels used by the oil and gas industry, and these vessels originate in a variety of locations along the GOM coast at or near ports.

Helicopters are one of the primary modes of transporting personnel between service bases and offshore platforms, drilling rigs, derrick barges, and pipeline construction barges. Helicopters are routinely used for normal crew changes and at other times to transport management and special service personnel to offshore exploration and production sites. In addition, equipment and supplies are sometimes transported. For small parts needed for an emergency repair or for a costly piece of equipment, it is more economical to get it to and from offshore fast rather than by supply boat.

3.11.1.5 Pipelines

Locations where offshore pipelines cross the shoreline to land are referred to as pipeline landfalls. In the GOM region, about 60% of OCS pipelines entering State waters tie into existing pipeline systems and thus do not require pipeline landfalls. Only a small percentage of onshore pipelines in the region are a direct result of oil and gas activities on the OCS. There are more than 100 active OCS pipelines making landfall (about 80% of these are in Louisiana), resulting in about 200 km (124 mi) of pipelines onshore. About 80% of the onshore length of OCS pipelines is in Louisiana, and about 20% are in Texas. The distribution of pipelines by State is shown in Figures 3.11.1-4 and 3.11.1-5.

Inland, the pipeline network in the GOM coast States is extensive. Pipelines transport crude oil and natural gas to processing plants and refineries, natural gas from producing States in the GOM region to users in other States, refined petroleum products such as gasoline and diesel from refineries in the GOM region to markets all over the country, and chemical products.

3.11.1.6 Pipecoating Plants and Yards

Pipecoating plants are facilities where pipe surfaces are coated with metallic, inorganic, and organic materials to protect against corrosion and abrasion. These facilities generally do not manufacture or supply pipe, although some facilities are associated with mills where certain kinds of pipes are manufactured. More typically, the manufactured pipe is shipped by rail or water to pipecoating plants or their pipe yards. The coated pipe is stored at the pipe yard until it is needed offshore. It is then placed on barges or layships where the contractors weld the pipe sections together and clean and coat the newly welded joints. Finally, the pipe is laid.

Pipecoating plants in the GOM region are located primarily in Texas and Louisiana, with a small number of plants in the eastern GOM States. In recent years, pipecoating companies have been expanding capacity or building new plants to respond to increased demand from deepwater oil and gas operations. The distribution of pipecoating plants within the region is shown in Figures 3.11.1-4 and 3.11.1-5.

3.11.1.7 Natural Gas Processing Plants and Storage Facilities

After raw gas is brought to the Earth's surface (either dissolved in the crude oil, combined with crude oil deposits, or from separate non-oil-associated deposits), it is processed at a gas processing plant to remove impurities and to transform it into a sellable commodity. Centrally located to serve different fields, natural gas processing plants have two main purposes: (1) remove essentially all impurities from the gas and (2) separate the gas into its useful components for eventual distribution to consumers. After processing, the gas is then moved into a pipeline system for transportation to an area where it is sold. Because natural gas reserves are not evenly spaced across the continent, an efficient, reliable gas transportation system is essential.

As of 2006, there were 249 gas processing plants in the GOM States, representing 58% of U.S. gas processing capacity. The distribution of these plants by State is shown in Figures 3.11.1-4 and 3.11.1-5. More than half of the current natural gas processing plant capacity in the United States is located near the GOM coast in Texas and Louisiana. Four of the largest capacity natural gas processing/treatment plants are found in Louisiana, while the greatest number of individual natural gas plants is located in Texas. In 2006, Louisiana led the United States in processing capacity, followed closely by Texas. In Alabama, Mississippi, and the eastern portion of south Louisiana, new larger plants and plant expansions were built to serve new offshore production, increasing the average plant capacity significantly (EIA 2006).

3.11.1.8 Refineries

A refinery is a complex industrial facility designed to produce various useful petroleum products from crude oil. Refineries vary in size, sophistication, and cost depending on their location, the types of crude they refine, and the petroleum products they manufacture. One-third of operable U.S. petroleum refineries are located in Alabama, Louisiana, Mississippi, and Texas. Most of the GOM region's refineries are located in Texas and Louisiana. As of 2010, Texas had 23 operating refineries, with a combined crude oil capacity of 4.7 million bbl/day, while Louisiana had 17 operating refineries with 3.2 million bbl/day of capacity, with the combined capacity of the two States representing more than 40% of total operating U.S. refining capacity (EIA 2010a). The distribution of these refineries within the region is shown in Figures 3.11.1-4 and 3.11.1-5.

3.11.1.9 Petrochemical Plants

The chemical industry converts raw materials such as oil, natural gas, air, water, metals, and minerals into more than 70,000 different products. The industrial organic chemical sector includes thousands of chemicals and hundreds of processes. The non-fuel components derived from crude oil and natural gas are known as petrochemicals. The processes of importance in petrochemical manufacturing are distillation, solvent extraction, crystallization, absorption, adsorption, cracking, reforming, alkylation, isomerization, and polymerization. Laid out like industrial parks, most petrochemical complexes include plants that manufacture any combination of primary, intermediate, and end-use products. Chemical manufacturing facility sites are typically chosen for their access to raw materials and to transportation routes. And, because the chemical industry is its own best customer, facilities tend to cluster near such end-users.

As of 2007, there were 56 petrochemical manufacturing establishments in the United States, 32 of which were in Texas and Louisiana (USCB 2011a). As of 2007, Texas (with 26 petrochemical manufacturing facilities) and Louisiana (with six petrochemical manufacturing facilities) contain more facilities than any other States in the United States. Alabama also had two petrochemical manufacturing facilities, primarily because petroleum and natural gas feedstocks are available from refineries. The distribution of these plants within the region is shown in Figures 3.11.1-4 and 3.11.1-5.

3.11.1.10 Waste Management Facilities

A number of different types of waste are generated as a result of offshore exploration and production activity. The physical and chemical characters of these wastes make certain management methods preferable over others. The infrastructure network needed to manage the spectrum of waste generated by OCS exploration and production activities and returned to land for management can be divided into three categories:

1. Transfer facilities at ports, where the waste is transferred from supply boats to another transportation mode, either barge or truck, toward a final point of disposition;

2. Special-purpose, oil field waste management facilities, which are dedicated to handling particular types of oil field waste; and

3. Generic waste management facilities, which receive waste from many American industries, with waste generated in the oil field being only a small part.

Regulations governing waste management facilities regarding storage, processing, and disposal vary depending on the type of waste. Waste management facilities in the GOM region that handle OCS oil and gas activity-related waste include transfer facilities, commercial salt dome disposal facilities, and landfills. Locations of major waste management facilities within the region (not including landfills) are shown in Figures 3.11.1-4 and 3.11.1-5.

3.11.1.11 Effects of Deepwater Horizon Event

As a result of the DWH event, land use experienced a short-term impact because temporary waste staging areas and decontamination areas were set up to handle the spill-related waste.

The impacts of the drilling moratorium put in place after the DWH event and subsequent permitting delays have affected some GOM ports and OCS infrastructure. Demand for services and supplies has dropped as a result. Some companies have removed a large portion of their equipment from Port Fourchon, and there has been a substantial decrease in helicopter flights and servicing of rigs. Many companies have had to cut staff hours and salaries. Support services companies, such as chemical suppliers and welders, have also been affected (Lohr 2010). The effects of this decreased demand will ripple through the various infrastructure categories (e.g., fabrication yards, shipyards, port facilities, pipecoating facilities, gas processing facilities, and waste management facilities) and will affect the oil and gas support sector businesses (e.g., drilling contractors, offshore support vessels, helicopter hubs, and mud/drilling fluid/lubricant suppliers).

It is too early to determine substantial, long-term changes in routine event impacts on land use and infrastructure as a result of the DWH event. BOEM anticipates that these changes will become apparent over time, and it will continue to monitor all resources for changes that are applicable to land use and infrastructure. This information, however, is not needed at the programmatic stage to make a reasoned choice among alternatives (see Section 1.4, Analytical Issues).

3.11.1.12 Climate Change

Coastal Louisiana provides an unstable land surface for development in many areas because of ongoing subsidence, exposure to tropical storms and hurricanes, and upstream and downstream alterations of the hydrology and sediment load and redistribution processes of the Mississippi River (see Section 3.4.4.1, Marine and Coastal Habitats). Even without considering the effects of climate change, coastal Louisiana is expected to undergo considerable landscape change during the life of the Program as a result of these processes. A 2004 U.S. Geological Survey (USGS) report includes projections of the areas of coastal Louisiana that are expected to experience land loss and land gain by 2050, a date that nearly coincides with the end of the 40–50-yr life of the Program (Barras et al. 2004). Projected areas of land gain and loss are shown in Figure 3.11.1-6 along with the locations of existing coastal OCS-related infrastructure. A visual inspection of the map shows a clear association between infrastructure locations and land loss in some areas.

The authors of the 2004 USGS report did not consider the effects of climate change on coastal processes that are expected to occur between now and 2050 as a factor affecting land loss (Barras et al. 2004). The USGS developed the data shown in Figure 3.11.1-6 by projecting into the future land loss patterns and rates that have been observed and studied for more than two decades. Climate change related effects that could affect land loss patterns include projected acceleration in the rate of rise of sea level, increase in the frequency and intensity of tropical weather systems in the GOM, and possible alterations in the hydrology and hydraulics of the Mississippi River system (IPCC 2007a; Barras et al. 2004). The USGS projections should therefore be considered a minimum land loss scenario for the year 2050 because the climate change effects that were not considered in the analysis, such as accelerated submergence and increased occurrence of large storms, should act to favor land loss over land accretion.

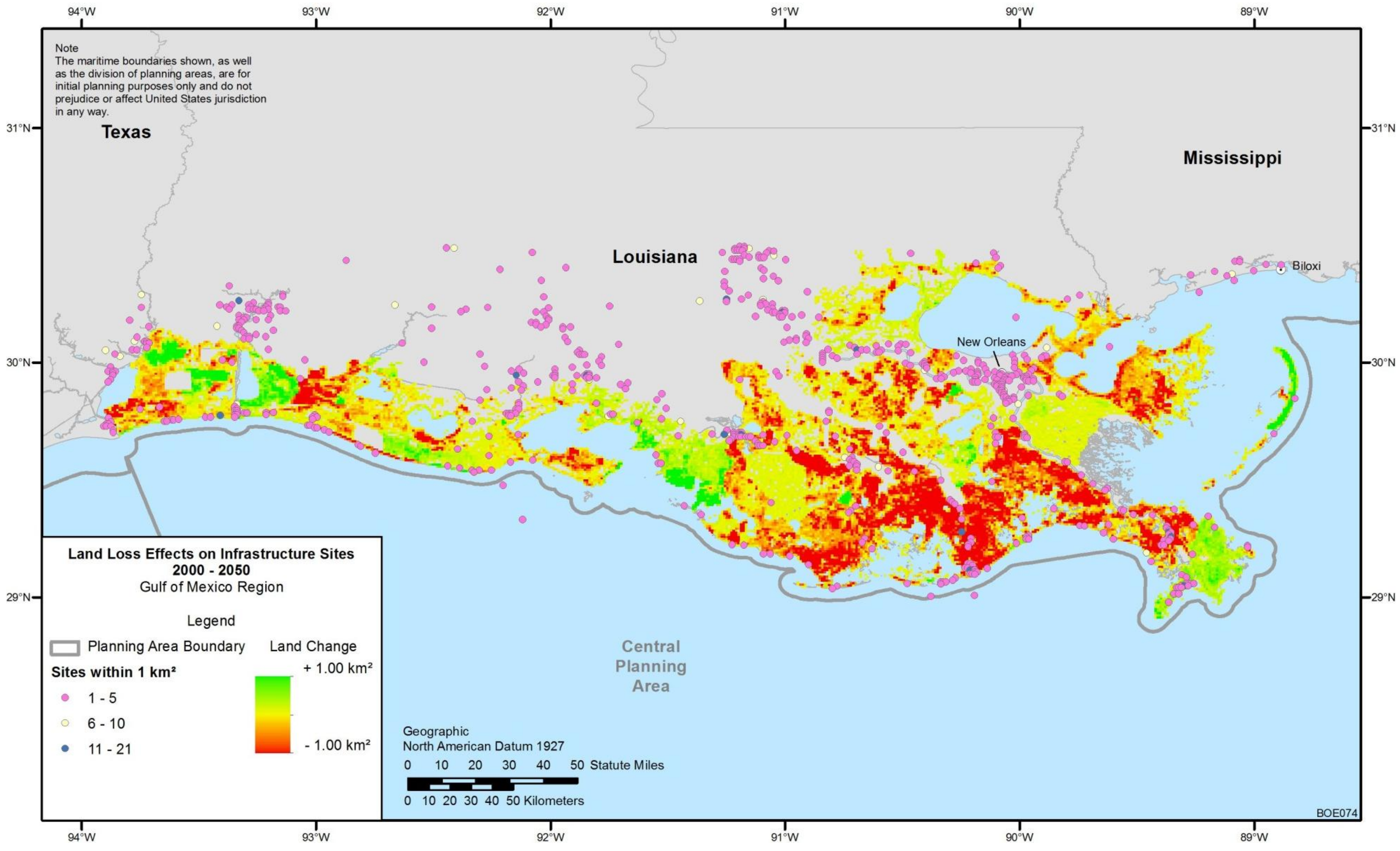


FIGURE 3.11.1-6 Land Loss Effects on Infrastructure Sites 2000-2050, GOM Region

Table 3.11.1-1 lists the types of infrastructure facilities discussed in the previous parts of this section in decreasing order of the percentage of facilities of that type that are projected to be affected by land loss. A facility was considered potentially affected by land loss if its location occurred within the 1-km^2 (0.4-mi^2) cell that the original USGS data projected would experience land loss by 2050. The table shows that 38% of all terminal locations (or 145 individual terminals) are located in cells projected to experience land loss. Only 2% of electric generator locations, in contrast, are located in cells projected to experience land loss. The table also shows that all petrochemical plants, pipe coating yards, and gas storage and processing facilities, and nearly all electric generator facilities are located in areas where land loss is not expected to occur and therefore this would not be an issue affecting the viability of these kinds of facilities.

This analysis suggests that land conditions in coastal Louisiana could become more unsuitable for some infrastructure uses during the life of the Program. Based on the data analyzed, terminals, ship repair yards, and service bases have the highest percentages of facility sites located in areas expected to experience land loss. These facilities are also located in areas expected to experience a relatively large amount of land loss, averaging nearly 10% of the nearby land, and would therefore likely be the most affected by the land changes expected to occur by 2050. As mentioned previously, the effects of climate change during the Program will likely act to increase the land loss amounts shown in the table.

This analysis focuses on land loss in coastal Louisiana. These are the result of ongoing coastal processes. Climate change will in all probability exacerbate land loss, but there are no quantified projections of land loss resulting from climate change. The intent of the analysis is to illustrate the potential effect on the viability of existing OCS-related coastal infrastructure during the life of the Program.

TABLE 3.11.1-1 Land Loss Effects on OCS-Related Facilities

Facility Type	Percent of Facilities with Local Land Loss	Number of Sites Affected	Average Percent of Nearby Land Loss
Terminals	38	145	10
Ship repair yard	32	25	10
Services bases	32	18	7
Heliports	23	45	6
Ports	18	3	10
Waste handling sites	15	5	20
Platform fabrication	14	5	4
Refineries	13	2	7
Electric generators	2	4	2
Petrochemical plants	0	0	0
Pipe coating yards	0	0	0
Gas storage and processing	0	0	0

The analysis suggests that this possibility exists and that the potential effect varies among infrastructure facility types. The effects of land loss and submergence on OCS-related infrastructure in coastal Louisiana have already begun to be addressed by the LA 1 Coalition, a non-profit organization working to improve transportation along the energy corridor through coastal Louisiana to the GOM. They have evaluated highway closures that could occur along LA 1 highway, a critical transportation link for OCS-related service and support bases, as a result of coastal submergence by 2050. Their analysis suggests that by 2030 critical sections of the highway could be closed up to 6% of the time and that by 2050 closures could occur 55% of the time (LA1 Coalition 2011). Such closures could have large effects on the OCS industry because of the high volume of OCS-related support and service products and materials transported across the highway.

3.11.2 Alaska – Cook Inlet

The Municipality of Anchorage, the Kenai Peninsula Borough, and the Matanuska-Susitna Borough in south central Alaska, along with the Kodiak Island Borough along the southern Cook Inlet, are the population centers of the State, with 60–65% of its population (USCB 2011b). Anchorage is the State center for scheduled aircraft and the regional center for chartered aircraft. Anchorage has a cargo facility that is served by a railroad connecting it to Alaska’s interior and the port at Seward. Anchorage is home to two military bases and the center for the State’s overall road network. As of 2010, the Municipality of Anchorage had a year-round population of approximately 291,826 (USCB 2011b).

The Cook Inlet and Kenai Peninsula area has an extensive road network and is served by the Ted Stevens Anchorage International Airport in Anchorage, as well as numerous smaller airfields and facilities. The more remote west side of Cook Inlet is not connected to the road system, and is home to the village of Tyonek, Alaska, a number of commercial set-net fish sites, and a number of oil camps.

The lands in the vicinity of the Cook Inlet Planning Area include large National Parks, National Wildlife Refuges, and a National Forest, including the Lake Clark National Park and Preserve, the Katmai Park and Preserve, the Kenai Fjords National Park, the Kenai National Wildlife Refuge, the Kodiak National Wildlife Refuge, and the Chugach National Forest (for a listing and discussion of these areas, see Section 3.9.2). The region also has numerous smaller State and municipal parks and refuges, and is economically important as a transportation hub, business center, tourism destination, and area of oil and gas activities.

The Port of Anchorage is the fourth largest port in Alaska (after Valdez, Nikiski, and Kivalina), and was ranked as the 96th largest port in the United States in 2009 (USACE 2010). The Port of Anchorage generally is limited to the use of barges and small container ships because of its shallow water depths and extreme tide variations. The port also serves as a staging and fabrication site for modules that are shipped to the North Slope for use in oil and gas activities.

Two ports are located on the east side of Cook Inlet, the Port of Homer in Kachemak Bay and a collection of special-purpose docks located in and around the town of Nikiski (formerly

Nikishka). The Port of Nikiski is the second largest port in Alaska (after Valdez), and was ranked as the 76th largest port in the United States in 2009 based on the port tonnage (USACE 2010).

Oil and gas are produced both onshore and offshore on State lands in the region; however, there are currently no active Federal leases in Cook Inlet. There are 16 active offshore production platforms in the Cook Inlet (Cook Inlet Regional Citizens Advisory Council 2011) on State submerged lands, north of the Cook Inlet Planning Area. There are onshore treatment facilities along the shores of the upper Cook Inlet and approximately 356 km (221 mi) of undersea pipelines, 126 km (78 mi) of oil pipeline, and 240 km (149 mi) of gas pipeline. These facilities, in addition to onshore pipelines, are listed in Tables 3.11.2-1 and 3.11.2-2 and shown in Figure 3.11.2-1.

Existing Cook Inlet region crude oil production (offshore and onshore) is handled through the Trading Bay production facility (Figure 3.11.2-1) and the Tesoro Refinery. Cook Inlet–produced gas is consumed by a variety of users: it is burned for electric power at Chugach Electric Association’s Beluga power-generation plant or transported to Anchorage for local usage.

The Trading Bay facility pipelines its received crude oil production to the Drift River tanker-loading facility at the Drift River Terminal. Facilities on both the Kenai Peninsula and in Anchorage have been used to fabricate large support modules for oil and gas development and production. With oil reserves mostly depleted, development in Cook Inlet in recent years has focused on natural gas; however, the Nikiski liquefied natural gas (LNG) plant, the only LNG export facility in the United States, closed in February 2011 (Bluemink 2011). The Agrium U.S., Inc., chemical plant, which also utilized Cook Inlet-produced gas, closed in 2008 (Agrium, Inc. 2007).

Since 1996, all Drift River tanker loadings are transported to the Tesoro Nikiski refinery, north of the city of Kenai. The Tesoro Refinery can process up to 72,000 barrels per day (bpd). The refinery produces ultra low sulfur gasoline, jet fuel, ultra low sulfur diesel, heating oil, heavy fuel oils, propane, and asphalt. Crude oil is delivered by double-hulled tankers via the Cook Inlet and Kenai Peninsula pipelines. A 114-km (71-mi), 40,000 bpd common-carrier products pipeline transports jet fuel, gasoline, and diesel to the Port of Anchorage and the Anchorage International Airport. Wholesale delivery occurs through terminals in Kenai, Anchorage, Fairbanks, and Tesoro’s Nikiski dock (Tesoro Corporation 2011).

In addition to oil- and gas-related activities, the Cook Inlet Planning Area and the land surrounding it are also important for commercial and recreational fisheries and hunting, as well as tourism and recreation. Subsistence use patterns of Cook Inlet are varied. As shown in Section 3.14.2, both urban and rural populations participate in hunting and fishing activities.

While facilities are present to support exploration and development of offshore oil and gas resources, existing and planned activities associated with exploration activities still would need to be consistent with current, local plans and initiatives. Within the State, Alaska Statutes provide certain cities and boroughs (i.e., municipalities) the authority for planning and land use

TABLE 3.11.2-1 Past and Present Operational Gas Pipelines in Cook Inlet and Cook Inlet Basin

ID	Current Operator	Location of Field or Pool	Location	Installed	Length in Miles[a]	Line Diameter in Inches
Offshore Cook Inlet Pipelines						
a	Unocal	Offshore	Baker to Platform A	1965	2.5	8
b	Cross Timbers	Offshore	Platform A to C	1967	2.2	8
c	Cross Timbers	Offshore	Platform C to Dillon	1967	2.2	8
d	Unocal	Offshore	Dillion to shore	1966	5.6	8
e	Unocal	Offshore	Grayling to shore	1967	6.0	10
f	Unocal	Offshore	King Salmon to shore	1967	7.0	8
g	Unocal	Offshore	Dolly Varden to shore	1967	5.7	8
h	Unocal	Offshore	Steelhead to shore	1986	6.5 (13)	2–10 lines
i	Unocal	Offshore	Monopod to shore	1966	9.0	8
j	Unocal	Offshore	Spurr to shore	1968	8.4	6
k	Marathon	Offshore	Spark to shore	1968	7.2	6
l	Unocal	Offshore	Anna to Bruce	1966	1.6	8
m	Unocal	Offshore	Bruce to shore	1974	5	6
n	Unocal	Offshore	Granite Point to shore	1966	6.0	8
o	Phillips	Offshore	Tyonek “A” to shore	1968	13 (26)	2–10 lines
p	Marathon	Offshore	Marine CIGGS, Granite Point to Nikiski[b]	1972	21 (42)	2–10 lines
Onshore Kenai Peninsula Pipelines						
q	Kenai Pipeline	Onshore	Swanson River to Nikiski	1960	19.2	16
r	Marathon	Onshore	Beaver Creek Field to Enstar Royalty Line	1982	4	12
s	Phillips	Onshore	Onshore continuation of Tyonek “A” to Nikiski	1968	26	16
t	Marathon	Onshore	Kenai Gas Field to Nikiski	1965	17	20
u	Enstar	Onshore	Kenai Mainline: Kenai Gas Field to Anchorage	Various[c]	71 (142)	2–12 lines
v	Military Pipeline (Enstar Lease)	Onshore	Anchorage to Whittier	1966[d]	47	8
w	Marathon	Onshore	Kenai Gas Field to Enstar Kenai Mainline	1965[e]	3	8
x	Enstar	Onshore	Enstar Royalty Line: Nikiski to Enstar Kenai Mainline	1978	25	8

TABLE 3.11.2-1 (Cont.)

ID	Current Operator	Location of Field or Pool	Location	Installed	Length in Miles[a]	Line Diameter in Inches
Onshore West Cook Inlet Pipelines						
y	Unocal	Onshore	Stump Lake and Ivan River Fields to Entar	1990	14	6 and 8
z	Forest Oil	Onshore	West Forelands #1 Well to Trading Bay	1994	5	6
aa	Enstar	Onshore	Lewis River Field to Enstar West Cook Mainline	1984	4	4
bb	Enstar	Onshore	West Cook Mainline, Beluga Gas Field to Anchorage	1984	99	20
cc	Marathon	Onshore	West Side CIGGS, Trading Bay to Granite Point	1972	27	16
dd	Marathon	Onshore	Granite Point to Beluga	1990	16.1	16

[a] Roughly estimated, there are 486 route miles for all gas pipelines offshore and onshore in the Cook Inlet region. Considering dual pipelines, actual pipe length is approximately 598 miles. These figures do not include gathering and connection pipelines that are internal to a field. To convert miles to kilometers, multiply by 1.6.

[b] CIGGS = Cook Inlet Gas Gathering System.

[c] Kenai Mainline pipeline: segments placed into service in various years beginning in 1961. Latest initial pipeline pressure test occurred in 1978.

[d] Year of Enstar pressure test and operational assumption.

[e] Pipeline not in use.

Sources: Robertson 2000; MMS 2002a, 2003c.

TABLE 3.11.2-2 Past and Present Operational Oil and Liquid Petroleum Pipelines in Cook Inlet and Cook Inlet Basin

ID	Current Operator	Location of Field or Pool	Location	Installed	Length in Miles[a]	Line Diameter in Inches
Offshore Cook Inlet Pipelines						
a	Cross Timbers	Offshore	A to shore	1965	7.0 (14)	2–8 lines
b	Cross Timbers	Offshore	C to A	1967	2.2	8
c	Unocal	Offshore	Baker to A	1965	2.5	8
d	Unocal	Offshore	Grayling to shore	1967	6.0	10
e	Unocal	Offshore	King Salmon to shore	1967	7.0	8
f	Unocal	Offshore	Dolly Varden to shore	1967	5.7	8
g	Unocal	Offshore	Steelhead to shore	1986	6.5	8
h	Unocal	Offshore	Monopod to shore	1966	9.0	8
i	Unocal[a]	Offshore	Spurr to shore[b]	1968	8.4	6
j	Marathon	Offshore	Spark to shore[b]	1968	7.2	6
k	Unocal	Offshore	Anna to Bruce	1966	1.6	8
l	Unocal	Offshore	–	1966	1.6	8.625
m	Unocal	Offshore	Granite Point to shore	1966	6.0	8
Kenai Peninsula Pipelines						
n	Tesoro	Onshore	Tesora Refinery to the Port of Anchorage	1974	70	10
o	Tesoro	Onshore	Nikiski Terminal to Tesoro Refinery	1983	<1	24
p	Kenai	Onshore	Swanson River to Kikiski	1960	19.2	8
West Cook Inlet Pipelines						
q	Cook Inlet Pipeline	Onshore	Drift River loading lines	1966	3.6	30 and 42
r	Cook Inlet Pipeline	Onshore	Granite Point to Drift River	1966	42.0	20 and 12
s	Forest Oil	Onshore	West McArthur to Trading Bay	1994	3.12	8

[a] Roughly estimated, there are 211 route miles for actual pipeline route and 218 miles of actual pipe length. This estimate does not take into account gathering lines that are internal to a producing field. To convert miles to kilometers, multiply by 1.6.

[b] Spurr and Spark oil pipelines are shut in. Marathon only operates gas lines.

Sources: Robertson 2000; MMS 2003c.

regulation (Alaska Department of Commerce 2007; Freer 2003); activities that occur within the boundaries of the coastal zones of these municipalities, including their offshore coastal zones, would require permitting and approval from the relevant municipality prior to those activities proceeding (MMS 2003a). The Inlet is primarily comprised of land located within the Kenai Peninsula Borough, with some portions within the Municipality of Anchorage, the Kodiak Island Borough, and other governmental jurisdictions.

Furthermore, much of the land within the Cook Inlet is managed by Federal land management agencies; for instance, approximately 65% of the Kenai Peninsula Borough is Federal land (Kenai Peninsula Borough 2005) (see Figure 3.9.3-2). Therefore, each of these agencies and their respective regulations would need to be considered for exploration and production activities that might affect lands or waters managed by the agencies.

