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Gulf of Mexico
Deepwater Operations and Activities

Environmental Assessment

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EXECUTIVE SUMMARY

This Environmental Assessment (EA) addresses the potential effects of oil and gas exploration, development, and production operations in the deepwater areas of the Gulf of Mexico Outer Continental Shelf (OCS) during the 10-year period 1998-2007. The western and central portions of the northern Gulf of Mexico constitute one of the world's major oil and gas producing areas, and have proved a steady and reliable source of crude oil and natural gas for more than 50 years. The pace of exploration and development in the deepwater (water depths greater than 1,000 ft [305 m]) Gulf of Mexico has accelerated rapidly in the last few years. In these water depths, the use of conventional, bottom-founded (fixed) platforms quickly becomes technologically infeasible and uneconomic. As new discoveries are made in progressively deeper water, the technology continues to evolve to meet technical, environmental, and economic needs of deepwater development. As a supplement to this EA, the MMS has prepared a series of technical papers that provide a summary description of the different types of structures that may be employed in the development and production of hydrocarbon resources in the deepwater areas of the Gulf of Mexico (Regg, 2000).

This EA is a programmatic assessment of current and projected deepwater activities on the Gulf of Mexico OCS. This document is intended to be used as a planning tool to help both the MMS and industry envision the level and the extent of a National Environmental Policy Act (NEPA) review that will be required for future deepwater activities. The MMS=s specific objectives in this document are the following:

- ensure that the deepwater activities occur in a technically safe and environmentally sound manner;
- determine which deepwater activities are substantially different from those on the continental shelf;
- determine which deepwater activities are substantially the same as those on the continental shelf;
- identify and evaluate the potential impacts of deepwater activities;
- develop mitigation measures for further evaluation;
- identify potential research or studies related to deepwater activities and environmental resources; and
- provide a summary document on deepwater technologies, activities, and impacts.

Issues

The issues addressed in this EA are related to deepwater technology, operations, and operational environment; water and air quality; accidental release of oil or chemical products; and potential impacts on biological communities or the socioeconomic infrastructure. These issues were identified through scoping or by MMS staff as warranting consideration. Many of these issues have been analyzed in previous NEPA documents.

Operational and Component-based Findings

Based on the information and analyses in the EA, MMS finds that a programmatic environmental impact statement (EIS) on regional deepwater activities on the Gulf of Mexico OCS is not required. The components of deepwater operations and associated activities are listed in the summary matrix in Chapter 2. As indicated below, some deepwater components have been addressed by requiring specific mitigation measures, initiating a more in-depth EA, and initiating an EIS.

Most deepwater operations and activities are substantially the same as those associated with conventional operations and activities on the continental shelf. These deepwater components and activities include anchoring, mooring, stationkeeping, most drilling and well completion activities (the exceptions are discussed below), well test and cleanup operations, flaring/burning, facility installation and production operations, host facilities, alternative transportation options, operational emissions, routine produced-water discharges, support service activities, decommissioning, and site clearance. Existing NEPA documents, established project-specific and programmatic NEPA review processes, and established mitigation measures are fully sufficient to address these deepwater components and associated activities.

Specific deepwater operations and activities that are substantially different from those associated with conventional operations and activities on the continental shelf have been addressed by requiring specific mitigation measures, initiating a more in-depth EA, and initiating an EIS.

Seafloor discharges from pre-riser and riserless drilling operation, and the discharge of synthetic drilling fluids (SDF) and cuttings wetted with SDF may pose potentially significant localized impacts to chemosynthetic communities. An appropriate mitigation measure has been developed to avoid or reduce the potential for significant impacts from these factors. Deepwater wells must be at least 1,000 ft away from any potential high-density chemosynthetic communities. Notice to Lessees and Operators (NTL) 98-11 is being modified to include this 1,000-ft buffer zone around all deepwater well sites. As the NTL goes through the formal review and implementation process, this mitigation is currently being applied on a site-by-site basis.

Accidental spills of chemical products and the subsea release of oil are low-probability events. Extensive mitigation measures for spill prevention and response are currently required.

Deepwater seismic surveying operations are essentially the same as seismic surveying operations on the continental shelf. Historically, the potential impacts of noise associated with seismic surveying have been considered insignificant; this EA does not support changing this position at this time. As this position has recently become controversial, the potential impacts of geological and geophysical (G&G) activities, including seismic surveying operations, on the Gulf of Mexico OCS are currently being analyzed in detail in a separate EA. The decision on the need to prepare an EIS on seismic surveying operations is pending completion of the G&G EA.