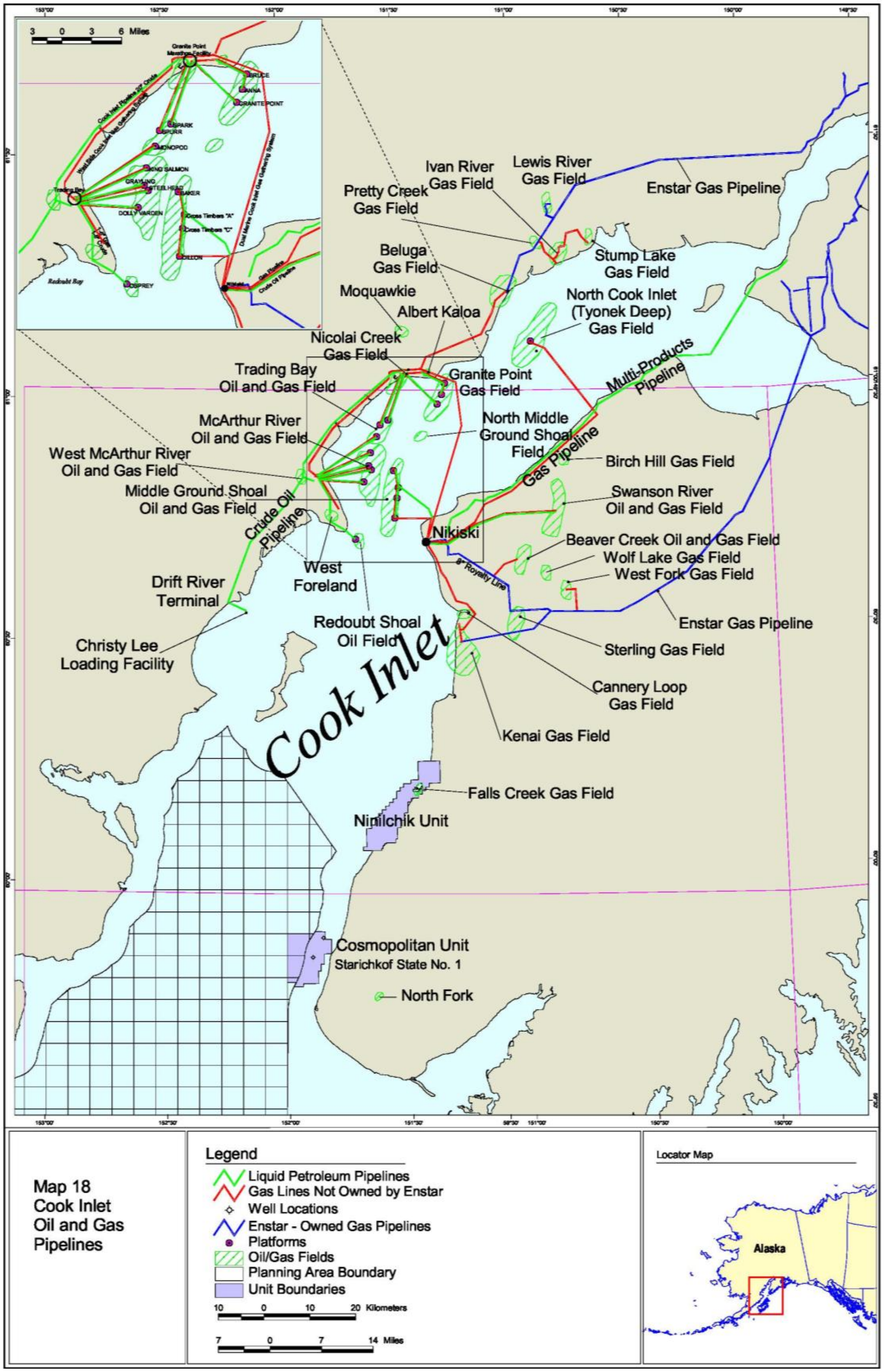


FIGURE 3.11.2-1 Oil and Gas Fields and Infrastructure Locations in Cook Inlet

3.11.2.1 Climate Change

One of the primary ecological drivers within Cook Inlet is climate, as it helps shape the land, as well as influences the ground cover. Current evidence suggests that the climate in Alaska is undergoing an unusual degree of change; records, for instance, show that temperatures in Anchorage have increased approximately 2.2°C (4.0°F) over the last 41 years and up to 4.5°C (8.2°F) in winter months since the 1960s. Estimates for this area of Alaska indicate that in the coming years, precipitation will increase slightly in the fall and winter and by up to 10% in the spring and summer (Nature Conservancy 2003). Climate change in these regions is associated with the loss of ice-cover and permafrost, as well as a slow rise in sea level; these changes in turn influence the infrastructure and land use planning decisions.

In response to these potential changes, communities within Cook Inlet have adapted new strategies, including analyses to further evaluate the vulnerability of the existing infrastructure. In 2007, for instance, the Kenai Peninsula Borough adopted a resolution to address the local climate change impacts, which indicated the need for a borough-wide plan in order to address "both short-term and long-term impacts to the natural environment and surrounding communities, including increased risks of forest fire, floods, and coastal erosion" (Kenai Peninsula Borough 2008).

3.11.3 Alaska – Arctic

The Arctic region includes the Beaufort Sea Planning Area and the Chukchi Sea Planning Area. Only the Beaufort Sea Planning Area has a well-developed oil and gas industry infrastructure on adjacent land and in State waters.

Land use in much of the Arctic region is not intense, with much of the region being used primarily for subsistence pursuits, except for the oil- and gas-related activities described above. There are only a few small communities located in the area, the largest of which is the city of Barrow, with an estimated population of about 4,212 persons (USCB 2010). Barrow is the economic, transportation, and administrative center for the North Slope Borough. The North Slope Borough includes other communities adjacent to the Chukchi and Beaufort Sea Planning Areas, including Point Hope, Point Lay, Wainwright, Nuiqsut, and Kaktovik, each with populations under 1,000 persons. Deadhorse is an unincorporated oil field service community at the end of the Dalton Highway, with fewer than 50 permanent residents, but with up to 2,000 or more oil workers present at a given time.

Various Federal agencies oversee large amounts of land in the North Slope Borough. federally managed lands include the Arctic National Wildlife Refuge (USFWS), Gates of the Arctic National Park (NPS), the National Petroleum Reserve-Alaska (BLM), and a number of Chukchi Sea coastal headlands and islands administered by the Alaska Maritime National Wildlife Refuge (USFWS) (for a listing and discussion of these areas, see Section 3.9.3).

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 (transferring cargo between vessels of different sizes) of cargo to shore because of the shallow coastal waters and the lack of dredging and heavy-lift equipment. Heavy-lift cranes and protected small boat shelters are found only at Prudhoe Bay's West Dock. The communities within this region are not connected by a permanent road system. Paved and unpaved roads are generally limited to the area within communities. During the winter, village residents travel to other villages via snowmobile. However, the residents of the community of Nuiqsut are close enough to active oil fields that they can use winter ice roads to access Prudhoe Bay and then travel down the Dalton Highway into the interior of Alaska.

Airports and related service facilities are also limited. Airports at Barrow, Kotzebue, and Deadhorse have scheduled jet service and are owned and maintained by the State of Alaska. ConocoPhillips maintains an airport near its operating headquarters at Ugnu-Kuparuk. This airfield serves chartered corporate passenger and cargo jets, as well as other types of air traffic. The most active airfield in Arctic Alaska is the Deadhorse airport, with most flights at that airport related to oil field activities. The second-most active facility is Barrow's Wiley Post–Will Rogers Airport; there are other smaller airports at Nuiqsut and other locations in the region as well.

Exploration activities moved offshore into the Beaufort and Chukchi seas in the 1970s, and development and production in the nearshore Beaufort Sea began in the early 1980s. Individual oil pools have been developed together as fields that share common wells, production pads, and pipelines. As of 2007, 35 fields and satellites had been developed on the North Slope and nearshore areas of the Beaufort Sea and were producing oil. Over time, fields also have been grouped into production units with common infrastructure, such as processing facilities (MMS 2008b).

Oil and gas infrastructure occurs intermittently along the Arctic coast from the northeast corner of the NPR-A to the Canning River. The core of production activity occurs in an area between the Kuparuk field and the Sagavanirktok River. The Prudhoe Bay/Kuparuk oil field infrastructure is served by nearly 483 km (300 mi) of interconnected gravel roads. These roads serve more than 644 km (400 mi) of pipeline routes and related processing and distribution facilities.

According to BLM (as cited in MMS 2008b), as of 2007, oil and gas activities had resulted in the development of 202 ha (500 ac) of peat roads, 3,642 ha (9,000 ac) of gravel roads and pads, 2,428 ha (6,000 ac) of gravel mines, and 809 ha (2,000 ac) of other facilities on the North Slope. Few of these acres had been restored to their original condition.

Oil and gas exploration activities are ongoing in the northeast NPR-A. No permanent roads have been constructed into the NPR-A; all activities there are currently supported by ice roads. Some lands within the NPR-A have special designations, including the Teshekpuk Lake, Kasegaluk Lagoon, Colville River, and Utukok Uplands Special Areas, established in recognition of the areas' outstanding wildlife resources, including geese and other birds, caribou, bears, fish, and other animals.

In 2008, the BLM issued a record of decision (ROD) for the Northeast NPR-A making nearly 17,800 km^2 (4.4 million acres) available for oil and gas leasing, though it deferred leasing on 1,740 km^2 (430,000 acres) north and east of Teshekpuk Lake for 10 yr. The decision also established performance-based stipulations and required operating procedures (ROPs), which apply to oil and gas and, in some cases, to other activities (BLM 2008).

The Prudhoe Bay/Kuparuk area is also served by the Dalton Highway. This road extends more than 644 km (400 mi) from Livengood (121 km [75 mi] north of Fairbanks) to Deadhorse. The Trans-Alaska Pipeline System (TAPS) roughly parallels much of the Dalton Highway.

Because new facilities would be necessary to develop offshore oil and gas resources, exploration and production activities would need to be coordinated with local jurisdictions in order to ensure consistency with local land use plans, zoning regulations (if present), and future land use initiatives. Alaska Statutes provide certain cities and boroughs (i.e., municipalities) the authority for planning and land use regulation; as such, planning commissions and/or city councils may review projects that would impact a municipality under its jurisdiction. Comments or recommendations may be provided to the agencies undertaking the action in order to account for local needs, or if local permits are needed (Alaska Department of Commerce 2007; Freer 2003).

Furthermore, a significant percentage of the land near the Beaufort and Chukchi Seas is owned by the Federal government, although it is located within the North Slope Borough. For instance, more than half of the North Slope Borough's land is included with the NPR-A and the ANWR. Other major landholders include the State, the Arctic Slope Regional Corporation, and eight Native village corporations (MMS 2010). Each of these agencies and their respective regulations would need to be considered for exploration and production activities that might affect lands or waters managed by the agencies.

3.11.3.1 Climate Change

Within the Arctic, impacts of climate change already have been recorded. Average Arctic temperatures, for instance, have increased at almost twice the global average rate in the past 100 years (IPCC 2007a). Observed decreases in snow and ice extent also are consistent with the indication of warming temperatures. Data since 1978, for example, has shown that annual average Arctic sea ice extent has shrunk by approximately 2.7% per decade, with larger decreases in the summer. Temperatures at the top of the permafrost layer generally have increased since the 1980s in the Arctic by up to 3°C (5.4°F) (IPCC 2007a). These changes have resulted in adaptations to local infrastructure and land use due to inundation, storm surge, erosion, and other coastal hazards.

Due to the anticipated effects of climate change, communities within the Arctic have initiated studies to account for potential damage to local infrastructure. For example, in Kivalina, the community has experienced severe erosion from sea storms, which particularly occur in late summer or fall. These storms can cause a sea level rise of approximately 3 m (10 ft) or more, and when combined with high tide, the storm surge can be accompanied by waves that contain ice. As a result of these climatic changes, the village of Kivalina had initiated studies to determine the costs of relocating the village and its associated infrastructure (GAO 2003). Other communities within the Arctic receiving Federal assistance to address flooding and erosion concerns include, but are not limited to, Point Hope, Barrow, and Kaktovik (GAO 2003).

3.12 COMMERCIAL AND RECREATIONAL FISHERIES

3.12.1 Commercial Fisheries

3.12.1.1 Gulf of Mexico

Commercial fisheries are very important to the economies of the GOM coast States; in 2009, commercial fishery landings in the GOM, which includes western Florida, Alabama, Mississippi, Louisiana, and Texas, reached almost 649,000 metric tons, which was worth more than $629 million (NMFS 2011d). 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. Louisiana led the GOM coast States in total landings and value in 2009, with 455,931 metric tons worth $284 million. Mississippi was second, with landings exceeding 104,456 metric tons, worth $47 million, followed by Texas (45,132 metric tons, worth $150 million), Florida’s west coast (29,626 metric tons, worth $116.1 million), and Alabama (13,469 metric tons, worth $41 million) (NMFS 2011d).

Commercially important species groups in the GOM include oceanic pelagic (epipelagic) fishes, reef (hard bottom) fishes, coastal pelagic species, and estuarine-dependent species (Table 3.12.1-1). On the basis of reported commercial fishery landing data, the two most valuable commercial fisheries in the GOM were white and brown shrimp, which accounted for 25% and 23%, respectively, of the entire GOM commercial fishery in 2009 (NMFS 2010f; Table 3.12.1-1). Other invertebrates such as blue crab, spiny lobster, and stone crab (*Menippe* spp.) also contributed significantly to the value of commercial landings. Finfish species that contributed substantially to the overall commercial value of the GOM fisheries in 2009 included menhaden ($60.6 million), red grouper ($10.5 million), red snapper ($7.9 million), and yellowfin tuna ($7.9 million). In terms of landing weight, Atlantic menhaden far surpassed other commercial fish species in the GOM, accounting for approximately 70% of the total weight of landed commercial species (Table 3.12.1-1). However, Atlantic menhaden accounted for only about 9.6% of the total value of the GOM commercial fishery.

Each species or species group is caught using various methods and gear types. Shrimps are taken by bottom trawling; menhaden are caught in purse nets; yellowfin tuna are caught on surface longlines; snapper and grouper are caught by hook and line; and pots and traps are used for crab, spiny lobster, and some fish species. Generally, the GOM fishing activities with the highest potential for interactions (or conflicts) with OCS oil and gas activities (e.g., oil and gas operations) are bottom trawling (potential for snagging on pipelines, cables, and debris) and

TABLE 3.12.1-1 Total Weights and Values of Commercially Important Fishery Species in the GOM Region

Species	Weight (metric tons)	Weight (pounds)	Value ($)	% Weight	% Value
Menhaden	454,761.20	1,002,566,613	60,603,671	70.1	9.6
Shrimp, brown	55,887.10	123,208,776	142,752,499	8.6	22.7
Shrimp, white	51,988.20	114,613,215	155,736,392	8.0	24.7
Crab, blue	26,823.20	59,134,370	43,673,691	4.1	6.9
Oyster, eastern	10,226.60	22,545,582	72,455,368	1.6	11.5
Crayfish	8,437.20	18,600,732	14,980,231	1.3	2.4
Mullet, striped	4,691.20	10,342,230	5,580,700	0.7	0.9
Shrimp, pink	3,485.80	7,684,797	14,202,829	0.5	2.2
Stone crab claws	2,389.80	5,268,490	17,567,663	0.4	2.8
Black drum	2,257.80	4,977,457	3,827,342	0.3	0.68
Red grouper	1,988.80	4,384,414	10,481,382	0.3	1.7
Lobster, Caribbean spiny	1,791.50	3,949,586	12,173,600	0.3	1.9
Vermillion snapper	1,722.20	3,796,731	8,230,448	0.3	1.3
Red snapper	1,134.30	2,500,630	7,963,886	0.2	1. 3
Bait and feed fish	1,120.50	2,470,199	471,243	0.2	0.1
Yellowfin tuna	1,118.20	2,465,234	7,935,150	0.2	1.3
Shrimp, Dendrobranchiata	1,080.60	2,382,249	9,950,718	0.2	1.6
Total	648,613.40	1,429,933,053	629,276,230		

Source: NMFS 2010f.

surface longlining (potential for space use conflicts with seismic survey vessels and possible entanglement with thrusters on dynamically positioned drillships). The portion of commercial fishery landings that occurred in nearshore and offshore waters of the GOM States is presented in Table 3.12.1-2.

Fishery statistics for major U.S. ports in the GOM region are presented in Table 3.12.1-3. In terms of reported total landing weight, the top U.S. ports in the GOM region in 2009 were Empire-Venice, Louisiana; Intracoastal City, Louisiana; and Pascogoula-Moss Point, Mississippi. GOM ports with the highest reported total catch values were Empire-Venice, Louisiana ($67.2 million), and Dulac-Chauvin, Louisiana ($50.9 million).

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 (CRS 2010). Portions of Louisiana, Alabama, Mississippi, and Florida State waters have also been closed. These areas are some of the richest fishing grounds in the GOM for major commercial species such as shrimp, blue crab, and oysters, and as prices for these items have increased, imports of these species have likely taken the place of lost GOM coast production. NOAA continued to reopen areas to fishing once chemical tests revealed levels of hydrocarbons or dispersants in commercial species were not of concern to human health. Extensive sampling of commercially and recreationally important fish and shellfish in Federal

TABLE 3.12.1-2 Value of Gulf Coast Fish Landings by Distance from Shore and State for 2009 ($1,000)

	Distance from Shore (mi)	
State	0–3	3–200
Florida (GOM)	11,319	36,390
Alabama	2,006	1,637
Mississippi	18,211	456
Louisiana	64,164	13,213
Texas	2,443	5,045
Total	98,143	56,741

Source: http://www.st.nmfs.noaa.gov/st1/commercial/landings/ds_8850_bystate.html.

TABLE 3.12.1-3 Reported Total Landing Weights and Values for Major Ports in the GOM Region in 2009

Rank[a]	Port	State	Total Landing (million lb)	Total Landing (million $)
2	Empire-Venice	LA	411.8	67.1
5	Intracoastal City	LA	244.7	30.2
6	Pascagoula-Moss Point	MS	217.4	18.6
7	Cameron	LA	178.8	No data
22	Dulac-Chauvin	LA	42.4	50.9
27	Brownsville-Port Isabel	TX	27.0	41.0
28	Lafitte-Barataria	LA	25.9	25.9
29	Golden Meadow-Leeville	LA	25.6	27.4
33	Galveston	TX	22.0	35.0
34	Bayou La Batre	AL	21.0	30.0
37	Palacios	TX	20.0	27.0
43	Port Arthur	TX	16.0	27.0
46	Delacroix-Yscloskey	LA	13.4	19.7
47	Gulfport-Biloxi	MS	12.9	19.3

[a] Rank among all U.S. commercial fishing ports based on landings.

Source: http://www.st.nmfs.noaa.gov/st1/fus/fus09/02_commercial2009.pdf.

waters for PAHs and dispersants found no evidence of PAH or dispersant contamination except in a few areas off the Louisiana coast (Ylitalo et al. 2012). In addition, a review of the safety of GOM seafood found that PAH concentrations were well below levels of concern set by the Food and Drug Administration (Gohlke et al. 2011). However, others have argued that risks from consumption of GOM seafood may exist for vulnerable populations such as pregnant women, children, and individuals that consume a large amount of seafood (Rotkin-Ellman et al. 2012).

The impact of the DWH event on fishery landings is still being investigated (McCrea-Strub et al. 2011). This information, however, is not needed at the programmatic stage to make a reasoned choice among alternatives (see Section 1.4, Analytical Issues). Because consumer perceptions of GOM seafood and seafood products may affect demand, future sales of GOM fisheries production may be lost (CRS 2010).

3.12.1.2 Alaska – Cook Inlet

Commercial fisheries of the Gulf of Alaska and Cook Inlet are diverse and chiefly target groundfish, Pacific halibut, Pacific salmon, herring, crab, shrimp, clams, scallops, sea urchins, and sea cucumbers. An assortment of gear, such as gill nets, seines, purse seines, trawls, dredges, pots, jigs, and/or diving equipment, is employed to harvest the various target species. The groundfish fisheries accounted for the largest share ($640 million; 48%) of the ex-vessel value of all commercial fisheries in Alaska in 2009 (Hiatt et al. 2010). The Pacific salmon fishery is the second most valuable ($345 million) with 26% of the total Alaska ex-vessel value. The value of the shellfish fishery was $195 million, or 15% of the total for Alaska (Hiatt et al. 2010). Fisheries in the Gulf of Alaska are described in Hiatt et al. (2010), including gear, geographic distribution, fisheries effort, and existing economic conditions.

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. All five species of Pacific salmon, razor clams, Pacific herring, and smelt are commercially harvested in UCI. The LCI 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).

Groundfish are primarily harvested by trawl, although hook and line (including longline and jigs) and pot gear are also used. In general, groundfish fisheries in the U.S. EEZ (5.6–370 km [3–200 NM] offshore) fall under Federal authority, while the State of Alaska manages groundfish within State territorial (0–5.6 km [0–3 NM]) waters (Trowbridge et al. 2008). The ADFG, Division of Commercial Fisheries, manages all commercial groundfish fisheries in Cook Inlet, where groundfish are typically harvested in the LCI Management Area. Commercial fisheries of groundfish in State waters have historically targeted Pacific cod, pollock, sablefish, ling cod, and rockfish (Trowbridge et al. 2008).

Pacific halibut fishery grounds occur throughout the entire Gulf of Alaska shelf. The commercial fishery is conducted exclusively using hook and line (NMFS 2004). The Pacific halibut fishery is managed by the International Pacific Halibut Commission (http://www.iphc.washington.edu/halcom).

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 [Hiatt et al. 2010]). The UCI supports gill net fisheries targeting Chinook, coho, pink, chum, and sockeye salmon. The LCI fisheries use gill net or seine gear and target pink, chum, and sockeye salmon. Total salmon harvest in LCI and UCI was approximately 4.07 million fish ($35.0 million ex-vessel value) in 2010 (Hammarstrom and Ford 2011; Shields 2010b). Pink salmon and sockeye salmon dominate the Cook Inlet salmon fishery by weight and monetary value. Commercial fishing seasons in these areas for salmon are species-specific and are published on the ADFG, Commercial Fisheries Division, website (http://www.cf.adfg.state.ak.us).

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 was closed during 2010 for the 12th successive season (Hammarstrom and Ford 2011). 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 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.

Commercial fisheries of crab and shrimp in the Gulf of Alaska are managed by the State of Alaska. Four species of king crab are harvested: red, blue, golden, and scarlet. Other commercially important crabs include golden king crabs, Tanner crabs, snow crabs, and Dungeness crabs. Commercial crab fisheries of the Gulf of Alaska chiefly operate in the following areas: Yakutat (king crab), Kodiak (Dungeness and Tanner crabs), and the Alaska Peninsula (Dungeness and Tanner crabs). Shrimp fisheries conducted in the Gulf of Alaska use pot, trawl, or otter-trawl gear. The commercial fisheries operate primarily in the Yakutat, Prince William Sound/Copper River, Kodiak, Chignik, and Alaska Peninsula areas. Cook Inlet historically supported king crab, Dungeness crab, and shrimp fisheries, but these fisheries are currently closed while stocks rebuild.

Commercial fisheries of bivalves (scallops or clams) occur in the Prince William Sound/Copper River, Cook Inlet, Kodiak, and Alaska Peninsula areas. Scallops are harvested using dredging gear. Razor clams are harvested exclusively by hand digging on the west shore of upper Cook Inlet, principally from the Polly Creek and Crescent River sandbar areas (Shields 2010b). The 2010 harvest of razor clams was approximately 380,000 lb and valued at $235,000. Steamer clams are also harvested in Cook Inlet.

Diver-based fisheries targeting sea cucumbers also exist around Chignik and Kodiak Island. Currently, each fishery is a competitive limited entry fishery. More information is available at http://www.adfg.alaska.gov/index.cfm?adfg=commercialbyfisherydive.main.

3.12.1.3 Alaska – Arctic

The Arctic Management Area, consisting of the U.S. EEZ of the Chukchi and Beaufort Seas from 6 km (3 NM) offshore the coast of Alaska is currently closed to commercial fishing (NPFMC 2009). In the State waters of the Beaufort Sea, there is a single commercial fishery targeting cisco and whitefish in the Colville River Delta that operates in the summer months. Markets for these fish are primarily regional, although some fish are sent to Anchorage and to more distant markets (NPFMC 2009). In the Chukchi Sea, there is a relatively small summer salmon fishery (MMS 2006a).

Although commercial fishing is limited in the Beaufort 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). Consequently, in the coming decades, commercially viable populations of fish and shellfish may develop in the Arctic. However, the development of a fishery in Federal waters is dependent upon Federal approval of commercial fishing activity.

3.12.2 Recreational Fisheries

3.12.2.1 Gulf of Mexico

Data collected by the National Marine Fisheries Service (NMFS) for Alabama, Florida, Louisiana, and Mississippi indicate that more than 4.5 million people engaged in some form of recreational fishing in the GOM States in 2010 (Table 3.12.2-1). Of the four States, western Florida had the highest number of anglers and fishing trips in 2010 (3.0 million), followed by Louisiana (0.8 million), Alabama (0.6 million), and Mississippi (0.2 million). Almost 67% of the fishing trips in the GOM coast left out of west Florida, followed by Louisiana (17%), Alabama (7%), Mississippi (5%), and Texas (4%). These anglers took more than 23 million trips and caught more than 173 million fish (NMFS 2011e). Although data on recreational fishing is not available at the same level of detail for Texas as it is for other GOM States, in 2004, it is estimated that 1,059,634 fishing license holders fished for one or more days in Texas (Tseng et al. 2006).

The most popular mode of fishing in all GOM States was private/rental boat, comprising 59.7% of trips in each State, followed by fishing from shore (37.5%) and fishing from charter vessels (2.8%) (Table 3.12.2-2). More than 69% of anglers fishing from shore confined their trips to inland waters, the remaining trips taking place within 16 km (10 mi) of shore. Most anglers (75.6%) using private or rental boats also preferred inland waters for their trips, or fished

TABLE 3.12.2-1 Estimated Number of People Participating in GOM Marine Recreational Fishing, 2010[a,b]

	Coastal	Non-Coastal	Out-of-State	Total
West Florida	1,542,556	0	1,473,928	3,016,485
Louisiana	601,240	66,340	118,292	785,872
Alabama	193,721	138,730	218,532	550,982
Mississippi	136,504	28,542	49,804	214,850
GOM Total	2,474,021	233,612	1,860,556	4,568,189

[a] “Coastal,” “non-coastal,” and “out-of-State” refer to place of residence of participants in marine recreation in each State.

[b] Data for Texas is not collected in the same level of detail as for the other GOM States.

Source: NMFS 2011e.

TABLE 3.12.2-2 Estimated Number of Trips and Trip Range by Trip Mode in GOM Marine Recreational Fishing, 2010

Fishing Mode	Trip Range	Number of Trips
Shore fishing	5 km (3 mi) or less	680,556
	Less than 16 km (10 mi)	1,707,550
	Inland	5,402,102
Total	–	7,790,208
Charter boats	5 km (3 mi) or less	10,378
	More than 5 km (3 mi)	21,892
	Less than 16 km (10 mi)	157,977
	More than 16 km (10 mi)	206,673
	Inland	175,939
Total	–	572,859
Private or rental boat	5 km (3 mi) or less	219,504
	More than 5 km (3 mi)	126,227
	Less than 16 km (10 mi)	2,132,905
	More than 16 km (10 mi)	540,061
	Inland	9,376,983
Total	–	12,395,680

Source: NMFS 2011e.

less than 16 km (10 mi) from the coast (17.2%). Only 30.7% of charter boats trips were made inland, while 36.1% were made more than 16 km (10 mi) from the coast, and 27.6% of trips were less than 16 km (10 mi) from shore.

A large majority of angling trips in Mississippi (98.6%) and Louisiana (97.7%) were made in inland waters in 2010, as opposed to waters up to 5 km (3 mi) from shore and farther distances. In Florida (66.2%) and Alabama (46.5%), inland trips were less important, with the more trips in Alabama made to State and Federal waters (46.7% and 6.8%, respectively), and to the same waters in Florida (28.5% and 5.3%, respectively).

Of the 145.3 million fish caught in the four GOM coast States in 2010, the majority (95.3 million, 65.6% of the total) were landed in Florida; landings by weight are more evenly distributed across the four States, with 41.8% of landings in Florida, 40.1% in Louisiana, 12.8% in Alabama, and 5.3% in Mississippi (Table 3.12.2-3). Almost all landings were made in inland waters in Mississippi (98.6%) and Louisiana (94.8%). While the inland catch was important in Alabama (50.0%) and Florida (44.0%), the offshore catch was larger in these States, with 34.1% of the total catch landed up to 5 km (3 mi) from shore, and 16% at more than 5 km (3 mi) in Alabama and 28.7% at less than 16 km (10 mi), and 27.3% at more than 16 km (10 mi) in Florida.

Types of fish caught in 2010 varied by State and by distance from shore (Table 3.12.2-3). In Alabama and Louisiana, drum, seatrout and herring were popular fish less than 5 km (3 mi) from shore, with shark, ray, and snapper caught at this distance in Mississippi. Snapper were commonly caught more than 5 km (3 mi) from shore in Alabama, Louisiana, and Mississippi, together with drum and seatrout in Louisiana. Jack, catfish, and tuna were also caught up to 16 km (10 mi) from shore in Florida. Inland species caught in Alabama were drum, mullet, flounder, and porgy, with seatrout also caught in Mississippi and catfish in Louisiana. In Florida, porgy, mullet, seatrout, and mackerel were popular. Most fishing occurred in State and inland waters (NMFS 2010f).

In 2004, a total of 1,276,667 Texas resident fishing licenses were purchased (Tseng et al. 2006). It is estimated that 1,059,634 (or 83%) of these license holders actually fished one or more days in Texas during the year. Of those who fished, 74% participated in freshwater fishing and 61% participated in saltwater fishing. Freshwater anglers fished an average of 27 days, while saltwater anglers fished an average of 20 days (Tseng et al. 2006).

When freshwater anglers were asked to name the fish they prefer to catch in Texas, 52% indicated a first-choice preference for black bass. Other species preferred by freshwater anglers included largemouth bass, catfish, crappie, and temperate basses (white bass, striped bass, and hybrid striped bass). Most saltwater anglers in Texas (40%) indicated a first-choice preference for red drum, followed by speckled trout, the drum family, and flounder (Tseng et al. 2006).

Recreational fishing off Alabama, Mississippi, Louisiana, and Texas often occurs around oil and gas platforms. BOEMRE supports and encourages the reuse of obsolete oil and gas facilities as artificial reefs and will grant a lessee/operator a departure from removal requirements provided that (1) the structure becomes part of a State artificial reef program that

TABLE 3.12.2-3 Estimated Number of Trips and Catch Weights in GOM Marine Recreational Fishing, 2010

	Number of Angler Trips	Catch (pounds)	Major Fish Types Caught
Alabama			
≤5 km (3 mi)	836,397	2,582,437	Drum, seatrout, herring
>5 km (3 mi)	121,006	1,210,837	Snapper
Inland	832,027	3,789,035	Drum, mullet, flounder, porgy
Total	1,789,430	7,582,309	
West Florida			
≤16 km (10 mi)	3,998,432	7,094,311	Herring, drum, seatrout, jack, catfish, seabass, tuna, snapper
>16 km (10 mi)	746,735	6,748,134	Snapper, grunt, herring
Inland	9,287,570	10,875,884	Porgy, mullet, tuna, mackerel
Total	14,032,737	24,718,329	
Louisiana			
≤5 km (3 mi)	61,274	771,959	Drum, seatrout
>5 km (3 mi)	22,980	450,170	Snapper, drum, seatrout
Inland	3,634,782	22,460,692	Drum, seatrout, porgy, catfish
Total	3,719,036	23,682,821	
Mississippi			
≤5 km (3 mi)	12,767	34,924	Shark, ray, snapper
>5 km (3 mi)	4,132	9,237	Snapper
Inland	1,200,644	3,093,236	Drum, seatrout, flounder, porgy
Total	1,217,543	3,137,397	

Source: NMFS 2011e.

complies with the criteria in the National Artificial Reef Plan; (2) the responsible State agency acquires a permit from the U.S. Army Corps of Engineers and accepts title and liability for the reefed structure once removal/reefing operations are concluded; (3) the operator satisfies any U.S. Coast Guard navigational requirements for the structure; and (4) the reefing proposal complies with Regional Engineering, Stability, and Environmental Reviewing Standards and Reef Approval Guidelines (http://www.gomr.boemre.gov/homepg/regulate/environ/rigs-to-reefs/Rigs-to-Reefs-Policy-Addendum.pdf).

The DWH event had immediate effects on recreational fishing in the GOM. By July 14, 2010, NOAA had closed 217,370 km^2 (83,927 mi^2) of the GOM to commercial and recreational fishing, or approximately 35% of the federally managed waters in the GOM (CRS 2010). Portions of Louisiana, Alabama, Mississippi, and Florida State waters have also been closed. These areas are some of the richest fishing grounds in the GOM for major species caught by recreational fishermen. Bookings and trips for recreational fishing charters have decreased, especially in Louisiana, and sport fishing tournaments have been cancelled (CRS 2010).

3.12.2.2 Alaska – Cook Inlet

Recreational fishing in the south central Alaska region includes marine sport fishing, freshwater fishing, and shellfish gathering activities, which together contribute substantially to the area's economy. Sport fishing in lower Cook Inlet is primarily for Pacific salmon, rockfish, cod, and Pacific halibut. Shellfish are collected near the shoreline as well. Kachemak Bay is particularly popular for recreational fishing, with halibut sport fishing in the Bay producing $8.7 million in angler expenditures in 1986 (Jones and Stokes Associates 1987), and for shellfish gathering. There is also a substantial salmon fishery in Kachemak Bay and in the rivers and streams flowing into Cook Inlet. Salmon fishing in the Kenai River, for example, generated up to $70 million annually in 1997 (Dorava 1999), while red salmon fishing in the Russian River generated $5.2 million in angler spending in 1986 (Jones and Stokes Associates 1987). Razor clams and other clams are gathered in Kachemak Bay and at various locations along the western side of the Kenai Peninsula and the shorelines bordering Cook Inlet.

In northern Cook Inlet, on the western bank, there exist recreational fisheries for razor clams and several species of hardshell clams, as well as Tanner crab and Dungeness crab. Extensive freshwater fishing also occurs throughout south central Alaska, and all five species of Pacific salmon can be found there, as well as trout, Arctic grayling, Dolly Varden, and northern pike. The Susitna River drainage is particularly important for recreational fishing in northern Cook Inlet.

3.12.2.3 Alaska – Arctic

There is little data on recreational fishing in the Beaufort and Chukchi Seas. The North Pacific Fishery Management Council concluded that there are few recreational fisheries in the Beaufort and Chukchi Sea Planning Areas. Sport fishing likely occurs at the larger population centers such as Barrow (NPFMC 2009). Any recreational fisheries that do occur in State waters would be regulated by Alaska State law. The available data is not adequate to determine the population trends in recreational and subsistence harvests in the Arctic Management Area.

3.13 TOURISM AND RECREATION

3.13.1 Recreational Resources

3.13.1.1 Gulf of Mexico

The GOM coastal zone is one of the major recreational regions of the United States, with marine fishing and beach-related activities particularly popular. The tourist industry contributed 620,000 jobs and more than $9 billion in wages to the GOM region (NMFS 2011e). The coasts of Florida, Alabama, Mississippi, Louisiana, and Texas offer diverse natural and developed landscapes and seascapes, and the beaches, barrier islands, estuarine bays and sounds, river deltas, and tidal marches are visited by residents of the GOM coast States and by tourists from throughout the United States and overseas. 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). Texas ranked fifth, with a little under 6.2 million participants, while in Alabama, Louisiana, and Mississippi (2.5 million, 2.2 million, and 1.8 million, respectively) participation was lower, but still significant.

3.13.1.2 Alaska – Cook Inlet

Opportunities for recreational activities such as hunting, hiking, boating, wildlife viewing, and sightseeing are abundant in the Cook Inlet area. Tour ships from the lower 48 States regularly traverse southeast Alaska, and many independent travelers use the Alaska Maritime Highway (ferry) system to access the subregion. Helicopter and small aircraft sightseeing tours have developed locally, along with a generally robust tourism sector. This includes a fleet of small regional tour ships, river jet-boat tours, fishing charters, bed-and-breakfast operations, and associated tourism-based enterprises (MMS 2006b).

The Kenai Peninsula and Prince William Sound are in close proximity to Cook Inlet and Anchorage, which is the population and logistical center of the State. Thus, these areas receive the heaviest recreational use, both by residents and nonresidents. The Kenai Peninsula has a developed road system and is directly connected to Anchorage. Prince William Sound also is connected by road to Anchorage via Whittier. Local boat tours of Prince William Sound and Kenai Fjords National Park are popular attractions. Cook Inlet and rivers and streams in the area, especially the Kenai River, are heavily fished by sport fishers. The Kenai Peninsula also is a popular hunting area. The Chugach National Forest attracts hikers, campers, and other users. An extensive tourism infrastructure is centered in Anchorage and extends into the surrounding region (MMS 2006b).

3.13.1.3 Alaska – Arctic

Tour groups to the North Slope Borough, primarily visiting Barrow or Deadhorse, make up most of the nonresident recreational activity. Both locations have lodging available, and Barrow has developed a limited tourism sector. Travel to these areas primarily is 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; 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 (MMS 2006b).

3.13.2 Beach Recreation

3.13.2.1 Gulf of Mexico

With 408 beaches in 22 coastal counties located on the GOM coast (USEPA 2004), beach visitation was the most important marine recreation activity, attracting tourists and residents for fishing, swimming, shelling, beachcombing, camping, picnicking, bird watching, and other activities. The Florida coast is the second longest in the United States, consisting of 13,518 km (8,400 mi) of tidally influenced shoreline, with approximately 1,328 km (825 mi) of sandy beaches on the Atlantic Ocean and GOM, attracting 15.2 million visitors in 2000. Tourists visiting Florida's beaches in 2000 spent approximately $21.9 billion, producing an indirect economic effect of $19.7 billion and a total economic impact of $41.6 billion (Florida Sea Grant 2005). Texas has 1,004 km (624 mi) of GOM coast, about 772 km (480 mi) of which are beach (National Resources Defense Council 2004), with 166 distinct beaches in 14 counties (USEPA 2004). Texas ranks fifth, with 3.9 million visitors. Most marine recreation occurs in Harris, Nueces, Cameron, and Galveston counties (NOAA 2005).

Louisiana has about 639 km (397 mi) of coastline and 12,426 km (7,721 mi) of tidal shoreline, behind only Alaska and Florida in length of marine shore. Louisiana's coastline is primarily wetlands, and much of the State's 19,829 km^2 (7,656 mi^2) of estuarine water is largely inaccessible to swimmers. There are 16 coastal beaches in seven counties along the GOM, half of which are in Cameron Parish (USEPA 2004). Louisiana beaches are primarily used by local and State residents, and use is highest during the spring and summer seasons (Louisiana Department of Health and Hospitals 2005). Over 600,000 visitors visited Louisiana beaches in 2000 (NOAA 2005). Mississippi's coastline on the GOM includes 578 km (359 mi) of beach bays, inlets, and promontories, and a series of low barrier islands, the largest being Cat, Ship, Horn, and Petit Bois Islands. The 12 coastal beaches in Harrison County, 6 in Jackson, and 3 in Hancock County (USEPA 2004) had over 1.0 million visitors in 2000 (NOAA 2005). Alabama has approximately 80 km (50 mi) of Gulf Beach (52 km [32 mi] in Baldwin County and 26 km [16 mi] on Dauphin Island) and an estimated 105 to 113 km (65 to 70 mi) of bay beaches, including Mobile Bay, Mississippi Sound, Perdido Bay, and Wolf Bay (Alabama Department of Environmental Management 2005) with a total of 95 coastal beaches in the State, 90 of which are in Baldwin County (USEPA 2004). In 2003, visitors to Baldwin County contributed more than $1.8 billion to the economy of the State (Gulf Shores and Orange Beach Tourism 2011), with more than 1.2 million visitors having visited Alabama beaches (NOAA 2005).

3.13.3 Recreational Benefits of Offshore Oil and Gas Platforms

3.13.3.1 Gulf of Mexico

The more than 4,000 petroleum structures in the northern GOM have provided significant benefits to recreational fishing (Brashier 1988). Witzig (1986) found that approximately 60% of the fish caught near structures within 5 km (3 mi) of the shore were kept, compared to less than 10% caught at sites with no oil and gas structures. The proportion of the catch kept on fishing trips greater than 5 km (3 mi) from shore was over 70% for trips to sites with oil and gas structures and approximately 35% to sites with no structures. Gallaway and Lewbel (1982) determined that structures constitute approximately 28% of the known hard bottom habitat off the Louisiana and Texas coasts.

Of the 11,911 boats observed fishing near major offshore structures off the Louisiana coast between April 1980 and March 1981, 10,881 were recreational boats (Ditton and Auyong 1984). This included 8,983 private fishing boats, 1,624 charter/party fishing boats, and 274 scuba boats. One charter boat operator in the northern GOM stated that he takes more than 10,000 people deep sea fishing annually, with all fishing activities on these trips conducted while tied up to oil and gas structures. Approximately one-quarter of all the offshore wean fishing originating in Texas, Louisiana, and Mississippi was directly associated with oil and gas structures. Ditton and Graefe (1978) found that oil and gas structures off the Texas coast attracted 87% of the boats and 50% of all offshore recreational fishing.

Research on sport fishing in the central GOM region suggests fishermen are often prepared to travel distances of up to 42 km (26 mi) to take advantage of reef fisheries established on oil and gas structures (Myatt and Ditton 1986), while Stanley and Wilson (1989) found larger travel distances of up to 80 km (50 mi) for platforms established under the Louisiana Artificial Reef Initiative, with distances travelled sometimes being as high as 167 km (104 mi). The highly specialized marine recreational fisherman profiled by Stanley and Wilson (1989) used equipment with sophisticated navigational and safety equipment in order to use reef structures located further offshore. Beyond 161 km (100 mi), structures have been used by fishermen drawn to deepwater habitat or for charter and commercial uses. More distant offshore locations were also found to benefit the tournament fishing community, who were prepared for more offshore travel than were non-tournament anglers (Gordon 1993).

Hiett and Milon (2001) estimated demand, expenditures, and economic impact associated with recreational fishing and diving near offshore oil and gas structures and artificial reefs created from these structures in Alabama, Mississippi, Louisiana, and Texas. Data came from field surveys of fishermen and divers using private, charter, and party boats. A subsample from each group received follow-up telephone interviews to obtain expenditure data. The survey data were combined with information from regional surveys of fishermen to generate State and regional estimates of aggregate expenditures. To expand the results from the sample to an estimate of impacts for the region, the authors relied on information from an annual survey conducted by the National Marine Fisheries Service. Their resulting estimates were that

$324.6 million in economic activity and 5,560 jobs in coastal counties of the GOM region resulted annually from fishing and diving activities near oil and gas structures.

3.13.3.2 Alaska – Cook Inlet and Arctic

Although offshore oil and gas structures in State waters may provide benefits to recreational fishermen and for diving, there is little documentation of visitation numbers, either by charter vessel or individual boating trips, and the distribution of fishing trips according to the depth of structures. Given the climatic restrictions on recreational fishing and especially on diving in the Arctic, the number of visitor trips to offshore areas is not known, but is likely to be small.

3.13.4 Recreation and Tourism Employment

3.13.4.1 Gulf of Mexico

Recreation and tourism are major sources of employment along the GOM coast, with total employment of 1,015,662 in these sectors (Table 3.13.5-1). The greatest concentration of tourism-related employment in 2008 was in Florida, with 46% of GOM coast region employment in the tourism and recreation sectors. Within the State, tourism-related employment is concentrated in the Miami and Tampa-St. Petersburg LMAs (MMS 2006b). Elsewhere in the GOM coast region, Texas had 31.9% of regional employment in tourism and recreational activities and Louisiana had 16.2%, with employment concentrated in the Houston-Galveston LMA and the New Orleans LMA (MMS 2006b).

3.13.4.2 Alaska – Cook Inlet

Recreation and tourism are major sources of employment in the south central Alaska region, with total employment of 21,302 in these sectors (Table 3.13.5-2). The greatest concentration of tourism-related employment in 2008 was in Anchorage, with 78.4% of south central Alaska region employment in the various tourism and recreation sectors.

3.13.4.3 Alaska – Arctic

Recreation and tourism are not major sources of employment in the Arctic region, with total employment of 619 in these sectors (Table 3.13.5-3). The greatest concentration of tourism-related employment in 2008 was in North Slope Borough, with 79% of Arctic region employment in the various tourism and recreation sectors.

TABLE 3.13.4-1 GOM Coastal Region Recreation and Tourism Employment Composition, 2008

Employment	Alabama	Florida	Louisiana	Mississippi	Texas	Total
Sporting goods retailers	353	6,155	2,715	224	6,269	15,716
Scenic tours	50	1,440	599	25	781	2,895
Automotive rental	221	9,582	2,406	110	4,866	17,185
Museums and historic sites	277	3,049	2,272	87	3,725	9,410
Amusement and recreation	2,085	44,670	14,052	4,036	24,801	89,644
Hotels and lodging places	3,001	74,192	24,351	14,895	27,087	143,526
RV parks and campsites	93	1,336	446	102	759	2,736
Eating and drinking places	21,542	326,287	117,648	13,333	255,740	734,550
Total	27,622	466,711	164,489	32,812	324,028	1,015,662

Source: USCB 2011f.

TABLE 3.13.4-2 South Central Alaska Region Recreation and Tourism Employment Composition, 2008

	Anchorage	Kenai Peninsula	Kodiak Island	Matanuska-Susitna	South Central Alaska Region Total
Sporting goods retailers	498	10	10	96	614
Scenic tours	175	80	10	60	325
Automotive rental	324	14	10	10	358
Museums and historic sites	156	60	60	4	280
Amusement and recreation	1,511	204	60	237	2,012
Hotels and lodging places	3,076	439	59	265	3,839
RV parks and campsites	60	60	10	43	173
Eating and drinking places	10,894	1,167	295	1,345	13,701
Total	16,694	2,034	514	2,060	21,302

Source: USCB 2011f.

TABLE 3.13.4-3 Arctic Region Recreation and Tourism Employment Composition, 2008

	North Slope Borough	Northwest Arctic Borough	Arctic Region Total
Sporting goods retailers	0	0	0
Scenic tours	0	0	0
Automotive rental	0	0	0
Museums and historic sites	0	0	0
Amusement and recreation	53	60	113
Hotels and lodging places	61	10	71
RV parks and campsites	0	0	0
Eating and drinking places	375	60	435
Total	489	130	619

Source: USCB 2011f.

3.13.5 Impact of Oil Spills on Recreation and Tourism

Oil from the DWH event reached many central GOM beaches, and visits to these areas in the immediate aftermath of the accident have decreased significantly; cancellations were reported for areas that are clear of oil, with the spill contributing to negative perceptions of the GOM region (CRS 2010). To counter these perceptions, BP has funded tourism promotion programs in Alabama, Mississippi, and Florida (CRS 2010). Although oil spills can have potentially devastating impacts on the marine and coastal environment, evidence of the longer-term impacts of spills on tourism and recreation in coastal areas impacted by oil spills is inconclusive. This information, however, is not needed at the programmatic stage to make a reasoned choice among alternatives (see Section 1.4, Analytical Issues).

Following the *Exxon Valdez* oil spill, visitor spending decreased 8% in south central Alaska and by 35% in southwest Alaska, resulting in an overall loss of $19 million in visitor spending (Alaska Visitor Statistics Program 1990a). Of all visitors who did travel to Alaska, 16% indicated that the spill influenced their trip planning; nearly half indicated they avoided Prince William Sound during their trip. One in 5 visitors to southwest and south central Alaska stated that their plans were affected significantly more than for other regions of the State. Independent visitors were more affected than package visitors, particularly those who planned to purchase sightseeing packages on arrival in Alaska (Alaska Visitor Statistics Program 1990b).

Another study found that 9% of high potential visitors reported the spill impacted travel into Alaska. As a result, 4% either changed or postponed their trip to Alaska in 1989. Of the population, 8% reported the spill impacted interest in travel to Alaska. As a result, 1% canceled, changed, or postponed a trip to Alaska in 1989. By March 1990, 5% of the general population reported the spill impacted interest in travel to Alaska, with 1% indicating that they did not want to travel to Alaska (Alaska Visitors Association 1990). The same research showed an estimated decline in visitation of 9,400 in the summer of 1989, representing a loss of $5.5 million in in-State expenditures. The 428,200 tourists visiting for vacation and pleasure or to visit friends and relatives in the summer of 1989 represents 97.8% of the total number of visitors who would have come to Alaska, meaning that only 2.2% of all vacation visits were negatively affected by the spill (Alaska Visitors Association 1990).

Perceptions of the extent of the impacts of the spill on the Alaskan economy seem to be in conflict with the results of visitor surveys. Using interviews, executives of tourist-affected businesses and relevant government agencies and organizations (The McDowell Group 1990) found decreased resident and nonresident vacation and pleasure visitor traffic in the spill-affected areas of Valdez, Homer, Cordova, and Kodiak due to lack of available accommodation, charter boats, and air taxis. Of the businesses surveyed in spill-affected areas, 43% felt their business had been significantly or completely affected by the oil spill. A severe labor shortage occurred in the visitor industry throughout the State due to traditional service industry workers seeking high-paying spill cleanup jobs, resulting in a higher cost of doing business among visitor industry businesses. Fifty-nine percent of businesses in the most spill-affected areas reported spill-related cancellations and 16% reported business was less than expected due to the spill. Business segments most negatively affected by the spill included lodges and resorts, Alaska-based tour companies, guided outdoor activities, and charter and sightseeing boats. These businesses did not have the opportunity to reap spill benefits (such as spending for accommodations) because they were located away from spill cleanup operations or operated a business that could not serve cleanup needs (The McDowell Group 1990).

There were major positive effects of the *Exxon Valdez* spill, with spill-related business in some major cleanup areas, and in recreation-related business sectors, such as hotels/motels, car and RV rental, air taxi and boat charters. This business offset the lack of vacation and pleasure business normally experienced in these areas (The McDowell Group 1990; USDOI 2002).

A study by Ellis et al. (1991) used the model proposed by David M. Dornbusch and Company (1987) to evaluate the impacts of the Huntingdon Beach, California, spill of 1990. The model was used to predict changes in beach recreational patterns in response to the closure of beaches due to an oil spill, with the results compared to independent estimates of actual impacts generated by the spill. As a result of cleanup activities and natural variations in terrain, individual beaches were closed for different lengths of time. Average beach closure times of 13.5 days in February and 3.1 days in March were used in the Dornbusch model. This results in a total of 2.28% of yearly beach attendance lost due to closures by the spill.

In the area most physically impacted by the spill, the Dornbusch model estimated a loss in water-based recreation (water-enhanced plus water-dependent) of 720,210 user days, representing a total loss of 2.28% of the yearly recreation days. Immediately south of the impacted area, there was an estimated decrease of 5,448 user days for water-based beach recreation, while immediately north of the impacted area, there was an estimated increase of 46,680 user days. There were significant increases in attendance in other beach areas. The associated consumer surplus changes for the impacted beach areas were $4,959,012 for combined water-dependent and water-enhanced recreation in the main area of impact, an increase of $253,695 in the area immediately south, and a decrease of $56,661 for the area immediately to the north. Total statewide consumer surplus decreased by $1,106,667, a 3.4% decrease from the baseline value of $32,355,916.

Oil spills present a unique set of impacts on recreation relative to the various forms of OCS development activity (A.T. Kearney, Inc. 1991). Whereas industrial development and other scenarios create permanent aesthetic impacts, oil spills are random events that have impacts for only a limited period of time. An oil spill is not considered to have a long-term impact on tourism, but would have larger impacts in the period immediately following an accident and smaller residual impacts in the succeeding months. While it is recognized that long-term ecological effects may occur, past experience with spills indicates that visitation returns to baseline levels within a number of years.

More recent research has focused on the relationship between the possibility of oil spills and the potential for a spill to degrade marine resources and inhibit recreation and tourism. Pulsipher et al. (1999) examined the social and economic impacts of a 5,000 bbl oil spill that occurred offshore in the Lake Barre region of the Louisiana coast in 1997. Based on interviews and information obtained from Texaco (responsible for cleanup), the cleanup contractors, and local area officials, business owners, and residents, the short-term social and economic effects were quite small. The major negative effect was a concern about long-term impacts on marine resources (shrimp, oysters, and fish), but there was no local consensus about whether such effects had occurred.

Although much has been learned in the aftermaths of major oil spills in the past several decades, and the nature and extent of their impacts, despite the attenuation of information from the media and other sources, social amplification of risk has tended to reduce public acceptance of the continued risk of oil production and oil transport by sea, at least in the short term (Leschine 2002) with the consequent potential impacts on recreation and tourism.

3.14 SOCIOCULTURAL SYSTEMS AND SUBSISTENCE

Sociocultural systems consist of the beliefs, ideas, tools, and behavioral patterns including social structure, culture, and institutional organizations that humans use to adapt to their physical and social environments. The sociocultural systems considered here are mostly associated with ethnic and social groups living along the coasts of the GOM and Alaska. While these coasts share the potential for offshore oil and gas development, they are ethnically and demographically dissimilar and are treated somewhat differently here. For example, the northern coast of Alaska is sparsely inhabited. Widely spaced Alaska Native communities dot the coast. They are largely isolated from enclaves of transient oil and gas workers. Few are employed in the oil and gas industry, while many are culturally and economically reliant on subsistence hunting and fishing. While subsistence harvesting exists along the GOM coast, it is of minor cultural and socioeconomic importance. Unlike Alaska's north coast, the offshore oil and gas industry is well developed and draws the majority of its workforce from the GOM coast counties. This relationship is discussed in the sections that follow. South central Alaska supports a more ethnically diverse population than the North Slope and includes isolated Alaska Native villages, ethnically diverse towns and cities dependent on commercial fishing, and a well-developed offshore oil and gas industry along with its supporting infrastructure.

3.14.1 Gulf of Mexico

3.14.1.1 Sociocultural Systems

The counties along the U.S. coast of the GOM are home to a large and heterogeneous mix of cultures, subcultural groups, and populations. Within this region, the effects of the offshore oil and gas industry are felt most directly by populations residing within the coastal community commuting zone where industry-support facilities are located and the people who work at them reside (see Figure 3.14.1-1). Coastal cultures and populations include Hispanic enclaves in southern Texas, Acadian (Cajun) and Native American populations in the bayou country of southern Louisiana, Vietnamese communities along the coast of Texas, Louisiana, and Mississippi, and substantial Caucasian and African American populations (see tables and maps in Sections 3.10.1 and 3.15.1). Native American populations include federally recognized (Table 3.14.1-1) and State-recognized tribes (Table 3.14.1-2). The metropolitan areas of the GOM coast are located in estuaries and are set back from the open coast. They have well-developed port facilities, with waterborne commerce playing an important role in their economies. Cities such as Houston and New Orleans and their surrounding suburban communities have served as destinations of opportunity and have attracted racially and ethnically diverse populations. However, many smaller communities maintain sociocultural environments that are less diverse, often supporting a single or small number of cultural groups in their most important activities. Beginning in the 1930s (and increasingly after World War II), coastal populations have been involved in the oil and gas industry to varying degrees.

Involvement in oil and gas industry activities has been uneven along the coast. Some areas are heavily involved, while other communities have little or no involvement. There is thus variability in the effects of the ups and downs of the industry’s business cycle. However, there do appear to have been aggregate effects. These include rapid migration of workers in and out of communities, volatility in social problems, and volatility in income distribution patterns. Communities with dense social networks based on kinship, culture, and other enduring relationships are less affected by industry volatility (Tootle et al. 1999).

The most heavily affected areas are located within the States of Texas and Louisiana, where both upstream and downstream activities are concentrated. Beginning in the early 1930s, the oil industry attracted new workers to Louisiana, affecting the ethnic composition, self-identity, and cultural persistence of groups already in the area and contributing to a rich ethnic mix, as both the immigrants and receiving communities adjusted socially and culturally through the assimilation process. Industry development has also affected the identity of existing ethnic groups. Blue collar jobs in the oil and gas industry have helped to maintain the Cajun culture in Louisiana. However, involvement in the oil and gas industry has affected some aspects of certain cultures. For example, the discouragement of the use of Cajun French on oil rigs and supply boats has reduced the usage of this language in coastal Louisiana (Henry and

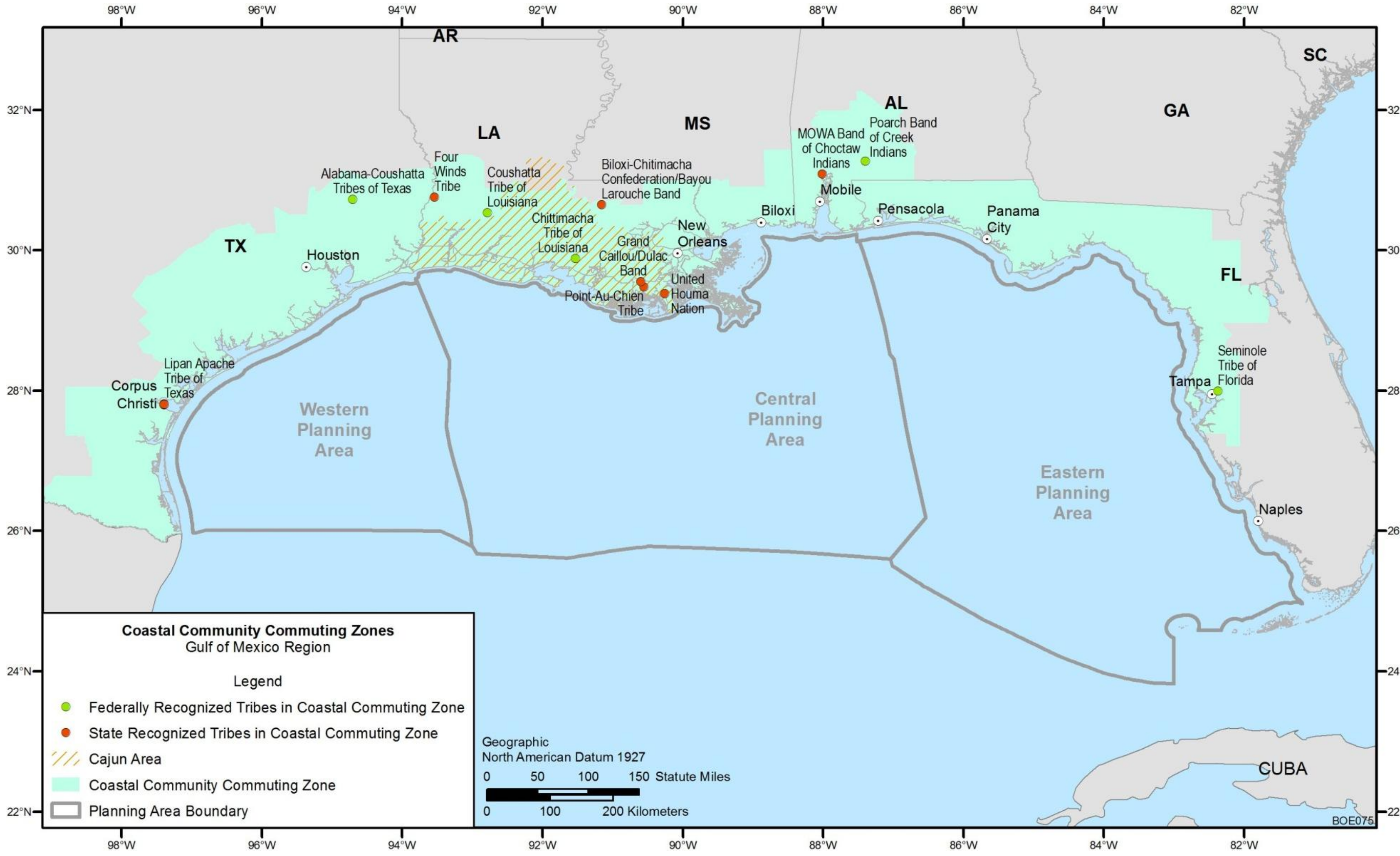


FIGURE 3.14.1-1 GOM Coastal Community Commuting Zone

TABLE 3.14.1-1 Federally Recognized Tribes in the Coastal Community Commuting Zone

State	County/Parish	Tribe
Alabama	Escambia	Poarch Band of Creek Indians
Florida	Escambia	Poarch Band of Creek Indians
Florida	Hillsborough	Seminole Tribe of Florida
Louisiana	Allen	Coushatta Tribe of Louisiana
Louisiana	St. Mary	Chittimacha Tribe of Louisiana
Texas	Polk	Alabama-Coushatta Tribes of Texas

Source: NPS 2010.

TABLE 3.14.1-2 State-Recognized Tribes in the Coastal Community Commuting Zone

State	County/Parish	Tribe
Alabama	Mobile	MOWA Band of Choctaw Indians
Louisiana	East Baton Rouge	Biloxi-Chitimacha Confederation/ Bayou Larouche Band
Louisiana	Vernon	Four Winds Tribe
Louisiana	Terrebonne	Point-Au-Chien Tribe
Louisiana	Lafourche	United Houma Nation
Louisiana	Terrebonne	Grand Caillou/Dulac Band
Texas	Nueces	Lipan Apache Tribe of Texas

Sources: AIAC 2011; FGCIA 2011; LATT 2009; LGOIA 2011.

Bankston 2002). While the oil and gas industry brought an increased exposure of the Cajun communities to a wider cultural mix and resulted in the adoption of some characteristics of broader American culture, the exposure to outsiders also reinforced behaviors held to be characteristically Cajun, including festivals and the preparation of certain foods such as crawfish (Esman 1982).

3.14.1.2 Subsistence and Renewable Resource Harvesting

The coastal estuaries along the GOM have long provided a wealth of wild resources suitable for harvesting. While the bulk of the harvest currently comes in the form of commercial shrimping, fishing, and oystering, traditional subsistence harvesting including fishing and hunting continues among some ethnic groups and low-income minorities (Hemmerling and Colton 2004). In the words of Tim Melancon, a Cajun shrimper, “We’re the last of the Mohicans. We still live off the land. Everything we need is right here” (Tidwell 2003).

Although most Cajuns are now urban dwellers with blue collar jobs, the cultural ideal of harvesting the bounty of the bayous remains and is practiced recreationally (Henry and Bankston 2002). Native American groups such as the State-recognized 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 (Brightman 2004; Campisi 2004). Despite being primarily commercial fishers, Vietnamese fishers normally retain up to 25% of their catch for family use and for barter (Alexander-Bloch 2010). These minority communities might have specific concerns related to their sociocultural welfare now and following disturbances to existing conditions, such as from a large hurricane or oil spill (Picou 2010; Yeoman 2010).

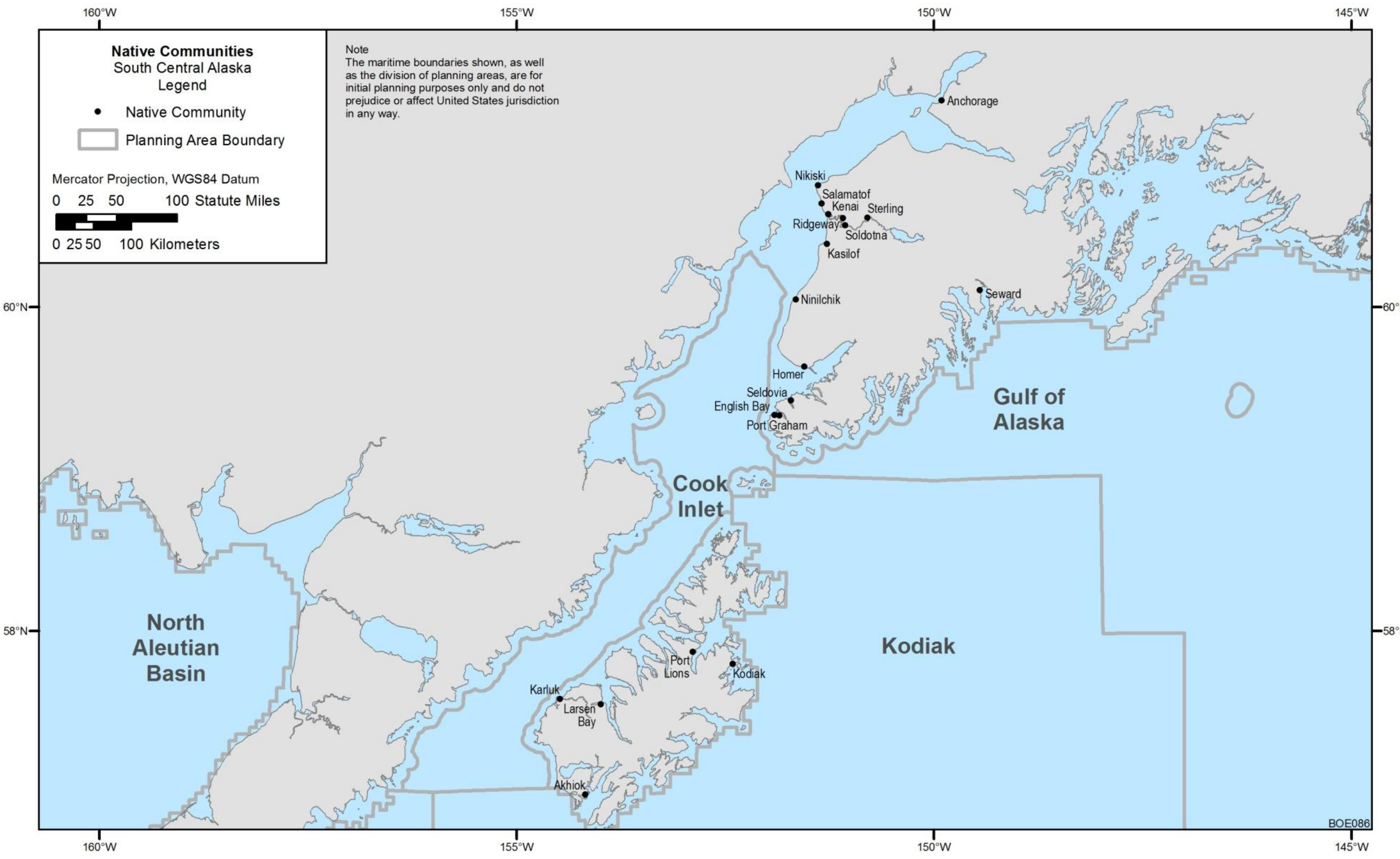
3.14.2 Alaska – Cook Inlet

3.14.2.1 Sociocultural Systems

The region surrounding the Cook Inlet Planning Area, referred to as south central Alaska, including both the southern portions of Cook Inlet and the Shelikof Strait, is quite diverse (Figure 3.14.2-1). It 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, on the Kenai Peninsula, as well as commercial fishing; smaller towns such as Port Lions that are dependent on commercial fishing; and small, predominantly Alaska Native communities. The northern Knik Arm of Cook Inlet extends into the Borough of Matanuska-Susitna (Mat-Su), which includes both urban communities tied to Anchorage and remote rural settlements. Subsistence harvesting plays some role in communities of all types.

Anchorage is the major service center for the area. It is located between the Knik and Turnagain Arms of upper Cook Inlet northeast of the Cook Inlet Planning Area. Oil and Gas activities in the Cook Inlet Planning Area would affect Anchorage to the extent that they affect the waters of the upper inlet and the oil and gas companies located in the Anchorage area. It is the center of the local road network and serves as a hub for scheduled and charter air traffic. Although majority Caucasian, it is home to significant Alaska Native, Asian, Black, and Hispanic populations. It is the center of commerce for the State, serving as the headquarters for the oil and gas industry, finance and real estate, communications, government offices, and military facilities, as well as much of the tourist industry (DCRA 2011). In spite of its urban character, the Anchorage community partakes in Alaskan values of independence and accessibility to the wild and remote. The ADFG estimates that 34 Anchorage households currently participate in subsistence harvesting (ADFG 2011e).

Lying north of Anchorage, the Mat-Su Borough, although including the northern reach of Knik Arm, is farther from the Cook Inlet Planning Area. Activities in the planning area would affect Mat-Su communities in much the same way as they would the Anchorage area. Palmer and Wasilla are major Mat-Su communities. Connected to Anchorage by the road network, they serve partly as bedroom communities for Anchorage, but also are home to a variety of retail,



Note
The maritime boundaries shown, as well as the division of planning areas, are for initial planning purposes only and do not prejudice or affect United States jurisdiction in any way.

FIGURE 3.14.2-1 Native Communities around Cook Inlet service, and light manufacturing enterprises. Seventy-seven Palmer residents have commercial fishing permits and could be affected by oil and gas activities in Cook Inlet (DCRA 2011). The ADFG has tracked subsistence use in four Mat-Su communities. Subsistence harvest includes marine resources (ADFG 2011e), indicating that subsistence users are harvesting in areas beyond the upper inlet, very likely within the planning area.

The Kenai Peninsula forms the southeastern coast of Cook Inlet and has direct access to the Cook Inlet Planning Area from its southern end. The Kenai-Soldota area (Kenai, Soldotna, Nikiski, Sterling, Ridgeway, and Kasilof) serves as a diversified center for the central Kenai Peninsula. Homer serves as a smaller-scale hub for the southern part of the peninsula. All communities on the peninsula except those lying south of Katchemak Bay are connected to Anchorage by a road network. Most communities are of mixed ethnicity or predominantly non-Native. Small communities that are not connected to the road network include Tyonek, Nanwalek, Port Graham, and Seldovia. These four communities share many of the same characteristics as communities in the less economically developed areas of the State. All but Seldovia are predominantly Alaska Native with limited commercial economic activities primarily related to fishing and fish processing. Tyonek is a Dena'ina village, while Nanwalek and Port Graham are Chugachmuit. In these communities, subsistence activities retain significant importance and reinforce their fundamental kin-based social organization.

The Cook Inlet Planning Area extends southwest beyond Cook Inlet proper and includes the heart of the Shelikof Strait. The Shelikof Strait lies between Kodiak Island and the Alaska Peninsula. The small communities along the northwestern coast of Kodiak Island, Ahiok, Karluk, Larsen Bay, and Port Lions are reachable only by sea and by air. Similar to the small isolated communities on the Kenai Peninsula, they have a high proportion of Alaska Native inhabitants and rely mostly on commercial fishing and subsistence harvesting (DCRA 2011). Given their reliance on marine resources, these communities have the potential to be directly affected by oil and gas development in the Cook Inlet Planning Area.

At the time of European contact, the area around Cook Inlet was inhabited by Dena'ina Athabascans. The southern end of the Kenai Peninsula was inhabited by the Chugachmuit, while Kodiak Island and the southwestern shores of the inlet were inhabited by Koniagmiut. The area covered by Cook Inlet Region, Inc. (CIRI), a regional Alaska Native corporation established under the ANCSA, closely follows traditional Dena'ina lands, but draws its membership from a cross section of Native cultures whose descendants now live in the Anchorage metropolitan area. Table 3.14.2-1 lists south central Alaska communities with Alaska Native populations (DCRA 2011).

3.14.2.2 Subsistence

Alaskans generally place a high value on being able to hunt, fish, and to live off the land, if desired. The Alaska Constitution guarantees equal access to fish, wildlife, and waters for all State residents. Traditionally, Alaska Natives hunted, fished, and lived off the land of necessity. They view subsistence hunting and gathering as a core value of their traditional cultures. For them, most subsistence activities are group activities that further core values of community,

TABLE 3.14.2-1 Alaska Natives in Communities around the Cook Inlet

Community	Population (2010)	Percent Native	Local Native Corporation	Federally Recognized Tribal Government	Incorporated?
Cook Inlet Region Inc.					
Anchorage	291,826	8	None	None	1920
Big Lake	529	23	None	None	No
Chickaloon	272	6	Chickaloon-Moose Creek Native Association	Chickaloon Native Village	
Eklutna	384	13	Eklutna, Inc.	Native Village of Eklutna	No
Fishhook	4,679	4	None	None	No
Glacier View	234	1	None	None	No
Houston	1,912	7	None	None	1966
Kenai	7,100	9	Kenai Natives Association, Inc.	Kenaitze Indian Tribe	1960
Knik Fairview	14,923	5	Knikatnu, Inc.	Knik Tribal Council	No
Knik River	744	4	None	None	No
Lake Louise	48	2	None	None	No
Ninilchik	883	5	Ninilchik Native Association, Inc.	Ninilchik Traditional Council	No
Palmer	5,937	9	Montana Creek Native Association		
Point Mackenzie	529	23	None	None	No
Salamatof	980	18	Salamatof Native Association, Inc.	Native Village of Salamatof	No
Seldovia	255	14	Seldovia Native Association, Inc.	Seldovia Village Tribe	1945
Trapper Creek	481	6	None	None	No
Tyonek	171	88	Tyonek Native Corp.	Native Village of Tyonek	No
Wasilla	7,831	5			1951
Chugach Alaska Corp.					
Nanwalek	254	80	English Bay Corporation	Native Village of Nanwalek	No
Port Graham	177	71	Port Graham Corp.	Native Village of Port Graham	No
Koniag, Inc.					
Akhiok	71	51	Ayakulik Inc.	Native Village of Ahiok	
Karluk	37	95	None	Native Village of Karluk	
Larsen Bay	87	71	None	Native Village of Larsen Bay	
Port Lions	194	59	Afognak Native Corp.	Native Village of Port Lion	

Source: DCRA 2011.

kinship, cooperation, and reciprocity. In Alaska, State and Federal definitions of subsistence and who is permitted to participate in the subsistence harvest differ. The ADFG defines subsistence fishing as "the taking of, fishing for, or possession of fish, shellfish or other fisheries resources by a resident of the State for subsistence uses [customary and traditional uses of fish]" (ADFG 2011f). Current Federal regulations define subsistence use as "the customary and traditional use by rural Alaska residents of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools of transportation; for making and selling handicraft articles out of inedible byproducts of fish and wildlife resources taken for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade" (FSMP 2010). The State definition makes subsistence harvesting available to all Alaska residents, while Federal land managers restrict the harvest to those whose primary residence is rural, and may restrict a particular harvest area to a specified community or group of communities. The entire State is defined as rural except for designated non-rural areas (FSMP 2011). Priority for subsistence harvesting in land management is expressed in the ANILCA, passed by Congress in 1980. Similar State legislation was struck down as violating the State Constitution. ANILCA now applies only to Federal lands. Both approaches to subsistence are represented in south central Alaska.

Subsistence resources on Federal lands and waters are managed by the Federal Subsistence Board (FSB). For some resources in certain areas, the FSB has determined that all rural Alaskans are qualified subsistence users. For other areas, the FSB has made more restrictive "customary and traditional" determinations of eligibility. For example, only the communities of Copper Landing, Hope, and Ninilchik may harvest salmon with dipnets in the Kenai River drainage. *Customary and traditional use* means "a long-established, consistent pattern of use, incorporating beliefs and customs transmitted from generation to generation. This use plays an important role in the economy of the community" (FSMP 2011).

Some marine resources are subject to Federal regulation. Subsistence hunting of marine mammals is governed by the MMPA, and is restricted to Alaska Natives who reside on the coast of the North Pacific Ocean or the Arctic Ocean. Halibut may be harvested by residents of rural communities through the Federal subsistence halibut program (ADFG 2011f).

While the State of Alaska makes regulated subsistence harvesting available to all residents of at least a year, it also designates some areas as nonsubsistence use areas. Alaska statutes define nonsubsistence use areas as "areas where dependence upon subsistence (customary and traditional uses of fish and wildlife) is not a principal characteristic of economy culture and way of life" (AS 16.05.258(c)). In south central Alaska, the Anchorage-Mat-Su-Kenai Nonsubsistence Use Area includes FSB-designated non-rural areas in Anchorage, the Mat-Su Borough, and on the Kenai Peninsula. The State does allow "personal use" fisheries within nonsubsistence use areas. Alaska defines "personal use" fishing 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" (ADFG 2011f). Personal use harvest is for food rather than sport. It is illegal to buy, sell, trade or barter personal use finfish, shellfish, or aquatic plants.

A discussion of subsistence in and around the Cook Inlet Planning Area must take into account, both Native and non-Native populations, urban and rural communities, Federal and State jurisdiction; and the Anchorage-Mat-Su-Kenai Nonsubsistence Use Area, and personal use fisheries. The Anchorage-Mat-Su-Kenai Nonsubsistence Use Area includes all but the southern tip of the Kenai Peninsula, State waters within Cook Inlet, and Anchorage and its suburbs and extends northward into Mat-Su Borough as far as Chickaloon, Talkeetna, and Petersville. Although subsistence harvesting is excluded from this area, personal use fishing does provide opportunities for harvesting fish with gear other than rod and reel within nonsubsistence areas at designated locations and in designated seasons. These include a salmon fishery off the mouth of the Kenai River, a razor clam fishery on the beaches between Homer and Kenai, and a hooligan and herring fishery in Cook Inlet (ADFG 2011f). The urban Anchorage area is home to 42% of the State's population. Its residents hunt and fish under personal use, sport, and subsistence regulations in other parts of the area, especially the Kenai Peninsula.

These hunting and fishing options are available to Alaska residents living in Mat-Su as well. The small Caucasian community of Chase, located just outside the nonsubsistence area, relies almost entirely on subsistence harvesting and gardening, and Trappers Creek with a small Native population, relies substantially on subsistence harvesting as well (DCRA 2011) (see Table 3.14.2-1). The most recent subsistence harvest data for Mat-Su communities dates to the 1980s (Table 3.14.2-2). While the bulk of the harvested species reported are terrestrial species or anadromous fish, subsistence harvesters were taking marine finfish and shellfish as well, suggesting that the effects of gas and oil activities in the Cook Inlet Planning Area would not be confined to communities directly on the coast.

In the predominantly Alaska Native communities (Table 3.14.2-1) adjacent to the planning area — Port Graham, Nanwelek, Tyonek, Akhiok, Karluk, Larsen Bay, and Port Lions — subsistence resources are an important part of household economy in terms of variety, amount, and sharing (see Table 3.14.2-3). The communities connected to the road network are of mixed ethnicity or predominantly non-Native and display somewhat different patterns of subsistence resource use.

Many species, often migratory species, play an important role in the annual cycle of subsistence-resource harvests. Thus, specific effects on subsistence can be serious, depending on the season in which they occur. Seasonally specific effects on subsistence can be serious, even if the annual net quantity of available food does not decline. Subsistence use patterns vary considerably in and adjacent to the Cook Inlet Planning Area. Smaller, more traditional villages harvest salt and freshwater fishes and small sea mammals in summer and fall, hunt moose in the fall, and harvest invertebrates and some sea mammals all year. Residents in the more urban-based communities tend to fish in the summer and hunt in the fall.

Where Alaska Natives are located in urban areas, such as the Kenaitze Indian Tribe, located in Kenai, a yearly Educational Fishery Permit has been issued so that they can instruct the younger generation in traditional food harvesting and preparation skills. In 2008, a quota of 8,000 salmon was allotted to the Kenaitze Tribe during a season lasting from May 1 to November 30 (Kenaitze Indian Tribe 2011). In 2010, due to low escapement numbers in the

TABLE 3.14.2-2 Reported Subsistence Use at Mat-Su Borough Communities

Resource	Scientific Name	Chase 1986	Chickaloon 1982	Lake Louise 1987	Trapper Creek 1985
Marine Mammals		–	–	–	–
Terrestrial Mammals					
Deer	Species not reported	X	–	X	–
Bison	*Bison bison*	–	X		X
Dall Sheep	*Ovis dalli*	X	–	–	–
Moose	*Alces alces*	X	X	X	X
Brown Bear	*Ursus arctos*	X	–	X	–
Black bear	*Ursus americanus*	X	X	X	X
Fox	Species not reported	X	X	X	X
Wolf	*Canis lupus*	X	–	X	–
Coyote	*Canis latrans*	X	X	–	–
Wolverine	*Gulo gulo*	X	–	–	–
Porcupine	*Erethizon dorsatum*	X	X	–	X
Beaver	*Castor Canadensis*	X	X	–	X
Marten	*Martes* spp.	X	X	X	X
Mink	Species not reported	X	–	X	X
Weasel	Species not reported	X	–	X	–
Hare	Species not reported	X	X	–	X
Land otter	*Lutra canadensis*	X	–	–	–
Muskrat	*Ondatra zibethicus*	–	X	–	–
Fish					
Salmon	Species not reported	X	X	X	X
Chum	*Oncorhynchus keta*	X	–	–	X
Pink (humpback)	*O. gorbuscha*	X	X	–	X
Silver (coho)	*O. kisutch*	X	X	X	X
Chinook	*O. tshawytscha*	X	X	X	X
Sockeye	*O. nerka*	X	X	X	X
Herring	*Clupea* spp.	X	–	–	–
Halibut	*Hippoglosus* spp.	X	–	X	X
Dolly varden	*Salverlinus mallma miyabei*	X	X	–	–
Char	Species not reported	X	–	X	–
Rock fish	Species not reported	–	–	X	–
Trout	Species not reported	X	X	–	X
Lake trout	*Salvelinus namaycush*	X	X	X	–
Smelt	Species not reported	X	X	–	–
Pacific cod	*Gadus macrocephalus*	–	–	–	X
Burbot	*Lota lota*	X	X	X	–
Pike	Species not reported	–	–	X	–
Grayling	*Thymallus arcticus*	X	X	X	X
Greenling	Species not reported	–	X	–	–
White fish	*Coregonus* spp.	X	–	X	X
Eulachon	*Thaleichthys pacificus*	X	X	–	–

TABLE 3.14.2-2 (Cont.)

Resource	Scientific Name	Chase 1986	Chickaloon 1982	Lake Louise 1987	Trapper Creek 1985
Marine Invertebrates					
Mussels	Species not reported	–	–	–	X
Clams	Species not reported	X	–	–	X
Crab	Species not reported	X	–	–	–
Shrimp	Species not reported	X	–	–	–
Birds		X	X	X	X
Ducks	Species not reported	X	X	X	X
Mallard	*Anas platyrhynchos*	–	X	–	–
Geese	Species not reported	X	–	–	–
Ptarmigan	*Lagopus* spp.	X	X	X	X
Grouse	Species not reported	X	X	X	X
Other Resources					
Berries	Species not reported	X	X	X	X
Greens/roots/mushrooms	Species not reported	X	X	X	X
Wood	Species not reported	X	–	X	–

Source: ADFG 2011e.

Ninilchik River, the Ninilchik Village Tribe was allotted 100 king salmon and 200 coho salmon during an educational fishery season lasting from May 1 through May 20 (NTC 2010).

Residents of Seldovia, Port Graham, and Nanwalek are the primary subsistence harvesters of the lower Kenai Peninsula, and, since the *Exxon Valdez* oil spill fouled local traditional clamming areas, residents of Nanwalek and Port Graham have used the area around Ninilchik for the harvest of clams. Subsistence harvesting of fish, wildlife, and vegetation also occurs at the head and along the southern shore of Kachemak Bay. Area residents harvest seals, sea lions, and sea otters around Yukon Island and Tutka Bay. Primary waterfowl harvest areas are in the vicinity of Seldovia, Tutka, and China Poot Bays and McKeon and Fox River flats. Seabirds and their eggs also are harvested. Moose, black bear, and mountain goats are hunted along local shorelines. Port Graham and Nanwalek residents harvest salmon in Nanwalek and Koyuktolik (“Dogfish”) Bays. Seldovians gather berries in larger quantities than any of the other Kenai Peninsula subsistence communities (ADNR 1999).

Resources preferred by Nanwalek and Port Graham residents include clams, chitons, bear, and especially salmon. These provide large quantities of food during a short period of the year that can be preserved for use throughout the remainder of the year. A combination of commercial, subsistence, personal use, and rod-and-reel fisheries provide salmon for domestic use. Residents of Nanwalek and Port Graham participate in permitted general subsistence and

TABLE 3.14.2-3 Reported Subsistence Use at Selected Alaska Native Villages Adjacent to the Cook Inlet Planning Area

Resource	Scientific Name	Nanwalek 2003	Port Graham 2003	Tyonek 2006	Akhiok 2003	Larsen Bay 2003	Poort Lions 2003
Marine Mammals							
Harbor seal	*Phoca vitulina*	X[a]	X	X	X	X	X
Steller sea lion	*Eumetopias jubatus*	X	X	X	X	—	—
Beluga whale	*Delphinapterus leucas*	—[a]	—	X	—	—	—
Bowhead whale	*Balaena mysticetus*	—	—	X	—	—	—
Sea otter	*Enhydra lutris*	X	X	—	—	—	X
Terrestrial Mammals							
Deer	Species not reported	—	X	X	X	X	X
Moose	*Alces alces*	—	X	X	—	—	X
Elk	*Cervus canadensis*	—	—	—	—	—	X
Black bear	*Ursus americanus*	X	X	X	—	—	—
Fox	Species not reported	—	—	X	—	—	X
Porcupine	*Erethizon dorsatum*	X	X	X	—	—	—
Beaver	*Castor Canadensis*	—	—	X	—	—	X
Coyote	*Canis latrans*	—	—	X	—	—	—
Snowshoe hare	*Lepus americanus*	—	—	—	—	X	X
Fish							
Salmon	Species not reported	X	X	X	X	X	X
Chum	*Oncorhynchus keta*	X	X	X	X	X	X
Pink (humpback)	*O. gorbuscha*	X	X	X	X	X	X
Silver (coho)	*O. kisutch*	X	X	X	X	X	X
Chinook	*O. tshawytscha*	X	X	X	—	—	—
Sockeye	*O. nerka*	X	X	X	X	X	X
Steelhead	*O. mykiss*	—	—	—	—	X	X
Herring	*Clupea* spp.	—	X	X	—	X	X
Halibut	*Hippoglosus* spp.	X	X	X	X	X	X
Dolly varden	*Salverlinus mallma miyabei*	X	X	X	X	X	X
Char	Species not reported	X	X	X	X	X	X
Rock fish	Species not reported	X	X	—	X	X	X
Sculpin	Species not reported	X	—	—	—	—	—
Trout	Species not reported	X	—	X	—	X	X
Smelt	Species not reported	X	X	X	—	—	—
Pacific cod	*Gadus macrocephalus*	X	X	—	X	X	X
Tomcod	*Eleginus gracilis*	X	X	X	—	—	—
Flounder	*Liopsetta glacialis*	X	X	—	—	—	X
Eel	Species not reported	X	X	—	—	—	—
Walleye Pollock	*Theragra chalcogramma*	—	—	—	—	—	X
Greenling	Species not reported	—	—	—	—	—	X
Shark	Species not reported	—	—	—	—	—	X
Sole	*Hippoglossoides elassodon*	—	—	—	—	—	X

TABLE 3.14.2-3 (Cont.)

Resource	Scientific Name	Nanwalek 2003	Port Graham 2003	Tyonek 2006	Akhiok 2003	Larsen Bay 2003	Poort Lions 2003
Marine Invertebrates							
Chitons	Species not reported	X	X	—	X	—	—
Limpets	Species not reported	X	—	—	—	—	—
Mussels	Species not reported	X	X	—	—	—	X
Clams	Species not reported	X	X	X	X	X	X
Oysters	Species not reported	—	X	—	—	—	—
Snails	Species not reported	X	X	—	—	X	—
Crab	Species not reported	X	—	—	X	X	X
Shrimp	Species not reported	X	—	—	—	—	—
Cockles	Species not reported	—	—	—	X	—	—
Sea urchins	Species not reported	—	—	—	X	—	X
Octopus	Species not reported	X	X	—	—	—	—
Birds							
Ducks	Species not reported	X	X	X	X	X	X
Mallard	*Anas platyrhynchos*	X	X	X	X	X	X
Pintail	*Anas acuta*	—	—	X	—	—	—
Canvasback	*Aythya valisineria*	—	—	X	—	—	—
Eider	*Somerteria* spp.	—	—	—	—	—	X
Bufflehead	*Bucephala albeola*	—	—	—	—	—	X
Gadwall	*Anas strepera*	—	—	—	—	—	X
Harlequin	*Histrionicus histrionicus*	—	—	—	—	—	X
Green-winged teal	*Anas carolinensis*	—	—	X	X	—	X
Scoter	Species not reported	X	X	—	—	—	X
Merganser	*Mergus merganser*	—	X	—	—	—	X
Goldeneye	*Bucephala* spp.	—	X	—	X	X	X
Snow goose	*Chen caerulescens*	—	—	X	—	—	—
Canada goose	*Branta canadensis*	—	—	X	—	—	X
Emperor goose	*Chen canagica*	—	—	—	X	—	—
Sandhill crane	*Grus canadensis*	—	—	X	—	—	—
Ptarmigan	*Lagopus* spp.	—	—	X	X	—	X
Grouse	Species not reported	X	X	X	—	—	—
Gulls	Species not reported	X	—	—	—	—	—
Other Resources							
Kelp	Species not reported	X	X	—	—	—	X
Berries	Species not reported	X	X	X	X	X	X
Bird eggs	Species not reported	X	X	X	X	X	X
Gull eggs	Species not reported	X	X	X	X	X	X
Greens/roots/mushrooms	Species not reported	X	X	X	X	X	X
Wood	Species not reported	X	X	X	X	X	X

[a] X = Reported; — = Not reported.

Source: ADFG 2011e.

personal-use fisheries that have existed in upper Cook Inlet since 1991 and are open to Natives and non-Natives. Dipnet fisheries take place on the Kenai and Kasilof Rivers and on Fish Creek. A set gillnet fishery takes place on the Kasilof River beginning June 21. In addition, a general Kachemak Bay subsistence and personal-use salmon fishery has taken place since before statehood. This fishery uses Fox River drainage salmon runs and hatchery stocks returning to the fishing lagoon on Homer Spit and to Fox Creek (ADNR 1999).

Other resources such as trout, cod, halibut, chitons, snails, whelks, and crabs are consumed fresh in season. Harbor seals and sea lions are highly valued marine mammals, are harvested by local Alaska Native residents year-round, and are extensively shared by the Alaska Natives in any community. A variety of plants also are harvested in Kachemak Bay and Cook Inlet. Bull kelp, rockweed, and brown seaweeds are collected from intertidal areas, and shoreline areas provide seaside plantain, rye grass, beach pea, wild parsley, and cow parsnip. Seldovia, Kasitsna, and Jakolof Bays are important areas for the harvest of marine invertebrates.

The Native villages on Kodiak Island rely on a varying mix of commercial fishing, fish processing, tourism, and subsistence harvesting. While the extent to which they rely on subsistence varies, all of these villages rely on subsistence harvesting to a greater or lesser degree. Salmon and halibut are subsistence mainstays, as are seals and migrating birds along with invertebrates such as clams and crabs (Table 3.14.2-3) (DCRA 2011).

Often overlooked, gardening has been part of village subsistence life since Russian times. Potatoes, cabbage, and turnips were brought to the Kenai Peninsula by Russian settlers who planted gardens due to the need for fresh vegetables (Fall 1981). A variety of local wild berries are picked, particularly low- and high-bush cranberries, rosehips, blueberries, moss berries, and wild raspberries. Locally harvested subsistence foods are distributed widely among community households.

Tyonek, on the west side of Cook Inlet, has a subsistence harvest area that extends from the Susitna River south to Tuxedni Bay; harvests concentrate in areas west and south of Tyonek. Moose and salmon are the most important subsistence resources, although important components of the harvest include non-salmon fishes such as smelt, waterfowl, and clams (ADNR 1999). In the past, the subsistence use of beluga in Cook Inlet was traditionally important to the village of Tyonek. Declines in the beluga population have led Cook Inlet beluga stock to be classified as depleted under the MMPA and endangered under the ESA (see Section 3.8.1.2.1) In 1999 and 2000, Federal laws established a moratorium on beluga whale harvests except for subsistence hunts under cooperative agreements between the NMFS and affected Alaska Native organizations. Co-management agreements between NMFS and the Cook Inlet Marine Mammal Council representing Native subsistence hunters were signed for 2000–2003 and 2005–2006. Two belugas were harvested from Cook Inlet as recently as 2005. Currently, harvest limits are determined in 5-yr increments based on the average beluga population over the preceding 5 yr and the population growth rate over the previous 10 yr. When that average falls below 350, no harvest is allowed. Since the 2003–2007 average abundance was below 350, there is no allowable beluga harvest for the years 2008–2012 (Allen and Angliss 2011). In April of 2011, the NMFS designated upper Cook Inlet, Katchemak Bay, and the eastern coastal waters of lower

Cook Inlet as critical habitat for beluga whales. The taking of belugas in these waters is prohibited (76 FR 69:20180–20194).

3.14.3 Alaska – Arctic

3.14.3.1 Sociocultural Systems

Since the planning areas under consideration here are for the most part located adjacent to sparsely populated rural areas that are largely inhabited by indigenous Iñupiat, this section focuses on Alaska Native sociocultural systems, although non-Native populations are considered as well. Unlike many of the indigenous populations in the lower 48 States, Alaska Natives continue to occupy and use their traditional lands. They maintain many traditions with respect to social organization and cultural values. Among the most prized values retained are those placed on social cohesion and group activities expressed in subsistence harvesting of wildlife and plant resources. Alaska Natives have been able to maintain these values partly because of the interaction between ecological possibilities, history of contact with non-Natives, and a commitment to retaining their culture and identity. The sociocultural systems of modern Alaska Natives have been modified to some extent from those existing prior to Euro-American contact; however, much of the earlier systems survive, resulting in modern sociocultural systems that to various degrees blend traditional and Euro-American characteristics.

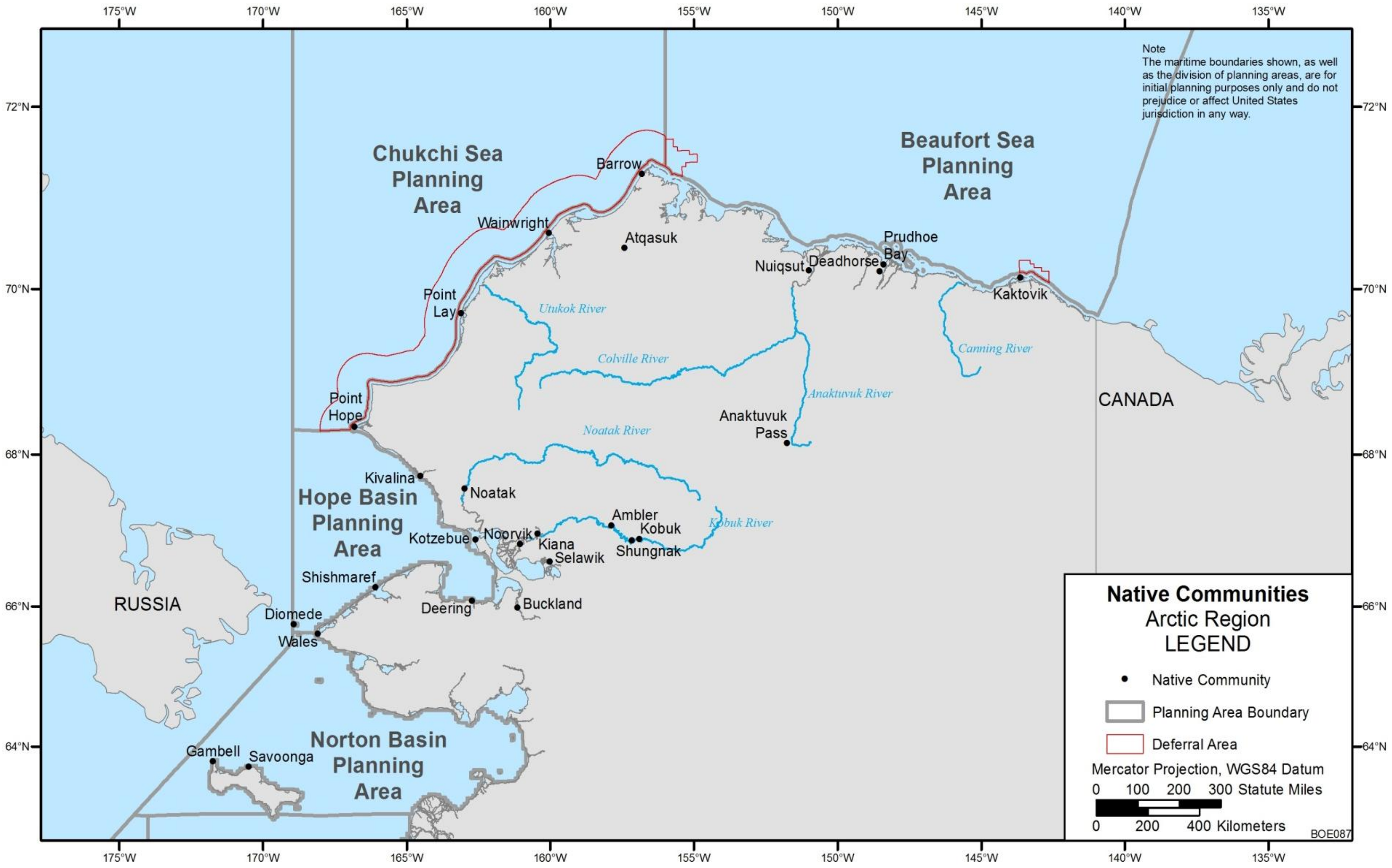
Native populations in Alaska are involved in a complex network of institutions, unique among Native populations in the United States that have allowed them to retain or regain control over much of their traditional homelands and modify western institutions of government and business to further traditional values. These include municipal governments, tribal councils, and regional and local ANSCA Native village and regional corporations, as well as non-governmental organizations (NGOs) such as the Alaska Federation of Natives (AFN) and the Alaska Eskimo Whaling Commission (AEWC). Under the terms of Section 4 of the Alaska Statehood Act (P.L. 85-508), the State of Alaska disclaimed all right and title to lands "title to which may be held by any Indians, Eskimos, or Aleuts (hereinafter called Natives) or is held by the United States in trust for said Natives." However, Section 6 allowed the State to select just over 42 million ha (104 million ac) of public or Federal lands that were "vacant, unappropriated, and unreserved at the time of selection." In many cases, lands selected by the State as vacant, unappropriated, and unreserved were lands that Alaska Natives considered to be theirs. In order to settle the resulting disputes, Congress passed ANCSA in 1971. Under ANCSA, Alaska Natives selected 18 million ha (44 million ac) of their traditional lands in fee title. In exchange for extinguishing claims to the remainder of the State, they received just under a billion dollars over a 10-year period. Under ANCSA, titles to the lands were given to 12 regional for-profit corporations and more than 200 village corporations that could be organized on either a not-for-profit or for-profit basis. Corporation shares were divided among Alaska Natives. In most cases, village corporations hold title to the surface estate while the regional corporations hold title to the subsurface estate. Despite initial concerns that Native cultural values would be enveloped by American corporate culture and that they could eventually lose control of their corporations and corporation lands, Alaska Natives have modified corporate culture to support traditional cultural values including sharing and subsistence (ASRC 2012). To make it more likely that Natives will maintain control of their corporations in the future, ANSCA was modified in 1987 to allow corporations to allocate shares to the younger generation not covered under the original Act and to restrict share ownership to Alaska Natives.

Given these multiple layers of jurisdiction and control, a Native community might be governed by a local municipal government, a wider borough government, and a local and regional tribal council. The land surface might be owned and administered by a village corporation while subsurface resources would be under the control of a regional corporation. The multiple concerned institutions do not always see eye to eye, and there is some tension between successful and less profitable corporations (Zellen 2008).

This section discusses the regional and community systems found on Alaska's North Slope and Northwest Arctic Borough (Figure 3.14.3-1) that could be affected by future oil and gas activities on the Arctic OCS. The oil and gas development under consideration in this EIS would take place offshore of North Slope Borough communities lying along the shores of the Beaufort and Chukchi Seas. These communities would be subject to direct effects from the widest array of development activities. These include the predominantly Alaska Native communities of Kaktovik, Nuiqsut, Barrow, Wainwright, Point Lay, and Point Hope, as well as the unincorporated community of Deadhorse that serves primarily to house as many as 5,000 transient workers in the nearby Prudhoe Bay oil fields. However, coastal Northwest Arctic Borough communities (Kivalina, Kotzebue, Buckland, and Deering) that are also on the shores of the Chukchi Sea could also be affected. The migrating whales and other sea mammals that are hunted by North Slope Borough communities are also hunted by Northwest Arctic Borough whaling communities. Any adverse effects on marine mammal populations migrating along the northern coast would also be felt by Northwest Arctic Borough communities along the coast as well as the inland villages that trade with them. Migrating whales continue south to the Bering Sea, and similar effects would also be felt in the Alaska Native whaling communities of Wales, Diomede, Savoonga, and Gambell, which lie along their migratory path, and by traditional whaling communities in Russia.

3.14.3.1.1 North Slope. The Chukchi Sea and Beaufort Sea Planning Areas lie off the northern coast of the North Slope Borough. At the 2010 Census, the population of the North Slope Borough was 9,430, almost 54% of which were Alaska Natives (USCB 2011c). The Alaska Natives living in communities lying along the shore of the Chukchi and Beaufort Sea Planning Areas are primarily Iñupiaq Eskimo whose traditional culture is based on cooperation, kinship ties, and subsistence hunting and gathering. In particular, traditional coastal North Slope cultures are specially adapted to whaling (Spencer 1984).

Chukchi Sea communities include Barrow, Wainwright, Point Hope, and Point Lay along the coast, while Atqasuk lies somewhat inland (Figure 3.14.3-1, Table 3.14.3-1). Barrow is the largest permanent community on the North Slope and serves as the administrative and commercial hub of the region. It is a traditional Iñupiaq settlement with 61% of the population being Alaska Natives. The North Slope Borough is the city's largest employer, but there are also numerous businesses providing support services to oil field operations. Subsistence whaling,



Note
The maritime boundaries shown, as well as the division of planning areas, are for initial planning purposes only and do not prejudice or affect United States jurisdiction in any way.

FIGURE 3.14.3-1 Native Communities around the Arctic Region

TABLE 3.14.3-1 North Slope Alaska Native Communities

Community	Population (2010)	Percent Alaska Native	Native Corporation	Federally Recognized Tribal Government	State Incorporated Municipality?
Anaktuvak Pass	325	83	Nunamiut Corp	Native Village of Anaktuvak Pass	Yes 1959
Atqasuk	233	92	Atqasuk Village Corp.	Native Village of Atqasuk	Yes 1982
Barrow	4,212	61	Ukpeagvik Iñupiat Corp.	Native Village of Barrow	Yes 1959
Kaktovik	239	89	Kaktovik Iñupiat Corp.	Native Village of Kaktovik	Yes 1971
Nuiqsut	402	87	Kuupik Village Corp.	Native Village of Nuiqsut	Yes 1975
Point Hope	674	90	Tikigaq (Tigara) Corp.	Native Village of Point Hope	Yes 1966
Point Lay	189	88	Cully Corp.	Native Village of Point Lay	No
Wainwright	556	90	Olgoonik Corp.	Native Village of Wainwright	Yes 1962

Source: ASRC 2012; DCRA 2011; North Slope Borough 2011; BIA 2010.

hunting, and fishing are important to the economy, and many residents with full- or part-time employment continue to hunt and fish for food (DCRA 2011; City of Barrow 2012). Wainwright is located on the coast 137 km (85 mi) southwest of Barrow. Alaska Natives make up 90% of its population, which is highly dependent on subsistence hunting, especially whaling. Most full-time employment is through the North Slope Borough. Traditional practices are preserved including the *nalukataq* festival that celebrates a successful spring whale hunt (DCRA 2011; ASRC 2012). Point Lay, located about 153 km (95 mi) farther down the coast, is another traditional Iñupiaq village heavily dependent on subsistence harvesting. Just under 90% of its population are Alaska Natives. One of the more recently established settlements in the North Slope Borough, it is unincorporated. Situated near the Kasugaluk Lagoon, it is a prime location for hunting beluga whales, but also participates in the bowhead hunt. Most year-round employment opportunities are through the borough government (DCRA 2011; ASRC 2012). Located on the Point Hope (*Tikweraq*) Peninsula, about 193 km (120 mi) to the southwest of Point Lay, Point Hope occupies one of the longest continuously occupied Iñupiaq areas in Alaska. The peninsula offers good access to marine mammals, and typical ice conditions allow easy boat launchings into open leads early in the spring whaling season. Most full-time employment is with North Slope Borough and city governments. Apart from subsistence hunting, residents supplement their income by the production of traditional craft items. The community has retained a strong traditional culture and is the site of the *oagrugvik* feast to celebrate a successful whale hunt (DRCA 2011; ASRC 2012). Atqasuk is located on the Meade River about 97 km (60 mi) south of Barrow. Reestablished in the 1970s, Atqasuk's population in 2010 was over 90% Alaska Native. Located well inland, it is still connected to the Beaufort Sea by the Meade River, and its inhabitants participate in both inland and marine subsistence activities (DCRA 2011; ASRC 2012). Subsistence harvesters from Barrow range as far as Atqasuk and beyond (SRBA 2010), and the two communities interact for subsistence purposes.

East of Barrow, the communities of Nuiqsut and Kaktovik are also subsistence-based. Nuiqsut is located on the western bank of the Colville River about 27 km (17 mi) from the Beaufort Sea and 219 km (136 mi) southeast of Barrow. It is only 13 km (8 mi) from the Alpine oil field, one of the major oil producing fields on the North Slope. About 87% of its 2010 population were Alaska Natives. With access to the Coleville delta, a rich source of subsistence resources, it is a traditional Iñupiaq village reliant on a variety of both marine and terrestrial resources. Even though located inland, bowhead whales are considered a vital resource for the community, and residents participate in the bowhead camp at Cross Island (SRBA 2010). Unemployment is high, with the school, borough services, a store, and the local Native corporation providing the most year-round employment (DCRA 2011; ASRC 2012). Kaktovik lies on the northern shore of Barter Island, the traditional bartering place between the Iñupiat and Inuit of Canada. The community is isolated, and Alaska Natives comprise about 89% of its population. Closer to the mountains than most coastal communities, the village harvests a wide variety of wild marine and terrestrial species. Other employment is mainly with the school, city, or the borough (DCRA 2011; ASRC 2012). Anaktuvak Pass is an inland Nunamiut community located in the central Brooks Range about 400 km (250 mi) southeast of Barrow. Hunting and trapping are important subsistence activities there. While not on the coast and directly affected by oil and gas development on the OCS, the community receives marine mammal subsistence foods from coastal communities through trade, bartering, and good will (Burris 2011).

Traditionally, the Iñupiat occupied small, independent, kin-based communities or camps dispersed across the North Slope and northwest Alaska. Communities were situated to take seasonal advantage of subsistence resources. Not all Iñupiaq communities practiced whaling themselves, but most were tied to whaling through ties of kinship and trade. For the most part, Iñupiat subsistence activities and whaling in particular were and continue to be group activities requiring cooperative efforts (SRBA 2010). Whaling crews, comprised of those pursuing whales on the water and their support teams on shore or ice, bound the society together (Spencer 1984; Burch 2006).

The arrival of Yankee commercial whalers in the mid- to late nineteenth century (Bockstoce 1995) prompted Iñupiaq settlement patterns to begin to change. The desire for Western trade goods drew an increasing number of Alaska Natives to the coast, where permanent communities remain today. In spite of significant population loss resulting from exposure to European diseases, the Iñupiat were slowly drawn into the world economy (Chance 1984; Spencer 1984). Even after Alaska was organized as a U.S. territory, Alaska Natives continued to outnumber immigrants from the United States until the military buildup during World War II. Communities on the Arctic coast remained relatively isolated from Western culture. Western influence increased when many Alaska Natives served in the Alaskan Territorial Guard and as a result of the military buildup on the North Slope during the Cold War, the construction of the Distant Early Warning (DEW) Line and the White Alice communication network, and the establishment of the Naval Arctic Research Laboratory (NARL) at Barrow in 1947. This military presence on the North Slope increased the exposure of the Iñupiat to industrialized Euro-American culture. Exposure to industrialization was significantly increased by the discovery of the Prudhoe Bay oil fields in 1967 and the construction of the TAPS along with the construction of the Dalton Highway connecting the North Slope to the south. The increasing presence of modern American culture has stressed traditional Native culture, yet the Iñupiat have managed to remain in and retain control over much of their traditional homeland. They have successfully incorporated modern technology into their subsistence way of life. Rifles and whale bombs have replaced spears and harpoons, aluminum skiffs are employed along with seal-skin boats (*umiak*) in the whale hunt, whaling crews use electronic global positioning and communication devices in the hunt, and snow machines and all-terrain vehicles (ATVs) have replaced dog teams and sleds (Roderick 2010; SRBA 2010). With increasing local control of land and resources has come a resurgence of traditional culture, as local and regional corporations and governments have supported the preservation of traditional languages and culture, and teaching of traditional values to the rising generation (Zellen 2008).

Local control has been increased through adaptation of Western business and governmental institutions to local values and needs. The municipal government of the North Slope Borough, established in 1972, is dominated by Alaska Natives. With ample resources from the taxation of the developing energy industry in the region, the North Slope Borough has been able to make marked improvements in municipal services and education. The Arctic Slope Regional Corporation (ASRC) is the regional corporation covering the Arctic coast. It is one of the more profitable regional corporations. It receives and distributes royalties from the development of mineral resources on Native lands. Half of the Alpine Oil Field lies on ASRC lands. ASRC has extended membership to Iñupiat born after 1971 and encourages the preservation and transmission of traditional Iñupiaq values including the maintenance of subsistence resources (ASRC 2012). As shown in Table 3.14.3-1, each Iñupiaq village is subject to multiple jurisdictions. Village corporations own the surface lands and further Iñupiat business interests. Local and regional municipal governments provide social services, public safety, education, and utilities. Tribal government councils, both village councils and the regional Iñupiat Community of Arctic Slope, are recognized by the Federal Government and have jurisdiction in the domestic affairs of tribal members and serve to transmit traditional culture to the next generation (Roderick 2010; Zellen 2008). The corporations tend to support tribal values, traditional culture, and subsistence activities. Through the North Slope Borough, Alaska Natives exert some measure of control over their traditional homeland beyond the lands retained by the Native corporations (Zellen 2008).

Based on past experience, many Alaska Natives approach their relationship with the Federal Government with some degree of mistrust. For much of the last century, the government either neglected or sought to acculturate Alaska Natives. Even today, Alaska Natives express skepticism that Native input at public hearings will have much, if any, effect on project decisions and the overall direction of the leasing program. In the past, Alaska Natives have expressed fear of losing or diluting their traditional culture as industrial development of oil fields results in an influx of outsiders (MMS 2007b).

3.14.3.1.2 Northwest Arctic Borough. The Northwest Arctic Borough lies south of the western portion of the North Slope Borough. Its 2010 population was 7,523, 81% of which were Alaska Natives (USCB 2011c). The Northwest Arctic Borough includes 11 communities, all of which are predominantly Alaska Native (Table 3.14.3-2). Seven of these are on the coast or are regularly involved in subsistence harvesting of marine resources.

Kotzebue is the administrative and communications hub of the Northwest Arctic Borough. As is the case with the North Slope Borough, Native Alaskans strongly influence local municipal government; however, unlike the North Slope Borough, most villages have no Native village corporations. These small communities found it difficult to support village corporations. All local corporations except the Kikiktagruk Iñupiat Corporation in Kotzebue merged with the NANA Regional Corporation in 1976 (Burch 1984a).

The traditional lifeway of the Alaska Natives living along and upstream from the Bering Sea and Kotzebue Sound was similar to that found on the North Slope. Mobile kin-based groups dispersed across the landscape taking seasonal advantage of a variety of wild food sources. Kin groups came together for a regional summer fair at Sheshalik, or combined in smaller groups in messenger feasts (Burch 1984b). Even after first European contact in 1816, they maintained their traditional lifestyle until mid-century. The latter half of the nineteenth century was a time of stress. Increased contacts with American and European traders lead to the introduction of disease, alcohol and firearms. This combined with a rapid decline in the caribou herd led to out-migration and depopulation of much of the Northwest Arctic Borough in the 1880s. A period of consolidation began in 1897 followed by a gold rush along the Noatak and Kobuk Rivers and Seward Peninsula. Newly established missions and schools and domesticated reindeer introduced in the first decades of the twentieth century became the foci for the Natives who continued for the most part to live in dispersed camps hunting and herding reindeer. The decline of the reindeer herds and the collapse of the fur market during the 1930s resulted in sedentarization in mission-school villages that have mostly persisted to the present day. An increase in caribou population and the arrival of a moose population in the 1940s and ‘50s, in combination with the maintenance of marine resources, allowed a subsistence lifeway to continue. By the 1960s, each community had a school, a store, a National Guard armory, and an all-weather airstrip and Natives lived on a combination of the subsistence harvest, welfare, and wage labor (Burch 1984a). The Northwest Alaska Native Association (NANA) was formed in 1966, as a not-for-profit organization to help northwest Iñupiat settle land claims issues. The association developed into an advocate for Alaska Native rights and continues today as the Maniilaq Association (Maniilaq Association 2003). After the passage of ANCSA in 1971, a separate for-profit corporation, NANA Regional Corporation, was formed in 1972 and Natives in the area began to have increased control of the development of the area (NANA 2010). NANA worked to develop resources, such as the Red Dog Mine. The Northwest Arctic Borough was established in 1986. Currently, the economy of the Northwest Arctic Borough relies on a combination, of subsistence harvesting, employment in the government sector, mining, other commercial ventures, and commercial fishing. Each of the villages along the coast has at least one inhabitant with a commercial fishing permit, while Kotzebue is home to 115 permitees (DCRA 2011). The borough’s inland communities, Ambler, Kiana, Kobuk, Noatak, Noorvik, Selawik, and Shungnak (Figure 3.14.3-1), lie mostly on rivers or estuaries and are tied to the coast through their reliance on anadromous fish resources, exchange relationships with coastal communities, and in some cases participation in the marine subsistence harvest.

TABLE 3.14.3-2 Northwest Arctic Borough Alaska Native Communities

Community	Population (2010)	Percent Alaska Native	Native Corporation	Federally Recognized Tribal Government	State Incorporated Municipality?
Ambler	276	85	Merged with NANA	Native Village of Ambler	Yes 1971
Buckland	416	95	Merged with NANA	Native Village of Buckland	Yes 1966
Deering	122	87	Merged with NANA	Native Village of Deering	Yes 1970
Kiana	361	90	Merged with NANA	Native Village of Kiana	Yes 1964
Kivalina	374	96	Merged with NANA	Native Village of Kivalina	Yes 1969
Kobuk	148	90	Merged with NANA	Native Village of Kobuk	Yes, 1973
Kotzebue	3,201	74	Kikiktagruk Iñupiat Corporation	Native Village of Kotzebue	Yes 1958
Noatak	514	95	Merged with NANA	Native Village of Noatak	No
Noorvik	668	88	Merged with NANA	Noorvik Native Community	Yes 1964
Selawik	868	85	Merged with NANA	Native Village of Selawik	Yes, 1974
Shungnak	261	94	Merged with NANA	Native village of Shungnak	Yes 1967

Source: DCRA 2011; Burch 1984a.

For all of the Northwest Arctic Borough communities, subsistence activities are the most significant food source and subsistence practices are essential to their economies, culture, and social structure. Subsistence practices are an integral part of the Kotzebue lifeway; however, Kotzebue is also the service and transportation hub of the Northwest Arctic Borough, and more opportunity for employment in the government sector, the NANA Regional Corporation, and the Maniilaq Association is available. Commercial fishing also plays an important economic role. The other smaller communities within the Northwest Arctic Borough, located around the Kotzebue Sound, are Kivalina, Deering, and Buckland. Within these communities, marine resources form a large part of the subsistence harvest. Kivalina and Kiana are the only communities within the Northwest Arctic Borough who hunt the bowhead whale. Kivalina residents also harvest bearded seals, beluga whales, and walrus. Deering and Buckland marine mammal subsistence harvests include beluga whales and seals. These communities also rely on saltwater fish, waterfowl, moose, and small mammals (DCRA 2011).

More than 75% of the population in each of the Kotzebue Sound communities are Alaska Natives (Table 3.14.3-2). Kivalina, Deering, and Buckland rely heavily on subsistence activities for their livelihood. Available year-round sources of income include jobs in the public sector (schools, city), health clinics, local stores, handicrafts, the Red Dog Mine, the Maniilaq

Association, the NANA Regional Corporation, tribal council, and the airlines. Kotzebue Sound is part of the Hope Basin Planning Area, and although oil and gas exploration is not included in the Hope Basin Planning Area in this five-year plan, the marine resources these communities rely on migrate through the Chukchi and Beaufort Seas seasonally, exposing them to the effects of oil and gas development there. Thus, these communities have the potential to be affected by oil and gas development in the neighboring Chukchi Sea Planning Area (see 4.4.13.3). .

The communities of Noatak, Noorvik, and Kiana are located east of Kotzebue Sound along rivers that flow into Hotham Inlet or Kotzebue Sound. These communities rely on the harvest of wild anadromous and freshwater fish species, waterfowl, moose, caribou, small mammals, and berries for subsistence (DCRA 2011). More than 85% of the population in each of these communities are Alaska Natives. Other year-round jobs include working for the school districts, local stores, and health care. Residents of Noorvik and Noatak find seasonal summer work either in Kotzebue, with the Bureau of Land Management (BLM), firefighting, or with the Red Dog Mine. Noatak residents also travel to fish camps during the summer (DCRA 2011).

The four inland Northwest Arctic Borough communities are Selawik, Shungnak, Ambler, and Kobuk. More than 85% of the population in each of these communities are Alaska Natives. These communities rely mainly on subsistence resources from the streams, lakes, mountains, and forests. Freshwater fish, caribou, moose, bear, and waterfowl are important parts of their subsistence harvests. Year-round employment opportunities include working for the school districts, tribal governments, city governments, local stores, health care institutions, and the production of handicrafts. Seasonal work includes employment with the BLM, mining, and construction (DCRA 2011).

3.14.3.1.3 Bering Strait Communities. Farther south are four more subsistence-dependent communities that participate in the whale hunt: Wales, Diomede, Gambell, and Savoonga (Table 3.14.3-3). These communities are located on or near the Bering Strait through which migrating whales must pass to reach their wintering locations in the Bering Sea and their summering locations in the Canadian Beaufort Sea. Located on the tip of the Seward Peninsula, Wales has a strong traditional Kinugmuit whaling culture, still preserved in songs, dances, and customs (DCRA 2011; Kawerak 2009; Braund and Langdon 2011). Located on Little Diomede Island in the Bering Strait, the Ingalikmiut village of Diomede is believed to have been the site of a spring whaling camp for the last 3,000 years. Diomede is almost entirely dependent on subsistence hunting, in marine waters and on the mainland, but is also a center of trade in walrus ivory (DCRA 2011; Kawerak 2009; Braund and Langdon 2011). Gambell and Savoonga are Yup'ik villages located on St. Lawrence Island in the northern Bering Sea, where whales that migrate through the Chukchi and Beaufort Seas over winter. When ANCSA was passed in 1971, Gambell and Savoonga decided not to participate and instead opted for title to the 0.460 million ha (1.136 million ac) of land in the former St. Lawrence Island Reserve. The island is jointly owned by Savoonga and Gambell. These communities are subsistence based with over 80% of their diet coming from subsistence resources. Commercial fishing, seafood processing, tourism, and handicrafts also contribute to the economies, and Savoonga considers itself the Walrus Capitol of the World. They are the southernmost subsistence bowhead whaling

TABLE 3.14.3-3 Bering Strait Whaling Communities

Community	Population (2010)	Percent Alaska Native	Native Corporation	Federally Recognized Tribal Government	State Incorporated Municipality?
Diomede	107	92	Diomede Native Corporation	Native Village of Diomede	Yes 1970
Gambell	677	96	Sivuqaq, Incorporated	Native Village of Gambell	Yes 1963
Savoonga	704	95	Kukulget, Incorporated	Native Village of Savoonga	Yes 1969
Wales	154	85	Wales Native Corporation	Native Village of Wales	Yes 1964

Source: DCRA 2011.

communities in Alaska, taking bowhead, grey whales, and beluga (DRCA 2011; Downs and Calloway 2008).

3.14.3.1.4 The Russian Chukchi Coast. Oil and gas activities on the OCS could also affect communities to the east of the Chukchi and Bering Seas located in Russia. The indigenous Chukotan peoples on the eastern shore of the Chukchi Sea are citizens of the Chukotsky Autonomous Okrug. Important coastal lagoons and near-shore subsistence harvest areas for beluga, gray, and bowhead whales; as well as other marine mammals and seabirds could be affected by a large oil spill. The concept of subsistence harvesting as known in Alaska does not exist on the Russian side of the sea, however local native leaders and activists are in support of indigenous concerns and initiatives. The North Slope Borough has cooperated with the Eskimo Society of Chukotka to aid in reestablishing whaling traditions and to help facilitate the gray whale harvest (MMS 2008b).

On the Russian side, the Arctic tundra region starting at East Cape and extending 200 mi west includes the coastal indigenous communities of Naukan (population 350); Uelen (population 678); Inchoun (population 362); Chegitun (a seasonal subsistence camp); Enurmino (population 304); Neshkan (population 628); Alyatki (a seasonal subsistence camp); Nutpel’men (population 155); and Vankarem (population 186). The former seasonal hunting and fishing sites of Naukan, Chegitun, and Alyatki may have been reoccupied. Uelen, Inchoun, Enurmino, Neshkan, Nutpel’men, and Vankarem are permanent indigenous settlements where subsistence hunting and fishing occur year-round. Both Naukan and Uelen are important areas for hunting polar bears. The area west of Inchoun, including the communities of Enurmino and Neshkan, was particularly hard hit by socioeconomic disintegration during the collapse of the Soviet Union in the 1990s (MMS 2008b)

Historically, there were a number of indigenous settlements in the region from Vankarem west and north to Cape Billings. In general, there has been a trend toward repopulating settlements (and reoccupying seasonal hunting and fishing camps) abandoned earlier due to forced relocation by the Soviet government into larger urban and centralized communities. Repopulation also has occurred to exploit natural food sources, as subsidies from Moscow to support employment and infrastructure have disappeared. The coastal settlements westward from Vankarem are Rigol (population unknown); Mys Shmidta (Cape Shmidt; population 717); Rypkarpyy (population 915); Polyarnyy (population unknown); Pil'gyn (population unknown); Leningradskii (population 835); Billings (Cape Billings; population 272); and Ushakovskoe (population 8) on Wrangel Island. Of all these named settlements, only Ushakovskoe is known to still have functioning subsistence-harvest practices. Many names that still appear on maps of the region are historical villages that no longer exist and, in some cases, they may be small family camps where a few Native inhabitants live on a seasonal basis (MMS 2008b).

3.14.3.2 Subsistence

The majority of permanent residents of the Arctic and Bering Sea coasts are Alaska Natives. For them, many subsistence activities are group activities that further core values of community, kinship, cooperation, and reciprocity. Current regulations define subsistence use as "the customary and traditional use by rural Alaska residents of wild renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools of transportation; for making and selling handicraft articles out of inedible byproducts of fish and wildlife resources taken for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade" (FSMP 2010). Section 109 of the MMPA applies the same definition explicitly to the subsistence harvesting of marine mammals.

Priority for subsistence harvesting in land management is expressed in ANILCA, passed by Congress in 1980. Similar State legislation was struck down as violating the Alaska constitution, which guarantees equal access to fish, wildlife, and waters for all State residents. ANILCA applies only to Federal lands (excluding the OCS).

Subsistence resources on Federal lands and navigable waters along the coast are managed by the Federal Subsistence Board (FSB). The FSB has determined that all communities on Alaska's North Slope and Kotzebue Sound are, with the exception of the Prudhoe Bay area, qualified subsistence users. Alaska Native communities would also qualify under the more restrictive customary and traditional use determination of eligibility. *Customary and traditional use* means "a long established, consistent pattern of use, incorporating beliefs and customs transmitted from generation to generation" (FSMP 2010).

While a subsistence lifestyle is a rural preference and not confined to Alaska Natives in rural communities, subsistence is inextricably intertwined with Alaska Native culture and is key to cultural identity. The harvest and consumption of wild resources are only the most visible aspects of a complex set of behaviors and values that extend far beyond the food quest. Kinship, sharing, and subsistence resource use behaviors (such as preparation, harvest, processing, consumption, and celebration) are inseparable. Beyond dietary benefits, subsistence resources provide materials for personal and family use, and the sharing of resources helps maintain traditional family organization.

Subsistence is a central focus of North Slope and Northwest Arctic Borough personal and group cultural identity (MMS 2007b, 2008b). Subsistence activities provide cultural identity, social integration and solidarity, and diet that Alaska Natives view as more healthy (BOEMRE 2011c–f). Many of the most important subsistence resources are found in or near the sea and are thus potentially subject to the effects of oil and gas exploration, production, and any spills on the continental shelf. The cultural value placed on subsistence harvesting and whaling in particular is found throughout the North Slope and in northwestern Alaska. For example, the CEO of the ASRC describes himself as a part-time subsistence hunter (ASRC 2012). Subsistence has been described as the "organizing concept for the North Slope Borough." The North Slope Borough has been described as "the most organized, strongest, and best-funded subsistence economy in Alaska" (MMS 2007b). Within the North Slope Borough and Northwest Arctic Borough, both subsistence activities and wage economic opportunities are highly developed and highly interdependent. Since money is needed to purchase resources, such as rifles, ammunition, fuel, snow machines, ATVs, boats, and motors, to most effectively harvest resources, Native communities most active in subsistence activities tend to also be very involved in the wage economy (MMS 2007b).

In general, subsistence foods consist of a wide range of fish and game products that have substantial nutritional benefits. They tend to be rich in nutrients and low in fats. In addition to health benefits, there are social and cultural benefits to subsistence food harvesting and sharing (MMS 2007b). Marine mammals are culturally most important even in villages where caribou or fish supply more meat. Bowhead whale meat is most preferred, and seal oil is a necessary adjunct to meals based on the sea harvest (MMS 2008b). Subsistence species supply more than meat. Skins and furs go into the production of clothing and *umiat*. Bone, baleen, and ivory provide raw materials for handicrafts.

The subsistence harvest plays an important role in all Native communities of the North Slope and northwest Alaska. However, each community has its unique harvest pattern and preferences. Table 3.14.3-4 provides information on the subsistence harvest by hunters and fishers from the villages of Barrow, Nuiqsut, and Kaktovik (SRBA 2010). Table 3.14.3-5 provides a fuller listing of species reported as harvested by communities along the Beaufort and Chukchi Seas. Table 3.14.3-6 provides a listing of species reported harvested by Northwest Arctic Borough communities Subsistence harvesting follows a seasonal pattern constrained by changes in climate and by the migration patterns of whales, fishes, birds, and terrestrial mammals such as caribou. A recent study of subsistence harvesting patterns in Beaufort Sea communities suggests that subsistence marine harvesting can occur anywhere along the coast, but tends to be concentrated in areas directly offshore from the villages and regularly used whaling camps, such as Cross Island where the village of Nuiqsut stages its fall bowhead hunt (SRBA 2010). Most seaward harvesting occurs within 40 km (25 mi) of shore but may extend to as much as three times that distance depending on the conditions of ice and sea. Preference is given to locations where returning harvesters do not have to fight against the currents to bring their harvest home (SRBA 2010).

The bowhead whale hunt is the most iconic of the Iñupiaq subsistence harvesting activities. The whaling crew consists of a captain, a harpooner, and other hunters (Spencer 1984). Whaling captains are influential figures both economically and socially in

TABLE 3.14.3-4 Important Subsistence Species Harvested from Kaktovik, Nuiqsut, and Barrow[a]

Marine Mammals	
Bowhead whale	Taken in spring and fall migrations; mostly within 32–40 km (20–25 mi) of the coast, but as far as 80 km (50 mi). Primarily for food.
Bearded seal	Taken in summer on ice mostly within 40 km (25 mi) of the coast, but as far out as 80 km (50 mi). Skins used for *umiak* construction by Barrow whalers. Seal oil is an important part of the diet.
Ringed seal	Taken year-round. Formerly used to feed sled dogs.
Walrus	As opportunity arises. Mostly in summer and fall on ice within 40 km (25 mi), as far out as 120 km (75 mi).
Terrestrial Mammals	
Caribou	A major meat source taken year-round, but primarily in summer, mostly inland but in summer hunted by boat along the coast.
Wolves and wolverines	Inland during winter.
Fish	
Broad white fish	Mostly summer and fall; major fish source along coast and in rivers.
Arctic cisco	Mostly summer and fall; along coast and in rivers.
Arctic char/Dolly varden	Mostly late summer/early fall along coast and in rivers.
Waterfowl	
Geese	In spring and fall, mostly inland but as far as 80 km (50 mi) offshore.
Eider	On ice in spring and fall mostly within 40 km (25 mi) of shore, but as far as 64 km (40 mi).

[a] The species listed here were the objects of mapped subsistence harvesting from three villages near the Beaufort Seas. It is not a complete inventory of species harvested from those villages.

Source: SRBA 2010.

Iñupiat communities, and crew members may be drawn from both coastal and inland communities. Bowhead whales are harvested during both the spring and fall in Barrow and Wainwright, and during the spring migration in Point Hope and Point Lay. Nuiqsut and Kaktovik only harvest bowhead whale in the fall. Most Western Arctic Stock bowheads migrate annually from wintering areas in the northern Bering Sea on the Bering Shelf north of Navarin Canyon through the Chukchi Sea, where most calving occurs, in the spring to summer in the Beaufort Sea and Amundsen Gulf in Canada's Northwest Territories (Quakenbush et al. 2010a) (see Section 3.8.1.3.1). Their distribution is governed primarily by prey and ice densities. Some animals remain in the eastern Chukchi and western Beaufort Seas during the summer. In September to mid-October, bowheads head west out of the Beaufort Sea into the Chukchi Sea. They often rest and feed in Camden Bay (Galginaitis 2010; Quakenbush and Huntington 2010). Their migratory path is less confined than in the spring. Some head for Wrangel Island while others migrating later follow the coast of Alaska southward (MMS 2008b; NMFS 2011j). Their migration patterns thus take them past whaling villages on islands in the Bering Sea, along the coast of the Northwest Arctic Borough, and along the shore of the North Slope Borough. Traditionally, whaling crews have headed out from some villages during both the spring and fall

TABLE 3.14.3-5 Reported Subsistence Use at Arctic Coast Alaska Native Villages[a]

			Native Villages						
Resource	Iñupiaq Name	Scientific Name	Point Lay	Point Hope	Wainwright	Barrow	Atqasuk	Nuisqut	Kaktovik
Marine Mammals									
Bearded seal	Ugruk	*Erignathus barbatus*	X[b]	X	X	X	X	X	X
Ringed seal	Natchiq	*Phoca hispida*	X	X	X	X	X	X	X
Spotted seal	Qasigiaq	*Phoca largha*	X	—[b]	X	X	X	X	X
Ribbon seal	Qaigulik	*Phoca fasciata*	X	—	X	X	X	—	—
Beluga whale	Quilalugaq	*Delphinapterus leucas*	X	X	X	X	X	—	X
Bowhead whale	Agviq	*Balaena mysticetus*	X	X	X	X	X	X	X
Polar bear	Nanuq	*Ursus maritimus*	X	X	X	X	X	X	X
Walrus	Aiviq	*Odobenus rosmarus*	X	X	X	X	X	—	X
Terrestrial Mammals									
Caribou	Tuttu	*Rangifer tarandus*	X	X	X	X	X	X	X
Moose	Tuttuvak	*Alces alces*	—	X	X	X	X	X	—
Brown bear	Aklaq	*Ursus arctos*	X	—	X	X	X	X	—
Dall sheep	Imnaiq	*Ovis dalli*	—	X	X	X	X	X	X
Muskox	Uminmaq	*Ovibus moschatus*	—	—	X	—	X	X	X
Arctic fox (blue)	Tigiganniaq	*Alopex lagopus*	X	—	X	X	X	X	X
Red fox	Kayuqtuq	*Vulpes fulva*	X	—	X	X	X	X	—
Porcupine	Qinagluk	*Erethizon dorsatum*	—	—	X	X	—	—	—
Ground squirrel	Siksrik	*Spermophilus parryii*	X	—	X	X	X	X	X
Wolverine	Qavvik	*Gulo gulo*	X	—	X	X	X	X	X
Weasel	Itigiaq	*Mustela erminea*	—	—	X	—	X	X	—
Wolf	Amaguk	*Canis lupus*	X	—	X	X	X	X	X
Marmot	Siksrikpak	*Marmota broweri*	X	—	X	—	X	X	X
Fish									
Salmon	Species not reported	Species not reported	X	X	X	X	X	X	—
Chum	Iqalugruaq	*Oncorhynchus keta*	X	X	X	X	X	X	—
Pink (humpback)	Amaqtuuq	*O. gorbuscha*	—	X	X	X	X	X	—
Silver (coho)	Iqalugruaq	*O. kisutch*	—	X	—	—	—	—	—
Whitefish	Aanaakliq	*Coregonus* spp.	—	X	X	X	X	—	—
Round whitefish	Aanaakliq	*Prosopium cylindraceum*	—	—	X	X	—	—	—
Broad whitefish	Aanaakliq	*Coregonus nasus*	—	—	X	X	X	X	X
Humpback whitefish	Pikuktuuq	*C. clupeaformis*	—	—	X	X	X	X	—
Least cisco	Iqalusaaq	*C. sardinella*	—	—	X	X	X	X	X
Bering and Arctic cisco	Qaaktaq	*C. autumnalis*	X	—	X	X	X	X	X

TABLE 3.14.3-5 (Cont.)

			Native Villages						
Resource	Iñupiaq Name	Scientific Name	Point Lay	Point Hope	Wainwright	Barrow	Atqasuk	Nuisqut	Kaktovik
Other Freshwater Fish									
Arctic grayling	Sulukpaugaq	*Thymallus arcticus*	X	X	X	X	X	X	X
Arctic char	Iqalukpik	*Salvelinus alpinus*	X	X	X	X	X	X	X
Burbot (ling cod)	Tittaaliq	*Lota lota*	—	—	X	X	X	X	—
Lake trout	Iqaluaqpak	*Salvelinus namaycush*	—	—	X	X	X	X	—
Northern pike	Siulik	*Esoxlucius*	—	—	X	X	—	—	—
Other coastal fish									
Rainbow smelt	Ilhuagniq	*Osmerus morda*	X	—	X	X	—	X	—
Arctic cod	Iqalugaq	*Boreogadus saida*	—	—	X	X	X	X	X
Tomcod	Uugaq	*Eleginus gracilis*	X	X	X	X	X	—	X
Flounder	Nataagnaq	*Liopsetta glacialis*	—	X	—	—	—	—	X
Birds									
Snowy owl	Ukpik	*Nyctea scandiaca*	—	X	X	—	—	X	—
Red-throated loon	Qaqsraupiagruk	*Gavia stellata*	*X*	—	X	X	—	—	—
Tundra swan	Qugruk	*Cygnus columbianus*	—	—	X	—	X	X	X
Eider	Species not reported	Species not reported	—	X	—	—	—	—	X
Common eider	Amauligruaq	*Somateria mollissima*	X	—	X	X	X	X	—
King eider	Qinalik	*Somateria spectabilis*	X	—	X	X	X	X	—
Spectacled eider	Tuutalluk	*Somateria fischeri*	X	—	X	X	—	—	—
Steller’s eider	Igniqauqtuq	*Polysticta stelleri*	X	—	X	X	—	—	—
Other ducks	Qaugak	Species not reported	—	X	X	X	X	—	—
Pintail	Kurugaq	*Anas acuta*	X	—	X	—	X	—	X
Long-tailed duck	Aaqhaaliq	*Clangula hyemalis*	*X*	—	X	X	X	—	X
Surf scoter	Aviluktuk	*Melanitta perspicillata*	—	—	X	X	—	—	—
Geese	Species not reported	Species not reported	—	X	—	—	—	—	X
Brant	Niglingaq	*Branta bernicla* n.	X	X	X	X	X	X	X
White-fronted goose	Niglivialuk	*Anser albifrons*	X	—	X	X	X	X	X
Snow goose	Kanuq	*Chen caerulescens*	X	—	X	X	X	X	X
Canada goose	Iqsragutilik	*Branta canadensis*	X	—	X	X	X	X	X
Ptarmigan	Aqargiq	*Lagopus* spp.	—	—	X	X	X	X	X
Willow ptarmigan	Nasaullik	*L. lagopus*	X	—	X	X	—	—	—
Other Resources									
Berries	Species not reported	Species not reported	X	X	X	X	X	X	
Cranberry	Kimminnaq	*V. vitisidaea*	—	—	X	X	—	—	—
Salmonberry	Aqpik	*Rubus spectabilis*	—	—	X	X	—	—	—
Bird eggs	Mannik	Species not reported	X	X	X	X	X	—	—
Gull eggs	Species not reported	Species not reported	—	—	X	—	X	—	—
Goose eggs	Species not reported	Species not reported	—	—	X	—	X	—	—
Eider eggs	Species not reported	Species not reported	—	—	X	X	X	—	—
Greens/roots	Species not reported	Species not reported	—	—	X	X	X	X	—

TABLE 3.14.3-5 (Cont.)

			Native Villages						
Resource	Iñupiaq Name	Scientific Name	Point Lay	Point Hope	Wainwright	Barrow	Atqasuk	Nuisqut	Kaktovik
Wild rhubarb	Qunulliq	*Oxyric digyna*	—	—	X	X	—	—	—
Wild chives	Quagaq	*Allium schoenoprasum*	—	—	X	X	—	—	—
Clams	Imaniq	Species not reported	X	—	X	X	—	—	—
Crab	Puyyugiaq	Species not reported	X	X	X	—	X	X	—

[a] This table is based on a variety of surveys conducted at different times between 1987 and 2006. The underlying data were not uniformly collected. The range of resources used in some communities, particularly Point Hope, may be underreported.

[b] X = Reported; — = Not reported.

Sources: ADFG 2011e; MMS 2008b.

migrations while other villages have confined themselves to a single migration; however, the AEWC reports that whaling patterns along the Chukchi Sea coast are changing rapidly and more villages are whaling during both migrations (Aiken 2012). In the North Slope Borough, Barrow, Wainwright, Point Hope, and Point Lay crews hunt in both the spring and fall, while crews from Nuiqsut and Kaktovik whale only in the fall (Galginaitis 2010).

In the Northwest Arctic Borough, Kivalina and Kiana take occasional bowheads in the spring if they follow nearshore leads, areas of open water resulting from the breaking up of ice flows, but more frequently hunt belugas, as do Noatak, Buckland, Deering, and Wales (MMS 2008b; ADFG 2011e). Farther south, the Bering Strait villages of Wales and Diomede also pursue bowheads, as do the villages of Savoonga and Gambell on Saint Lawrence Island in the Bering Sea. Proximity to the Russian territorial waters limits Diomede’s ability to pursue and land bowheads. Changes in the ice in recent years has led the St. Lawrence villages to change from a spring to a winter bowhead hunt (AEWC 2011). The St. Lawrence villages also hunt gray whales (Braund and Langdon 2011; Downs and Calloway 2008; DRCA 2011; Kawerak 2009; Noongwook et al. 2007).

The smaller beluga whales also migrate past Northwest Arctic Borough and North Slope Borough villages. Belugas spend the winter in the Bering Sea. In the spring, belugas migrate to coastal estuaries, bays, and rivers. The eastern Chukchi Sea stock gather in the nearshore waters of Kotzebue Sound and Kasegaluk Lagoon, near Point Lay, and Omalik Lagoon in June and July. Between July and September, females tend to remain near the Beaufort and Chukchi Seas shelf break, while the males head for deeper water. In September and October, they migrate west, returning to the Bering Sea (NMFS 2011j) providing additional opportunities for whalers. Point Lay has traditionally hunted only beluga whales in the spring, but now hunts bowheads in the spring. In the spring, when whales are migrating toward the pole, Barrow and Point Hope

TABLE 3.14.3-6 Reported Subsistence Harvest by Coastal Northwest Arctic Borough Communities[a]

		Native Villages[b]										
Resource	Scientific Name	Kivalina	Noatak	Kiana	Selawik	Kotzebue	Noorvik	Buckland	Kobuk	Deering	Ambler	Shungnak
Marine Mammals							X					
Seal	Species not reported	X	X	X	—	X	—	X	—	X	—	—
Bearded seal	*Erignathus barbattus*	X	X	X	—	X	—	—	—	X	—	—
Ringed seal	*Phoca hispida*	X	X	X	—	X	—	—	—	X	—	—
Spotted seal	*Phoca largha*	X	X	X	—	X	—	—	—	X	—	—
Ribbon seal	*Phoca Fasciata*	X	—	—	—	X	—	—	—	X	—	—
Beluga whale	*Delphinapterus leucas*	X	X	X	—	X	—	X	—	X	—	—
Bowhead whale	*Balaena mysticetus*	X	—	X	—	—	—	—	—	—	—	—
Polar bear	*Ursus maritimus*	X	—	X	—	X	—	—	—	X	—	—
Walrus	*Odobenus rosmarus*	X	X	X	—	X	—	—	—	X	—	—
Terrestrial Mammals												
Caribou	*Rangifer tarandus*	X	X	X	X	X	X	—	X	X	X	X
Moose	*Alces alces*	X	X	X	X	X	X	—	X	X	X	X
Brown bear	*Ursus arctos*	X	X	X	X	X	X	—	X	X	X	X
Black bear	*Ursus americanus*	—	X	X	X	X	X	—	X	—	X	X
Muskox	*Ovibus moschatus*	X	X	X	—	—	—	—	—	—	—	—
Dall sheep	*Ovis dalli*	X	X	X	X	X	—	—	X	—	X	X
Arctic Fox (blue)	*Alopex lagopus*	X	X	X	X	—	—	—	X	X	X	X
Red fox	*Vulpes fulva*	X	X	X	X	X	—	—	X	X	X	X
Porcupine	*Erethizon dorsatum*	X	—	X	—	X	—	—	—	X	—	—
Ground squirrel	*Spermophilus parryii*	X	—	—	X	X	—	—	X	X	X	X
Wolverine	*Gulo gulo*	X	X	X	X	X	X	—	—	X	X	—
Wolf	*Canis lupus*	X	X	X	X	X	X	—	—	X	—	—
Beaver	*Castor canadensis*	X	X	X	X	X	—	—	X	X	X	X
Land otter	*Lutra Canadensis*	X	X	X	—	X	—	—	—	X	—	—
Marten	*Martes sp.*	—	X	X	X	X	—	—	X	—	X	X
Muskrat	*Ondatra zibethicus*	—	X	X	X	X	—	—	X	X	X	X
Fish												
Salmon	Species not reported	X	X	X	X	X	—	X	X	X	X	X
Chum	*Oncorhynchus keta*	—	X	X	X	X	—	—	X	X	X	X
Pink (humpback)	*O. gorbuscha*	X	X	X	—	X	—	—	—	X	—	—
Silver (coho)	*O. kisutch*	X	X	X	—	X	—	—	—	X	—	—
Chinook	*O. tshawytscha*	X	X	X	X	X	—	—	—	X	—	—
Sockeye	*O. nerka*	—	X	X	—	X	—	—	—	X	—	—
Whitefish	*Coregonus sp.*	X	X	—	X	X	—	—	X	—	X	X
Broad whitefish	*Coregonus nasus*	—	—	—	X	X	X	—	X	—	X	X
Humpback whitefish	*C. clupeaformis*	—	—	—	X	X	—	—	X	—	X	X
Least cisco	*C. sardinella*	—	X	X	X	X	—	X	X	—	—	X
Bering and Arctic cisco	*C. sutumnalis*	X	—	—	—	X	—	X	—	X	—	—

TABLE 3.14.3-6 (Cont.)

		Native Villages[b]										
Resource	Scientific Name	Kivalina	Noatak	Kiana	Selawik	Kotzebue	Noorvik	Buckland	Kobuk	Deering	Ambler	Shungnak
Other Freshwater Fish												
Arctic grayling	*Thymallus arcticus*	X	X	X	—	X	—	—	X	X	X	X
Arctic char	*Salvelinus alpinus*	X	X	X	—	X	—	—	—	—	—	—
Burbot (ling cod)	*Lota lota*	X	X	X	—	X	—	—	—	—	—	—
Dolly Varden Trout	*Salvelinus malma malma*	X	X	X	X	X	—	X	X	X	X	X
Lake Trout	*Salvelinus namaycush*	—	X	X	X	—	—	—	—	—	X	—
Northern Pike	*Esoxlucius*	—	X	X	X	X	—	—	X	—	X	X
Sheefish	*Stenodus leucicthyes*	X	X	X	X	X	—	—	—	—	X	X
Sucker	Species not reported	—	—	—	X	—	—	X	X	—	X	X
Mudshark/Spiny Dogfish	*Squalus acanthias*	—	—	—	X	—	—	X	X	—	X	X
Other Coastal Fish												
Rainbow smelt	*Osmerus morda*	X	—	X	—	X	X	X	—	X	—	—
Arctic cod	*Boreogadus saida*	X	—	—	—	X	—	X	—	X	—	—
Tomcod (Saffron cod)	*Eleginus gracilis*	X	—	—	—	X	—	X	—	X	—	—
Herring	*Clupea sp.*	—	—	—	—	X	—	—	—	X	—	—
Halibut	*Hippoglosus sp.*	—	—	X	—	X	—	—	—	—	—	—
Flounder	*Liopsetta glacialis*	—	—	—	—	X	—	X	—	X	—	—
Birds												
Snowy owl	*Nyctea scandiaca*	X	X	—	X	—	X	X	X	X	X	X
Ptarmigan	*Lagopus sp.*	X	X	X	X	X	X	X	X	X	X	X
Grouse	Species not reported	X	X	X	X	X	X	X	X	X	X	X
Murres	Multiple species	X	—	—	X	—	X	X	X	X	X	X
Waterfowl	Species not reported	X	X	X	X	X	X	X	X	X	X	X
Loon	Multiple Species	—	—	—	X	—	X	X	X	X	X	X
Red-throated loon	*Gavia stellata*	—	—	—	X	X	X	X	X	X	X	X
Gull	Multiple species	—	—	—	X	—	X	X	X	X	X	X
Tundra swan	*Cygnus columbianus*	X	X	X	X	X	X	X	X	—	X	X
Eider	Species not reported	X	—	—	X	X	X	X	X	X	X	X
Common eider	*Somateria mollissima*	X	—	—	X	—	—	X	X	X	X	X
King eider	*Somateria spectabilis*	X	—	—	X	—	X	X	X	X	X	X
Spectacled eider	*Somateria fischeri*	—	—	—	X	—	X	X	X	X	X	X
Pintail	*Anas acuta*	X	X	—	X	X	X	X	X	X	X	X
Long-tailed duck	*Clangula hyemalis*	—	X	—	X	—	X	X	X	X	X	X
Scoters	Multiple species	—	X	—	X	—	X	X	X	X	X	X
Bufflehead	Bucephala albeola	—	—	—	X	—	X	X	X	X	X	X
Canvasback	*Aythya valisineria*	—	—	—	X	—	X	X	X	X	X	X
Harlequin	*Histrionicus histrionicus*	—	—	—	X	—	X	X	X	X	X	X
Mallard	*Anas platyrhynchos*	X	X	—	X	X	X	X	X	X	X	X
Merganser	Multiple species	—	X	—	X	—	X	X	X	X	X	X
Scaup	Multiple species	—	—	—	X	—	X	X	X	X	X	X
Teal	Multiple species	—	—	—	X	—	X	X	X	X	X	X

TABLE 3.14.3-6 (Cont.)

		Native Villages[b]										
Resource	Scientific Name	Kivalina	Noatak	Kiana	Selawik	Kotzebue	Noorvik	Buckland	Kobuk	Deering	Ambler	Shungnak
Wigeon	Multiple species	—	X	—	X	—	X	X	X	X	X	X
Other ducks	Species not reported	X	X	X	X	X	X	X	X	X	X	X
Geese	Species not reported	X	X	X	X	X	X	X	X	X	X	X
Brant	*Branta bernicla n.*	X	X	X	X	X	X	X	X	X	X	X
White-fronted goose	*Answer albifrons*	X	X	X	X	X	X	X	X	X	X	X
Snow goose	*Chencaerulescens*	X	X	X	X	X	—	X	X	X	X	X
Canada goose	*Branta Canadensis*	X	X	X	X	X	X	X	X	X	X	X
Sandhill crane	*Grus canadensis*	—	—	—	X	—	X	X	X	X	X	X
Snipe	Multiple Species	—	—	—	X	—	—	X	—	X	X	X
Plover	Multiple Species	—	—	—	X	—	X	X	X	X	X	X
Auk	Multiple Species	—	—	—	X	—	X	X	X	X	X	X
Bird eggs	Species not reported	X	X	X	X	X	X	X	X	X	X	X
Gull eggs	Species not reported	X	X	—	X	X	X	X	X	X	X	X
Goose eggs	Species not reported	X	X	X	X	—	X	X	X	X	—	X
Duck eggs	Species not reported	X	X	X	X	—	X	X	X	X	X	X
Eider eggs	Species not reported	X	—	—	X	—	X	X	X	X	X	X
Other Resources												
Berries	Species not reported	X	X	X	X	X	—	—	—	—	X	X
Cranberry	*V. vitisidaea*	X	X	X	—	—	—	—	—	—	—	—
Salmonberry	*Rubus spectabilis*	X	X	X	—	—	—	—	—	—	—	—
Blueberry	*Vsccimium sp.*	X	X	X	X	—	—	—	X	—	X	X
Blackberry	*Rubus sp.*	X	X	—	—	—	—	—	—	—	—	—
Crowberry	*Empetrum sp.*	—	—	X	—	—	—	—	—	—	—	—
Greens/roots	Species not reported	X	X	X	X	X	—	—	X	—	X	X
Wild rhubarb	*Oxyric digyna*	X	X	X	X	—	—	—	X	—	X	X
Wild celery	*Vallisneria Americana*	X	X	—	X	—	—	—	X	—	X	X
Eskimo potato	Species not reported	X	X	X	—	—	—	—	—	—	—	—
Stinkweed	Species not reported	X	X	X	—	—	—	—	—	—	—	—
Sourdock	*Rumex crispus*	X	X	X	—	—	—	—	—	—	—	—
Willow leaves	Species not reported	X	X	X	X	—	—	—	X	—	X	X
Clams	Species not reported	—	—	X	—	X	—	—	—	—	—	—
Crab	Species not reported	X	X	X	—	X	—	—	—	—	—	—
Shrimp	Species not reported	—	—	—	—	X	—	—	—	—	—	—

[a] This table is based primarily on data from the Alaska Department of Fish and Game. Subsistence harvest data are not uniformly reported. Data for Noorvik, Buckland, Deering, Amble, Kobuk, Selawikand, and Shungnak are mostly confined to migrating bird species. The date next to the community name is the date of the subsistence harvest data designated as "most representative" on the ADFG subsistence website.

[b] X = Reported; — = Not reported.

Sources: ADFG 2011e; ASRC 2012; MMS 2008b.

crews bring light seal skin *umiat* to leads in the ice. Aluminum and fiberglass skiffs are used in open water for the fall harvest, which targets younger, smaller whales (MMS 2008b). In addition to boat crews, there are camp crews on ice or shore that provide food and other support to the whalers. Some crews may hunt ringed seals to provide camp food. Crews help one another in hauling and butchering their take. Whale meat and blubber are distributed according to cultural norms relating to the roles played in the hunt and support, kin and other social ties, and the values placed on generosity and the social responsibility to provide for widows and others unable to hunt. With the *Nalukataq* festival, an important Iñupiaq ceremony, the community the marks the end of the whale hunt (SRBA 2010).

In recent public meetings, Alaska Natives in the Arctic have voiced concerns regarding past and potential effects of oil and gas exploration on subsistence resources and are concerned that traditional knowledge of subsistence resources is not regularly taken into account. They express concerns that noise, particularly from seismic testing, disturbs whales and other sea mammals, causing them to avoid the noise source and stay farther out to sea, making the whale hunt in small craft more difficult and more dangerous, and exposing the whalers to rougher seas, more shifting ice, shipping traffic, and stronger offshore currents (see also Quakenbush and Huntington 2010a). They are concerned that any oil spill, even if rare, could result in harm to subsistence species and could cause others to avoid the area. They also feel that existing pipelines on land have altered caribou migration patterns (BOEMRE 2011c–f).

Alaska Natives have also voiced concerns over increased shipping facilitated by the opening of the Northwest Passage, since shipping noise may interfere with marine subsistence hunts. They are currently adapting to later ice formation in the fall and earlier ice retreat in the spring. The lengthening of the ice-free season allows for more shipping to support the oil and gas industry, community resupply, or tourism. With increased traffic, there is a tendency to stretch the ice-free season even longer by the use of ice breakers. It follows that shipping plays a role and has an impact on the formation of sea ice not only on its own, but also through combining with other drivers of change (e.g., climate change) (Arctic Council 2009). Annual sea ice formation is critical for Alaska Natives as well as marine fish and mammals. Alaska Natives are very concerned by the loss of multiyear ice, which forms a sturdy platform of sufficient depth to allow for camping, butchering whales, and hunting along sea ice routes that remain passable for hunters as well as for the migratory game they pursue (Arctic Council 2009).

3.15 ENVIRONMENTAL JUSTICE

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" (59 FR 7629), formally requires Federal agencies to incorporate environmental justice as part of their missions. Environmental justice is defined by the Executive Order as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, or socioeconomic group should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of Federal, State, local, and tribal programs and policies." Specifically, it directs them to address, as appropriate, any disproportionately high and adverse human health or environmental effects of their actions, programs, or policies on minority and low-income populations.

The analysis of the impacts of offshore oil and gas development projects on environmental justice issues follows guidelines described in the Council on Environmental Quality's (CEQ's) *Environmental Justice Guidance under the National Environmental Policy Act* (CEQ 1997). The analysis method has three parts: (1) a description of the geographic distribution of low-income and minority populations in the affected area is undertaken; (2) an assessment is conducted to determine whether oil and gas activities would produce impacts that are high and adverse; and (3) if impacts are high and adverse, a determination is made as to whether these impacts would disproportionately affect minority and low-income populations.

Construction and operation of offshore oil and gas development projects could affect environmental justice if any adverse health and environmental impacts resulting from either phase of development are significantly high and if these impacts disproportionately affect minority and low-income populations. If the analysis determines that health and environmental impacts are not significant, there can be no disproportionate impacts on minority and low-income populations. In the event impacts are significant, disproportionality would be determined by comparing the proximity of any high and adverse impacts with the location of low-income and minority populations.

A description of the geographic distribution of minority and low-income groups in the affected area was based on demographic data from the 2000 Census (USCB 2011g,h). The following definitions were used to define minority and low-income population groups:

- **Minority.** Persons are included in the minority category if they identify themselves as belonging to any of the following racial groups: (1) Hispanic, (2) Black (not of Hispanic origin) or African American, (3) American Indian or Alaska Native, (4) Asian, or (5) Native Hawaiian or Other Pacific Islander.

  Beginning with the 2000 Census, where appropriate, the census form allows individuals to designate multiple population group categories to reflect their ethnic or racial origins. In addition, persons who classify themselves as being of multiple racial origin may choose up to six racial groups as the basis of their racial origins. The term minority includes all persons, including those classifying themselves in multiple racial categories, except those who classify themselves as not of Hispanic origin and as White or "Other Race" (USCB 2009a).

- **Low-Income.** Individuals who fall below the poverty line. The poverty line takes into account family size and age of individuals in the family. In 1999, for example, the poverty line for a family of five with three children below the age of 18 was $19,882. For any given family below the poverty line, all family members are considered as being below the poverty line for the purposes of analysis (USCB 2009b).

The CEQ guidance proposed that minority and low-income populations be identified where either (1) the minority or low-income population of the affected area exceeds 50% or (2) the minority or low-income population percentage of the affected area is greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.

This PEIS applies both criteria in using the U.S. Census Bureau data, wherein consideration is given to the minority and population that is both greater than 50% and 20 percentage points higher than in the State as a whole (the reference geographic unit).

3.15.1 Gulf of Mexico

The analysis of environmental justice issues associated with the development of offshore oil and gas development facilities considered impacts within the 129 counties that constitute the 23 Labor Market Areas (LMAs) located along the GOM coast, defined on the basis of inter-county commuting patterns using a method suggested by Tolbert and Sizer (1996). Analysis at the county level for each LMA allows the inclusion of impacts that would potentially occur at the various facilities and infrastructure directly and indirectly associated with the construction and operation of offshore oil and gas developments.

The data in Table 3.15.1-1 show the minority and low-income composition of the total population located within the LMA counties along the GOM coast based on 2000 Census data and CEQ guidelines. Individuals identifying themselves as Hispanic or Latino are included in the table as a separate entry. However, because Hispanics can be of any race, this number also includes individuals identifying themselves as being part of one or more of the population groups listed in the table.

A large number of minority and low-income individuals are located in the LMA counties along the GOM coast. Within the combined LMA counties in each State along the GOM coast, the percentage of the total population classified as minority varies between 23.6% in Mississippi and 55.8% in Texas. The number of minority individuals in the LMAs combined exceeds 50% of the total population in Texas, but the number of minority individuals does not exceed the State average by 20 percentage points or more in any of the combined LMA counties in each State; thus, there is a minority population only in the LMA counties in Texas, based on 2000 Census data and CEQ guidelines. The number of low-income individuals in the combined LMA counties in each State does not exceed the State average by 20 percentage points or more and does not exceed 50% of the total population in any of the LMA counties; thus, there are no low-income populations in any of the combined LMA counties in any of the five States.

In the Alabama portion of the GOM coast, more than 50% of the population is classified as minority in Wilcox County, northeast of Mobile, where the low-income population is more than 20 percentage points higher than the State average. In Florida, more than 50% of the population is classified as minority in Gadsden County, west of Tallahassee, and in Miami-Dade County. In Louisiana, Iberville Parish, to the southwest of Baton Rouge; St. Helena Parish, to

TABLE 3.15.1-1 Gulf Coastal Region Minority and Low-Income Populations, 2000

Population Segment	Alabama	Florida	Louisiana	Mississippi	Texas	Total
Total Population	599,405	8,955,931	3,382,809	458,674	6,939,834	20,336,653
White, Non-Hispanic	401,434	5,297,536	2,116,976	350,300	3,068,665	11,234,911
Hispanic or Latino	7,790	2,002,650	91,720	9,761	2,584,430	4,696,351
Non-Hispanic or Latino minorities	190,181	1,655,745	1,174,113	98,613	1,286,739	4,405,391
One Race	184,863	1,520,754	1,143,483	93,437	1,215,951	4,158,488
Black or African American	173,361	1,341,280	1,073,021	83,554	942,898	3,614,114
American Indian or Alaskan Native	4,751	23,724	17,988	1,778	16,203	64,444
Asian	6,193	135,194	47,637	7,470	247,451	443,945
Native Hawaiian or Other Pacific Islander	124	3,574	793	234	2,254	6,979
Some Other Race	434	16,982	4,044	401	7,145	29,006
Two or More Races	5,318	134,991	30,630	5,176	70,788	246,903
Total Minority	197,971	3,658,395	1,265,833	108,374	3,871,169	9,101,742
Percent Minority	33.0%	40.8%	37.4%	23.6%	55.8%	44.8%
Low-Income	101,236	1,200,105	611,737	65,629	1,194,653	3,173,360
Percent Low-Income	16.9%	13.4%	18.1%	14.3%	17.2%	15.6%

Sources: USCB 2011g, h.

the northeast of Baton Rouge; and West Feliciana Parish, to the north of Baton Rouge, have populations in which more than 50% is classified as minority. The case is similar in Orleans Parish, in central New Orleans, and St. James Parish, to the west of New Orleans.

In Texas, more than 50% of the population in Brooks County, southwest of Corpus Christi, is classified as minority, where the low-income population is more than 20 percentage points higher than the State average. Elsewhere in the Corpus Christi area, in Duval County, Jim Wells County, Kenedy County, Kleburg County, Nueces County, and Refugio County, more than 50% of the population is classified as minority. In the Brownsville area, Harris and Starr Counties have more than 50% of the population classified as minority, and have a low-income population that is more than 20 percentage points higher than the State average. The low-income population in Starr County also exceeds 50% of the total population. In Cameron and Willacy Counties, more than 50% of the population is classified as minority. In the Houston area, in Fort Bend County, Harris County, and Waller County, more than 50% of the population is classified as minority.

There are 81 counties and parishes in the GOM coast region that contain oil-related infrastructure, including platform fabrication yards, port facilities, shipyards, shipbuilding yards, support facilities, transport facilities, waste management facilities, pipelines, pipe coating yards, natural gas processing facilities, natural gas storage facilities, refineries, and petrochemical facilities (MMS 2006b). Thirty-nine counties contain more than five facilities. Ten counties (or parishes in Louisiana) have a high concentration of oil-related infrastructure (50 or more facilities). Of these 10 counties, 5 have higher minority percentages than their respective State average. These counties include Mobile, Alabama; St. Mary, Louisiana; and Galveston, Harris, and Jefferson, Texas. Two of the 10 high infrastructure concentration counties also have higher poverty rates than their respective State rate. St. Mary Parish, Louisiana, and Jefferson, Texas, have higher poverty rates than the average poverty rate in their States. Fifteen counties (or parishes in Louisiana) are considered to have a medium concentration of oil-related infrastructure (15–49 facilities). Five of these counties have a higher poverty rate than the mean rate in their States: Iberia, Orleans, and Vermillion, Louisiana; and Nueces and San Patricio, Texas. Eight of the 15 medium concentration counties also have higher minority populations than their State average. These counties include Hillsborough, Florida; East Baton Rouge, Iberia, Orleans, and St. James, Louisiana; and Calhoun, Nueces, and San Patricio, Texas.

3.15.1.1 Oil Spills and Human Health Effects

The potential health effects of oil spills include effects related to worker safety, toxicological effects in workers and community members, and mental health effects emanating from social and economic disruption (Goldstein et al. 2011). Toxicological effects include chemical effects such as respiratory and dermal irritation, headaches, eye irritation, nausea, and dizziness. The short-term and long-term natures of these impacts are dependent on the contaminants involved and the characteristics of the exposed populations.

Crude oil contains many different hydrocarbons, and the relative amounts of trace metal and sulfur content can vary significantly (Goldstein et al. 2011). Some crude oil components can cause respiratory, hepatic, renal, endocrine, neurologic, hematologic effects at high doses after a threshold concentration has been exceeded. Mutagenic effects, on the other hand, can result from a single molecular DNA alternation (Goldstein et al. 2011). Carcinogens in crude oil include benzene, which is present at a concentration of between 1 and 6%, and PAHs, which are present at lower, variable concentrations. Benzene and PAHs are also present from the offshore controlled burning of crude oil (Goldstein et al. 2011). Benzene is a known hematotoxicant and hematocarcinogen (Goldstein and Witz 2009). Benzene affects the circulating blood cells in workers exposed to concentrations below current occupational health standards (Lan et al. 2004), and has reproductive and developmental effects (Xing et al. 2010). Benzene is only a risk close to an oil source; it appears to evaporate, with other VOCs, before reaching shore, meaning that community exposures are relatively minimal (Morita et al. 1999). PAHs are more persistent, and can cause skin and lung cancer, in addition to reproductive and neurological effects (Department of Health and Human Services 2010). All organic components of crude oil may contribute to acute short-term effects, but are unlikely to be present in sufficient concentrations to cause long-term health effects (Goldstein et al. 2011). During summer months VOCs are converted to ozone, which can cause respiratory irritation, including asthma (Eggleston 2007; Leikauf 2002).

Surfactants used as dispersants during the DWH event contained petroleum distillate, propylene glycol, and sulfonic acid salt, which contained dioctyl sodium sulfosuccinate, or stool softener (Goldstein et al. 2011). Another surfactant used was 2-butoxyethnol, known to cause hepatic angiosarcoma and hemolytic anemia in rodents (Gualtieri et al. 2003). Exposure to trace quantities of metals such as arsenic, chromium, lead, and nickel could be a toxicological concern, and statistical evidence of association with endocrine and genotoxic effects after spills has been established (Perez-Cadahia et al. 2008). Water monitoring by the USEPA did not find positive evidence of benzene or PAHs in water samples, and air monitoring did not find evidence of VOCs except for trace levels of naphthalene (USEPA 2011f).

Approximately 52,000 workers responded to the DWH event (NIOSH 2011), and a number of symptoms were reported in evaluations undertaken by NIOSH, including chemically induced upper respiratory illnesses, throat and eye irritation, headaches, dizziness, nausea, and vomiting (Goldstein et al. 2011). Longer-term health effects in workers include pulmonary abnormalities (Meo et al. 2009), bronchial hyperresponsiveness, acute and persistent genotoxic effects, and endocrine effects (Aguilera et al. 2010).

The DWH event affected many communities that had health disparities compared to others in the United States, and that were also still suffering from the impacts of Hurricane Katrina (Goldstein et al. 2011). Louisiana, for example, is currently ranked among the most severely affected States in the nation in terms of rates of infant death, death from cancer, premature death, death from cardiovascular disease, children in poverty, and violent crime (United Health Foundation 2009). Children are particularly at risk for effects of environmental exposure; they breathe more air per unit of body mass, detoxify chemicals less effectively, and may suffer from accidental exposure more readily than adults (Goldstein et al. 2011). No evidence has been found regarding the risk of asthma or impaired respiratory function in children (Crum 1993), although indoor exposure may pose additional risk for children with asthma (Barbeau et al. 2010). The effects of crude oil components, such as higher-weight molecular compounds, are unknown (Xu et al. 2005).

Although symptoms of deterioration in mental health following an oil spill are reflected in increases in calls to mental health and violence hotlines (Yun et al. 2010), assessments of factors leading to deterioration in mental health, lack of adequate baseline data, study design, and delay in study initiation have limited the validity of studies on mental health impacts (Savitz et al. 2008). In addition, in the case of the DWH event, many communities were still recovering from Hurricane Katrina, complicating the response by community members to the DWH event (Goldstein et al. 2011). After Katrina, the severity and frequency of mental health symptoms seems to have increased, but there has also been a decline in the use of mental health services and the use of prescribed medication (Kessler et al. 2008). The Centers for Disease Control reported that 50% of adults in New Orleans had psychological stress, while post-traumatic stress disorder was prevalent among first responders, leading to alcohol and domestic abuse (Goldstein et al. 2011). Another survey found that in 2005–2006, 48% of returning students in the main parishes affected by Katrina had mental health symptoms, a rate that had only dropped to 30% by 2009–2010, indicating that repeated trauma increases vulnerability to deterioration in mental health (Kronenberg et al. 2010).

Minority communities may have specific concerns related to their psychosocial welfare. Working-age Vietnamese residents in New Orleans had numerous unresolved problems in the aftermath of Katrina, and then 1 yr later, including inadequate access to healthcare (Vu et al. 2009). Suspension of free health services led to the reemergence of disparities between racial and ethnic groups (Do et al. 2009). Symptoms of post-traumatic stress disorder were found in this population group, especially among members with a low degree of acculturation and high exposure to floods, together with long stays in emigration transit camps (Norris et al. 2009). As was the case for small, isolated Alaskan native communities with the *Exxon Valdez* spill (Goldstein et al. 2011), it is likely that the DWH event could lead to higher levels of depression, generalized anxiety disorder, post-traumatic stress disorder, violence, and other psychological problems among minority communities.

3.15.2 Alaska – Cook Inlet

The analysis of environmental justice issues associated with the development of offshore oil and gas development facilities considered impacts for the south central Alaska region, which includes Anchorage Municipality, Kenai Peninsula Borough, Kodiak Island Borough, and Matanuska-Susitna Borough.

The data in Table 3.15.2-1 show the minority and low-income composition of the total population located within the south Alaska region based on 2000 Census data and CEQ guidelines. Individuals identifying themselves as Hispanic or Latino are included in the table as a separate entry. However, because Hispanics can be of any race, this number also includes individuals identifying themselves as being part of one or more of the population groups listed in the table.

A large number of minority and low-income individuals are located in the south central Alaska region. However, the number of minority individuals in each of the boroughs does not exceed 50% of the total population, and the number of minority individuals does not exceed the State average by 20 percentage points or more in any of the boroughs; thus, there is no minority population in the south central Alaska region, based on 2000 Census data and CEQ guidelines. The number of low-income individuals in the three boroughs does not exceed the State average by 20 percentage points or more and does not exceed 50% of the total population; thus, there are no low-income populations in any of the boroughs.

3.15.2.1 Consumption of Fish and Game

Subsistence is “an activity performed in support of the basic beliefs and nutritional need of the residents of the borough and includes hunting, whaling, fishing, trapping, camping, food gathering, and other traditional and cultural activities” (ADNR 1997). Subsistence fishing is for direct personal or family consumption. Many thousands of Alaskans participate in subsistence fishing and processing, and it is an important element of Alaska’s social and cultural heritage. For a more complete discussion of subsistence and its cultural and nutritional importance, see Section 3.5.5.6. In rural Alaska, subsistence fisheries harvest produces about 230 lb per person per year (MMS 2006b). Although important as a source of food, subsistence fisheries are only about 2% of the fisheries harvest. Commercial fisheries account for about 97% of the wild harvest, and sport fisheries the remaining 1% (MMS 2006b).

TABLE 3.15.2-1 South Central Alaska Region Minority and Low-Income Populations, 2000

Population Segment	Anchorage Municipality	Kenai Peninsula	Kodiak Island	Matanuska-Susitna	South Central Alaska Region Total
Total population	260,283	49,691	13,913	59,322	383,209
White, Non-Hispanic	181,982	42,263	8,001	51,175	283,421
Hispanic or Latino	14,799	1,087	848	1,485	18,219
Non-Hispanic or Latino Minorities	63,502	6,341	5,064	6,662	81,569
One Race	50,119	4,549	4,439	4,195	63,302
Black or African American	14,667	220	129	398	15,414
American Indian or Alaskan Native	18,326	3,644	1,997	3,168	27,135
Asian	14,208	471	2,193	401	17,273
Native Hawaiian or Other Pacific Islander	2,335	85	105	66	2,591
Some Other Race	583	129	15	162	889
Two or More Races	13,383	1,792	625	2,467	18,267
Total Minority	78,301	7,428	5,912	8,147	99,788
Percent Minority	30.1	14.9	42.5	13.7	26.0
Low-Income	18,682	4,861	901	6,419	30,863
Percent Low-Income	7.3	10.0	6.6	11.0	8.2

Sources: USCB 2011g, h.

Subsistence fishing and hunting are an important part of the economies of rural Alaskan communities, providing sources of food, clothing, and employment. While the harvest of animals, birds, shellfish, and plants only represents 2% of the fish and game harvested annually (MMS 2006b), the subsistence harvest contains about 35% of the caloric requirements of the rural population. In some areas of Alaska, notably the interior and western areas, subsistence products provide up to 50% of the daily requirement (MMS 2006b; Bersamin et al. 2007). Approximately 2% of the daily requirement of the urban population is met through subsistence activities.

Although it is difficult to establish the economic importance of subsistence harvests because the consumption and exchange of subsistence products do not occur in the marketplace, estimates of their importance have been made based on the dollar value of replacing subsistence products in the market. Using a replacement value of $3/lb, the replacement value of subsistence harvests in rural Alaska is estimated to be $131 million annually; at $5/lb, the replacement value of these products would be $219 million. In Alaska as a whole, the replacement value of subsistence products is estimated to be between $160 million and $267 million (MMS 2006b).

3.15.2.2 Oil Spills and Subsistence

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 (MMS 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 evacuations of people and avoidance of marine and terrestrial foods that may be affected. Avoidance of shellfish, which accumulates 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 the testing agency 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. According to MMS (2006b), a discussion of subsistence food issues must be cross-disciplinary, reflecting a spectrum of disciplines from toxicology, to marine biology, to cultural anthropology, to cross-cultural communication, to ultimately understanding disparate cultural definitions of risk perception itself. 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 “must include the re-establishment of a social equilibrium between the biophysical environment and the human community” (Picou and Gill 1996; 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).

3.15.3 Alaska – Arctic

The analysis of environmental justice issues associated with the development of offshore oil and gas development facilities considered impacts for the Arctic region, which consists of the North Slope Borough and the Northwest Arctic Borough.

The data in Table 3.15.3-1 show the minority and low-income composition of the total population located within the Arctic region, based on 2000 Census data and CEQ guidelines. Individuals identifying themselves as Hispanic or Latino are included in the table as a separate entry. However, because Hispanics can be of any race, this number also includes individuals identifying themselves as being part of one or more of the population groups listed in the table.

A large number of minority and low-income individuals are located in the Arctic region. The number of minority individuals in the region exceeds 50% of the total population, and the number of minority individuals exceeds the State average by 20 percentage points; thus, there is a minority population in the Arctic region, based on 2000 Census data and CEQ guidelines. The number of low-income individuals in the region does not exceed the State average by 20 percentage points or more and does not exceed 50% of the total population; thus, there are no low-income populations in the region.

3.15.3.1 Health Status of Alaska Native Communities

The potential health effects of oil spills, including effects related to worker safety, toxicological effects in workers and community members, and mental health effects emanating from social and economic disruption, can disproportionately impact Alaska Native and other minority population groups and low-income communities (see Section 3.15.1.1). In addition to the impacts of oil spills, there are more general concerns regarding the possible health effects of oil and gas exploration and development on minority and low-income populations. Based on analysis undertaken for MMS, this section summarizes the current health status of the North Slope Iñupiat, the changes that have taken place over the past 50 yr, and the important determinants of public health in the North Slope communities, based on a series of meetings between the North Slope Borough and BOEM on this issue (MMS 2006b). Although specifically related to health issues in the North Slope Borough, many of the health issues identified in this section are also relevant to Alaskan Native populations in south central Alaska. “Health” is defined as “a state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity” (MMS 2006b). The disease and mortality figures discussed are age-adjusted unless otherwise specified.

Alaska Native health has undergone profound changes over the last 50 yr, and the changes in health status among the Iñupiat residents of the North Slope mirrors Statewide trends in Alaska Native health status in many respects. Since 1950, infant mortality, overall mortality, and life expectancy have improved significantly, as has been the case in American Indian tribes throughout the United States. However, over the same time period, cancer, chronic diseases (such as diabetes, hypertension, and asthma), and social pathology have increased (MMS 2006b).

Much of the overall improvement in mortality figures is attributable to decreased rates of infectious diseases such as tuberculosis. In 1950, tuberculosis was the leading cause of death, causing over 45% of deaths; by 2000, the proportion of deaths caused by infection had fallen to 1.3%; life expectancy at birth had increased from 46.6 to 69 yr, and infant mortality had decreased from 90/100,000 to 9.5/100,000. The most rapid improvement in general health indicators occurred in the 1950s and 1960s. However, since 1979, health status has continued to

TABLE 3.15.3-1 Arctic Region Minority and Low-Income Populations, 2000

Population Segment	North Slope Borough	Northwest Arctic Borough	Arctic Region Total
Total Population	7,385	7,208	14,593
White, Non-Hispanic	1,228	878	2,106
Hispanic or Latino	175	57	232
Non-Hispanic or Latino Minorities	5,982	6,273	12,255
One Race	5,530	6,101	11,540
Black or African American	51	15	66
American Indian or Alaskan Native	4,982	5,919	10,901
Asian	435	64	499
Native Hawaiian or Other Pacific Islander	59	4	63
Some Other Race	3	8	11
Two or More Races	452	263	715
Total Minority	6,157	6,330	12,487
Percent Minority	83.4	87.8	85.6
Low-Income	663	1,243	1,906
Percent Low-Income	9.1	17.4	13.2

Sources: USCB 2011g, h.

improve based on general indicators, with a decline of roughly 20% in all-cause mortality (MMS 2006b).

Health improvements have been facilitated by a combination of region-wide increases in general socioeconomic status (a powerful determinant of health); improved housing, sanitation, and health care; and specific infection-control efforts. Since 1979, much of the continued improvement in mortality figures can be accounted for by decreasing fatality from injuries. Mortality from unintentional injury, the second leading cause of death in Alaska Natives, accounts for much of the more recent improvement, with a decline of roughly 40% between 1979 and 1998. Much of this change can be attributed to local health departments' injury prevention programs and the efficacy of local alcohol control and local prohibition ordinances (MMS 2006b).

Despite these improvements in overall mortality figures, significant health disparities remain, and cancer, social pathology, and chronic diseases are rapidly increasing. Health disparities between Alaska Natives and American Indians and the general U.S. population constitute one of the top priorities in current public health efforts. Life expectancy at birth for Alaska Natives remains significantly lower than for the general population (69 compared with 76 yr). Since 1979, Alaska Native mortality rates remain roughly 30% higher than the

U.S. population, and on the North Slope, overall mortality rates are 1.5 times higher than the U.S. population. Rates of assault, domestic violence, and unintentional and intentional (homicide and suicide) injury and death on the North Slope remain far higher than in the general U.S. population, despite the improvements noted above in unintentional injuries (MMS 2006b).

To understand the changes in Iñupiat health status and the reasons behind the current health disparities in general health indicators, it is useful to examine the prevalent health issues among the North Slope Iñupiat communities individually.

3.15.3.1.1 Cancer. Cancer has increased roughly 50% since 1969, and is now the leading cause of death on the North Slope. Three cancers — breast, colon, and lung — account for much of the overall increase. North Slope Alaska Natives have the highest incidence of cancer in Alaska, at 579/100,000. Cancer mortality rates for all Alaska Natives, including North Slope residents, at 303/100,000, are significantly higher than the U.S. rate of 163/100,000, a disparity of great concern to health care providers in the State (MMS 2006b).

A substantial percentage of the increase in cancer incidence, particularly for lung cancer, is attributable to smoking. There may be other, much less significant environmental factors at work as well, such as environmental contamination due to increases in industrialization, the use of locally generated electricity and of vehicles, and the adoption of highly insulated housing. Cancer mortality rates due to these factors are less well understood. The possible contribution of environmental factors such as contaminants in subsistence resources is of great concern to local residents, but does not likely constitute the sole or perhaps the most likely explanation. Current public health efforts focus on smoking cessation efforts, early detection, surveillance of carcinogens in subsistence foods, and curtailing exposure to known carcinogenic compounds as much as possible while discouraging their continued use (MMS 2006b).

3.15.3.1.2 Psychological and Social Problems. Alcohol and drug problems, accidental and intentional injury (a high percentage of which are associated with alcohol use), depression, anxiety, and assault and domestic violence are now highly prevalent in the North Slope Borough (as they are in many rural Alaska Native villages) and cause a disproportionate burden of suffering and mortality for these communities. Suicide rates among Alaska Natives have increased dramatically since 1960 (MMS 2006b). The prevalence of suicide on the North Slope in recent years has been estimated at roughly 45/100,000, more than four times the rate in the general U.S. population. Still more strikingly, the age distribution of suicide has shifted to become a phenomenon of youth; before 1960, it was exceedingly rare and generally occurred primarily among elderly individuals. The rate of suicide among young Iñupiat men in the Alaskan Arctic has been documented as high as 185/100,000, nearly 16 times the national rate (MMS 2006b).

Domestic violence and child abuse are also now generally acknowledged as epidemic problems in rural Alaska and, internationally, in other Arctic indigenous communities as well. Unprocessed arrest data from the U.S. Department of Health and Social Services in 2000–2003, for example, show rates of rape and assault 8–15 times the national rate (MMS 2006b).

Homicide rates have dropped more than 50% since 1979, but remain markedly higher than the U.S. population. Alcohol and substance abuse are thought to contribute substantially to the rates of these problems (MMS 2006b).

Research in circumpolar Inuit societies suggests that social pathology and related health problems, which are common across the Arctic, relate directly to the rapid sociocultural changes that have occurred over the same time period (MMS 2006b). In the North Slope Borough, suicide rates increased dramatically in the 1960s and 1970s, and since 1979 have remained relatively constant but dramatically higher than the overall U.S. rates.

3.15.3.1.3 Injury Rates. Injury — including unintentional (or accidental) injury, suicide, assault, and homicide — is the second leading cause of death on the North Slope. Accidental injury rates have declined 43% since 1979, but mortality from accidental injury remains 3.5 times more common for Alaska Natives than U.S. whites (MMS 2006b). Injury is the second leading reason for hospitalization, after childbirth. Figures from the Alaska Trauma Registry indicated that the hospitalization rate for injuries in the North Slope Borough was the highest in the State, at 141/10,000 residents, and over twice the State average. Alcohol has been estimated to be involved in up to 40% of injuries and traumatic deaths in Alaska Natives (MMS 2006b).

Unintentional injury rates are high in the North Slope, not only because of the challenges of life in Arctic Alaska, but also because of factors such as high rates of alcohol and substance abuse and risk-taking behavior in youth (MMS 2006b). Many public health officials in Alaska have speculated that many “accidental” injuries in younger people may actually reflect abnormal risk-taking or latent suicidal behaviors.

3.15.3.1.4 Diabetes and Metabolic Diseases. Diabetes, obesity, and related metabolic disorders were previously rare or nonexistent in the Iñupiat. Diabetes rates in the North Slope Borough are low compared with other Alaska Native groups — and extremely low compared with all American Indians — but have begun to climb quite rapidly (MMS 2006b). The prevalence of diabetes in the North Slope is estimated at only 2.4% compared with the U.S. rate of roughly 7%. However, between 1990 and 2001, the rate of diabetes climbed roughly 110%, nearly three times the rate of increase in the general U.S. population (MMS 2006b). Subsistence diets and the associated active lifestyle are known to be the main protective factors against diabetes. The increase in diabetes is felt to reflect increased use of store-bought food, and a more sedentary lifestyle, potentially against the backdrop of a baseline genetic susceptibility (MMS 2006b).

3.15.3.1.5 Cardiovascular Disease. Cardiovascular disease rates, the second leading cause of death in Alaska, are significantly lower in Alaska Natives than in U.S. non-Natives. In the North Slope Borough, recent mortality figures show death rates roughly 10% less than the U.S. population (MMS 2006b). However, as discussed above, many of the risk factors are increasing, and smoking rates are already extremely high (MMs 2006b). As in the case of diabetes, many public health researchers have explained the lower mortality from cardiovascular disease as stemming primarily from subsistence diets and the associated active lifestyle.

3.15.3.1.6 Chronic Pulmonary Disease. Chronic pulmonary disease mortality rates in Alaska Natives have climbed 192% since 1979. North Slope Borough residents have the highest mortality in the State from chronic lung diseases, at nearly three times the mortality rate for the United States (130/100,000 compared with 45/100,000) (MMS 2006b). As in the case of cancer, the primary reason for the disparate rates of increase and mortality in pulmonary disease is ascribed to the high smoking rates in the North Slope Borough. However, there may be environmental reasons for the rates of increase as well, such as air pollution generated by industrialization and changes in local energy use (see discussion on cancer above). Because there are no available data on local fine particulate concentrations, no data on hazardous air pollutants, and little data on intra-regional variation in other USEPA criteria pollutants, it is difficult to determine the possible contribution of these environmental factors.

In the United States in recent years, the field of public health has focused on efforts to explain and address health disparities between ethnic groups and social classes (MMS 2006b). That health disparities tend to accrue predominantly in minority and low-income populations is an indication of the vulnerability of these groups to outside societal-level influences on health status. An impressive body of data has demonstrated a direct association between measurable societal factors, which have been collectively termed the “social determinants of health” — including income inequity within a society, the “social gradient” (or disparities of social class), stress, social exclusion, decreasing social capital (the social support networks that provide for needs within a group or community), unemployment, cultural integrity, and environmental quality — and the incidence, prevalence, and mortality rates of many specific diseases. These disparities persist and can be dramatic, even after controlling for standard risk factors such as smoking rates, cholesterol and blood pressure levels, and overall poverty (MMS 2006b).

The determinants of health status in North Slope Iñupiat communities are complex and reflect a wide array of considerations, including genetic susceptibility, behavioral change, environmental factors, diet, and sociocultural inputs (MMS 2006b). Identifying the potential influences, or “determinants,” of health status is an essential step for public health programs seeking to address health disparities. State, regional, and village-specific influences on health and health behavior can be directly or indirectly associated with past oil and gas development on the North Slope. For example, modernization and socioeconomic change are common to all of rural Alaska, and are one of the dominant influences on the evolution of health status. As noted above, North Slope petroleum development provided the economic tax base that funded many of the programs and activities that define these changes in rural Alaska. The associations between these influences and oil and gas development can be very complex and indeterminate (MMS 2006b). For example, regional differences exist between the North Slope Borough and other rural regions, such as the Northwest Arctic Borough, in terms of family income and employment status, largely related to oil and gas taxation and employment opportunities that came into being not because of the oil development alone, but because of the establishment and policymaking of the North Slope Borough. Similarly, residents of the North Slope village of Nuiqsut have experienced socioeconomic changes related not only to the State and regional-level influences discussed above, but also from local social and economic influences of the petroleum industry from the Alpine oilfield such as profits of the Kuukpik Corporation, shifts in income distribution, oilfield-related employment, the increased presence of oil workers in the village, a new road connection to the Alaska road system, and changes in hunting patterns and the availability of game due to oil-related infrastructure (MMS 2006b).

Public testimony on prior NEPA-based onshore and offshore actions in the region has indicated a persistent concern that regional industrialization may be at the root of some of the human health disparities described above. For example, testifying in 2001 on MMS' Liberty draft EIS, Rosemary Ahtuangaruak, a former health aide who received advanced training as a physician's assistant, stated:

"Increased incidents of community social ills associated with rapid technological and social change cause problems with truancy, vandalism, burglary, child abuse, domestic violence, alcohol and drug abuse, suicide, and primarily the loss of self-esteem. This has materialized during transient employment cycles. The influx of construction workers brings their own problems to a village impacted by oil development activities already. Historically, from past experience, we know that the incidents of alcohol and drug use increase dramatically" (MMS 2006b).

Similarly, former North Slope Borough Mayor George Ahmaogak noted: "The benefits of oil development are clear — I don't deny that for a moment. The negative impacts are more subtle. They're also more widespread and more costly than most people realize. We know the human impacts of development are significant and long-term. So far, we've been left to deal with them on our own. They show up in our health statistics, alcohol treatment programs, emergency service needs, police responses — you name it" (MMS 2006b).

The health status of the North Slope Iñupiat people has improved significantly since the 1950s; however, significant new pathologies, most importantly cancer, cardiovascular and metabolic problems, and social pathology, have emerged during this period. The reasons for the improvements, the continuing disparities, and the new problems are very complex and originate in many different sources. However, while there is little definitive data linking degradation of environmental quality and local health impacts, and no data indicating specific health impacts of a particular oil and gas development project, a consideration of regional health data does allow for the recognition of risks associated with projects, and for the development of mitigation strategies. In general, the field of health impact assessment responds to concerns of environmental health impacts through efforts to control exposure to environmental contaminants rather than through attempts to identify specific increases in disease rates with specific exposures (MMS 2006b).

3.16 ARCHAEOLOGICAL AND HISTORIC RESOURCES

As defined in the Advisory Council on Historic Preservation (ACHP) regulations at 36 CFR 800.16, "historic property" means any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the *National Register of Historic*

Places (NRHP). The term includes properties of traditional religious and cultural importance to an Indian tribe or Native Hawaiian organization and that meet the NRHP criteria. As used in this analysis, the more general term "cultural resources" also includes those historic resources not yet determined eligible for the NRHP.

Section 106 of the National Historic Preservation Act of 1966, as amended (NHPA; 16 USC 470(f)) requires that Federal agencies such as BOEM take into account the effect of an undertaking under their jurisdiction on significant cultural resources. A cultural resource is considered significant when it meets the eligibility criteria for listing on the NRHP (36 CFR 60.4). The Section 106 process requires the identification of cultural resources within the area of potential effect of a Federal project, consideration of a project's impact on cultural resources, and the mitigation of adverse effects on significant cultural resources. The process also requires consultation with State Historic Preservation Officers (SHPOs), the ACHP, Native American tribes, and interested parties. In the case of oil, gas, and sulfur leases, BOEM has established regulations (e.g., 30 CFR 250.194) and issues guidance to lessees (e.g., Notice to Lessees [NTL] No. 2005-G07 and G10, NTL No. 2006-G07, NTL No. 2005-A03, NTL No. 2006-PO3) to ensure compliance with Section 106 of the NHPA and its implementing regulations in 36 CFR Part 800. The NTLs provide guidance on the regulations regarding archaeological discoveries and the conduct of archaeological surveys and identify specific OCS lease blocks with a high potential for containing cultural resources on the basis of previous studies.

3.16.1 Gulf of Mexico

3.16.1.1 Offshore Prehistoric Resources

The GOM region consists of approximately 2,600 km (1,600 mi) of coastline. Onshore cultural resources are highly varied in coastal areas. Prehistoric cultural resources range from small, temporary use sites to substantial permanent settlements ranging in age from the earliest known human occupation of the area, approximately 12,000 yr ago, through the post-contact period (e.g., the last several hundred years). It is estimated that the current water levels of the GOM were reached approximately 3,000 yr ago (Stright et al. 1999). Therefore, sites predating this period could be located under water.

Approximately 19,000 yr ago, during the late Wisconsinan glacial advance, much of the OCS constituted dry land, as the sea level was approximately 120 m (390 ft) lower than present levels. During the earliest period of uncontested human prehistoric populations in the GOM coast region (approximately 12,000 yr ago), the sea level would have been approximately 45 to 60 m (150 to 200 ft) lower than present (CEI 1982). The submerged area between the paleoshoreline (vicinity of the 45- to 60-m [150- to 200-ft] bathymetric contour) to the present-day shoreline would, therefore, have the potential to contain prehistoric sites. Studies conducted in the 1980s and 1990s confirmed that inundated former terrestrial archaeological sites do exist in the GOM (Dunbar et al. 1989; Anuskiewicz and Dunbar 1993). A growing body of information suggests that North America may have been populated much earlier than 12,000 yr ago (e.g., Waters et al. 2011). If an earlier date can be established for the settling of North America, the depth and extent of areas with the potential for inundated terrestrial sites could expand.

3.16.1.2 Offshore Historic Resources

From the historic period (1492 to present), offshore cultural resources primarily consist of numerous shipwrecks dating from as early as the sixteenth century. However, other historic structures can also be found offshore, such as the Ship Shoal Lighthouse. Literature searches can be completed for reported ship losses and known shipwrecks, but they offer only a partial understanding of the resources that may be present. It can be assumed that some percentage of the reporting is inaccurate, some locations were imprecisely recorded, some of the ships were badly broken up and widely dispersed during drift, and additional ship losses may not have been documented (e.g., the losses of small coastal fishing boats were largely unreported, and the regular reporting of other larger watercraft did not occur until the nineteenth century). Often there is only a record that a ship was lost in the GOM region.

The preservation potential of shipwrecks varies throughout the GOM. The preservation of shipwrecks is dependent on several factors including the level of sedimentation at a wreck site, the depth the wreck, the strength and extent of water current activity near a site, and the temperature of the water. Shipwrecks in areas with high sediment loads are expected to be better preserved. The sediment protects the sites from the effects of severe storms and wood-eating shipworms. The coasts of Texas, Louisiana, Mississippi, and Alabama are likely to have sufficient sediment load to preserve shipwrecks. However, as a result of differences in sedimentation rates, it is anticipated that preservation would be slightly better off the Mississippi/Alabama coast than off the Louisiana coast due to the greater amount of sediment being discharged and deposited from the Mississippi River (CEI 1977).

Deepwater shipwrecks are expected to have a moderate to high preservation potential. Studies conducted in 2004 and 2008 for BOEM suggest that the high level of preservation in deep water is partially attributable to these areas being low-energy environments (Church et al. 2004; Ford et al. 2008). In addition, the water is colder at deepwater sites; this slows the oxidation process. Finally, the cause of a shipwreck could also affect its preservation potential. Shipwrecks nearer to the shoreline have a greater potential to be broken up and scattered by subsequent storms.

Several studies have been conducted for BOEM to model areas in the GOM where shipwrecks have the highest potential to exist. The first study, conducted in 1977, concluded that two-thirds of all shipwrecks in the northern GOM are located within 1.5 km (0.9 mi) of the shore (CEI 1977). A second study in 1989 (Garrison et al. 1989) concluded that the highest frequency of shipwrecks occurred in areas of the highest volume of marine traffic (e.g., approaches to seaports and mouths of navigable rivers and straits). This study also reported an increased frequency in shipwrecks in the open sea of the eastern GOM that was double that reported for the western or central GOM, attributed to changes in sailing routes in the late nineteenth and early twentieth centuries. In addition, the study looked at distribution patterns of shipwrecks relative to ocean currents, storm tracks, natural navigational hazards, and economic histories of ports. The final study, conducted in 2003 (Pearson et al. 2003), incorporated new data that had been compiled over 15 yr of high-resolution shallow hazard surveys for oil and gas development and sonar surveys. To date, shipwrecks have been discovered in water depths of over 2,700 m (~9,000 ft).

Many of the deepwater wrecks, or at least their locations, were not previously known; several of the deepwater shipwrecks date to the World War II era (Church et al. 2009). Six World War II–era vessels, for instance, were found during modern oil and gas surveys in water depths ranging from 87 to 1,964 m (285 to 6,444 ft). These wrecks included the *Virginia,* the *Halo,* the *Gulfpenn,* the *Robert E. Lee,* the *Alcoa Puritan,* and the *U-166.* Each shipwreck was identified during BOEM-required surveys; each was investigated to determine its individual site boundaries, its eligibility for the NRHP, and its state of preservation and stability (Church et al. 2009).

As a result of the findings in these studies, BOEM updated its guidelines to include lease blocks in deepwater areas within the approach to the Mississippi River as high-potential areas requiring archaeological survey. For instance, BOEM updated or created new NTLs that provided clarification on when archaeological surveys are needed for activities on the OCS. Among these notices was NTL No. 2006-G07, which provided new additions and modifications to the list of OCS blocks that required archaeological resource surveys and reports for submittal to BOEM, as well as the required survey line spacing for each block.

Another NTL (NTL 2011-Joint-G01) issued in 2011 provided additions and modifications in survey line spacing, as well as identifying new OCS blocks that require archaeological resource surveys. The 2011 NTL superseded NTL 2008-G20. The 2011 NTL did not rescind NTL No. 2005-G07, which provided specific guidance on how to satisfy the BOEM requirements concerning archaeological surveys in the GOM (BOEM 2011).

3.16.1.3 Onshore Archaeological and Historic Resources

Geographic features associated with onshore prehistoric archaeological sites in coastal areas in the western and central GOM include river channels and associated floodplains, terraces, levees and point bars, barrier islands, back barrier embayments, and salt domes. In the eastern GOM, off the coast of Florida, additional features include chert outcrops, solution caverns, and sinkholes. These same types of features are present on the OCS, are submerged and often buried by estuarine and marine sediments, and have the same potential for being associated with prehistoric site locations in this region. BOEM requires high-resolution remote sensing surveys prior to any bottom-disturbing activities associated with oil, gas, and sulfur leasing.

Historic resources located in coastal regions can include historic residences and communities, lighthouses, historic forts (e.g., Fort Livingston at Grande Terre Island, Louisiana), and piers and docks. Onshore historic resources also can include shipwrecks that have been buried on beaches.

3.16.1.4 Climate Change

The effects of climate change have the potential to alter archaeological and historic sites. Climate change is expected to result in increased sea temperatures, rising sea levels, and increased ocean acidity (Howard et al. undated). Most archaeological and historic resources have stabilized to the current environmental setting. Coastal archaeological sites and historic structures are at greater risk due to flooding, coastal erosion, and subsidence, which all have been identified as potential impacts of climate change (Cassar 2005). Some archaeological sites that are found on the OCS have already experienced the effects of climate change, as they were inundated when the last ice age ended. The primary effect from climate change for the BOEM archaeological and historic program could be an alteration of the lease blocks resulting from sea level change, requiring archaeological investigations.

3.16.2 Alaska – Cook Inlet

3.16.2.1 Offshore Prehistoric Resources

Minimal research has been conducted in the Cook Inlet Planning Area concerning the potential for submerged landforms that could contain archaeological material. During the time that Alaska was first populated (c. 13,000 yr ago), sea levels were significantly lower than today (Dixon et al. 1986). Much of the shoreline, where the first peoples would have lived, is now inundated in water up to 60 m (197 ft) in depth. Most of the research concerning identification of these old shorelines has occurred in the Beaufort and Chukchi Seas (see Section 3.6.5.8.1). However, an archaeological baseline study completed by Dixon et al. (1986) compiled available geologic, bathymetric, geophysical, climatic, and archaeological data in an effort to outline those areas of the Alaska OCS that may have the highest potential for preserved prehistoric archaeological sites. The primary indicators used to evaluate offshore prehistoric site potential were coastal geomorphic features onshore, relict geomorphic features offshore, and ecological data. It was proposed in the baseline study that these lines of evidence, taken together, indicate areas where subsistence resources used by prehistoric human populations would have been concentrated for sustained periods of time. However, actual geophysical data would be required to reconstruct the offshore paleogeography and determine specific areas where prehistoric archaeological sites might occur. The results of the baseline study suggest that the area around the Aleutian Islands has potential for preserved prehistoric sites. While the information contained in the Dixon et al. (1986) report is useful for understanding Alaskan prehistory, the Alaska SHPO requires that baseline reports be updated regularly (McMahan 2011).

Portions of Cook Inlet are subject to high-energy 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 archaeological resources to be present. Additional research is needed to determine the extent of the disturbance.

3.16.2.2 Offshore Historic Resources

A total of 108 shipwrecks were lost in Cook Inlet between 1799 and 1954 (Tornfelt and Burwell 1992). With some exceptions, the sites of most of these shipwrecks are within State waters. However, 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. No shipwreck studies have been done in Cook Inlet since 1992.[15]

3.16.2.3 Onshore Archaeological and Historic Resources

Records for known onshore archaeological and historic resources around Cook Inlet are maintained by the Alaska Office of History and Archaeology (Alaska OHA). Along the shoreline surrounding Cook Inlet, the predominant types of prehistoric resources are house pits containing the household and subsistence artifacts (stone lamps, sinkers, arrowheads, etc.) of prehistoric people. Historic sites found onshore consist of early Russian houses, churches, roadway inns, fish camps, and mining camps.

3.16.2.4 Climate Change

The effects of climate change have the potential to alter archaeological and historic sites. Climate change is expected to result in increased sea temperatures, rising sea levels, and increased ocean acidity (Howard et al. undated). Most archaeological and historic resources have stabilized to the current environmental setting. Coastal archaeological sites and historic structures are at greater risk due to flooding, coastal erosion, and subsidence, which all have been identified as potential impacts of climate change (Cassar 2005). Some archaeological sites that are found on the OCS have already experienced the effects of climate change, as they were inundated when the last ice age ended. The primary effect from climate change for the BOEM archaeological and historic program could be an alteration of the lease blocks resulting from sea level change, requiring archaeological investigations.

3.16.3 Alaska – Arctic

3.16.3.1 Offshore Prehistoric Resources

At the height of the late Wisconsinan glacial advance (approximately 19,000 yr ago), the global (eustatic) sea level was approximately 120 m (394 ft) lower than present. During this time, large expanses of what is now the OCS were exposed as dry land. Where the actual shorelines were located varied depending on the location and the amount of ice that was present.

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[15] The *Torrent* shipwreck was found by a private dive team in 2007 off the coast of Cook Inlet. The team has since launched an exploration and Web site to attract funding to continue their studies (Lee 2007; Lloyd 2008).

The lower sea levels created land bridges between the Asian continent and the North American continent. It is commonly thought that it was over these land bridges that the first people came to North America roughly 13,000 yr ago (Darigo et al. 2007). It is also commonly held that the first inhabitants of North America would have settled along the coasts. Therefore, if the relic coastlines or landforms (which are now completely inundated) can be found and identified, it is possible that archaeological evidence for the populating of North America could be found.

Studies using data collected during various explorations in the Beaufort Sea attempted to clarify if landforms dating to the early Holocene Period (between 13,000 and 11,000 yr ago) could be found and whether there was any potential for intact archaeological material to remain in these areas (Darigo et al. 2007). The studies found that the shoreline at 13,000 yr ago was approximately 60 m (197 ft) below sea level and that landforms do appear to exist from that time period. Similarly, in 1992, studies conducted in the Chukchi Sea also seem to indicate that landforms from the early Holocene may remain (Elias et al. 1992). However, major disturbances have occurred to these landforms. Ice gouging resulting from large pieces of ice dragging along the bottom of the ocean may have altered the landform sediments and removed all archaeological evidence of the first peoples. The full extent of the disturbance is not known. Some areas near barrier islands or areas that are protected by shorefast ice show less evidence of ice gouging (Darigo et al. 2007). The amount of disturbance also varies between the Beaufort and Chukchi Seas. Because more investigations have occurred in the Beaufort Sea, there is a better understanding of the situation in that area. Ultimately, sonar and seismic surveys are needed to determine the condition of the sediments and underlying strata.

3.16.3.2 Offshore Historic Resources

Numerous shipwrecks have been documented in the Beaufort and Chukchi Seas. Most of the shipwrecks off of Alaska’s north coast were associated with commercial whaling, which occurred between 1849 and 1921 (Bockstoce and Burns 1993). Archival research has identified numerous reports of shipwrecks (Bockstoce 1977; Tornfelt and Burwell 1992; Rozell 2000). BOEM maintains an Alaska Shipwreck Database which includes information on all known shipwrecks. As a result of the studies conducted on shipwrecks, BOEM has identified some areas in the Chukchi and Beaufort Seas as having high probability for containing wrecks. Most of the wrecks off northern Alaska are likely in State waters and are not under the direct jurisdiction of BOEM. High resolution geophysical surveys are needed to determine shipwreck locations. The following contains some information on the types and locations of shipwrecks in the Beaufort and Chukchi Seas.

Based on archival research cited above, between 1849 and 1921, 34 shipwrecks occurred within a few miles of Barrow; another 13 wrecks occurred to the west and east of Barrow in the waters of the Chukchi and Beaufort Seas. No surveys of these shipwrecks have been made; therefore, no exact locations are known. These wrecks would be important finds, providing information on past cultural norms and practices, particularly with regard to the whaling industry (Tornfelt and Burwell 1992).

At Point Belcher near Wainwright, 30 ships were frozen in the ice in September 1871; 13 others were lost in other incidents off Icy Cape and Point Franklin. Another 7 wrecks occurred off Cape Lisburne and Point Hope. From 1865 to 1876, 76 whaling vessels — an average of more than 6 per year — were lost because of ice and also because of raids by the *Shenandoah*, which burned 21 whaling ships near the Bering Strait during the Civil War (Bockstoce 1977). The possibility exists that some of these shipwrecks have not been completely destroyed by ice and storms. The probabilities for preservation are particularly high around Point Franklin, Point Belcher, and Point Hope (Tornfelt and Burwell 1992).

A remote sensing survey in the Beaufort Sea recorded a large side-scan sonar target. The size and shape of this object and historical accounts suggest that it may be the crash site of the Sigismund Levanevsky, a Russian airplane that was lost during a transpolar flight in 1939 (Rozell 2000). Subsequent attempts at relocating the object and confirming its identity were unsuccessful.

3.16.3.3 Onshore Archaeological and Historic Resources

Archaeological and historic resources are found along the Chukchi and Beaufort Sea coasts. Onshore archaeological resources near the Chukchi Sea coast receive less damage from the eroding shoreline than those on the Beaufort Sea coast, which is subjected to more slumping because of water action and permafrost (Lewbel 1984). Therefore, known onshore archaeological resources exist in greater numbers in the coastal areas adjacent to the Chukchi Sea; additional unknown resources are also more likely to exist. Known historic and archaeological resources are cataloged in the Alaska Heritage Resources Files maintained by the Alaska OHA. The types of onshore archaeological and historic resources known to exist include prehistoric and historic villages, graves, whaling camps, fishing/hunting camps, and whaling ship remains (Tornfelt and Burwell 1992). In addition, Cold War era historic sites including former Distant Early Warning line outposts, radar stations associated with the Aircraft Control and Warning System, missile sites, and others can be found along the Chukchi and Beaufort Sea coasts (Whorton and Hoffecker 1999).

Significant resources found along the Chukchi and Beaufort Seas include the Ipiutak Site National Historic Landmark at Point Hope, the Cape Krusenstern National Monument, the Bering Land Bridge National Preserve, and the Birnirk Site National Historic Landmark at Barrow. These areas are known to contain significant archaeological resources, occasionally in large numbers.

3.16.3.4 Climate Change

The effects of climate change have the potential to alter archaeological and historic sites. Climate change is expected to result in increased sea temperatures, rising sea levels, and increased ocean acidity (Howard et al. undated). Most archaeological and historic resources have stabilized to the current environmental setting. Coastal archaeological sites and historic structures are at greater risk due to flooding, coastal erosion, and subsidence, all of which have been identified as potential impacts of climate change (Cassar 2005). Some archaeological sites that are found on the OCS have already experienced the effects of climate change, as they were inundated when the last ice age ended. The primary effect from climate change for the BOEM archaeological and historic program could be an alteration of the lease blocks resulting from sea level change, requiring archaeological investigations.

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