The use of floating production, storage, and offloading (FPSO) systems represents new and unusual technology for the Gulf OCS and may pose potentially significant impacts to the marine and coastal environments. The need for an EIS was recognized early during the preparation of this EA. A Notice of Intent to Prepare an EIS was published in the *Federal Register* on June 10, 1999.

Deepwater operations have the potential to result in oil spills on the OCS that are greatly larger than those previously analyzed. An occurrence of a spill associated with deepwater operations or activities is a very low-probability event. The behavior and transport dynamics of accidental subsea release of oil are not completely understood. After weathering and dissipation, proportionally greater volumes of oil could remain in the marine environment or be delivered to coastal habitats than spill volumes that have been previously analyzed in MMS NEPA documents. Tankering of oil from deepwater operations has the potential to result in substantially larger OCS oil spills that could occur closer to or directly in coastal habitats. Deepwater-produced oils may contain high asphaltene concentrations. Spills of such oils may permanently cover water bottoms and wetlands, increasing the occurrence and volume of tar in the marine and coastal environments. The extensive mitigation measures for oil-spill prevention and response currently required are considered adequate to minimize the risk of spills and potential impacts. The unknown aspects of the behavior and transport dynamics of subsea oil releases are being addressed through current and planned contractual studies and joint government/academia/industry research.

Resource Analyses

The potential impacts and environmental consequences of deepwater activities are analyzed by resource topic. Summaries of the impact conclusions are presented below.

Chemosynthetic Communities

Chemosynthetic communities are susceptible to physical impacts from structure placement (including templates or subsea completions), anchoring, and pipeline installation. NTL 98-11 prevents these physical impacts by requiring avoidance of potential chemosynthetic communities. Potentially severe or catastrophic impacts could occur to high-diversity communities located near deepwater wells from partial or complete burial by muds and cuttings associated with pre-riser discharges or some types of riserless drilling. Variations in the dispersal and toxicity of synthetic-based drilling fluids may contribute to the potential areal extent of these impacts.

Studies indicate that periods as long as hundreds of years are required to reestablish a chemosynthetic community once it has disappeared, although a community may reappear relatively quickly once the process begins. Tube-worm communities may be the most sensitive of all communities because of the combined requirements of hard substrate and active hydrocarbon seepage. Mature tube-worm bushes have been found to be several hundred years old, with individual worms potentially reaching 400 years of age. There is evidence that substantial impacts on these communities would permanently prevent reestablishment.

Nonchemosynthetic Benthic Communities

Most impacts of deepwater operations to nonchemosynthetic benthic communities are similar to impacts associated with OCS Program activities in general. Some impact to benthic communities from drilling and production activities would occur as a result of physical impact from structure placement, anchoring, and installation of pipelines. Megafauna and infauna communities at or below the sediment/water interface would be impacted from the muds and cuttings normally discharged at the seafloor at the start of every new well prior to riser installation. The impact from muds and cuttings discharged at the surface is expected to be low in deep water as drilling muds would not be expected to reach the bottom beyond a few hundred meters from the surface-discharge location, and cuttings would be dispersed. Even if substantial burial were to occur, recolonization from populations from neighboring substrate would be expected over a relatively short time for all size ranges of organisms, in a matter of days for bacteria and probably less than one year for most all macrofauna species.

Deepwater coral reefs and other potential hard-bottom communities not associated with chemosynthetic communities appear to be very rare in deep water. These unique communities are similar in nature to those on protected pinnacles and topographic features on the continental shelf. Any hard substrate communities located in deep water would be particularly sensitive to impacts from OCS activities. Impacts to these sensitive habitats could permanently prevent recolonization by similar organisms requiring hard substrate.

Marine Mammals

As a result of a progression of activities into deeper water, there will be an increase in the number of cetacean species (a different constellation of animals) and individual animals affected. Deepwater cetaceans may be more behaviorally sensitive to OCS activities, since these animals occur in areas where they may have had little or no previous exposure to or experience with exploration and development activities. Deepwater cetaceans have a different ear structure than shallow-water cetaceans; deepwater cetaceans are more sensitive to low-frequency sounds, while shallow-water cetaceans are more sensitive to relatively high-frequency sounds. Cetacean stock discreteness also becomes a more important issue.

Deepwater activities are unlikely to have long-term adverse effects on the size and productivity of any marine mammal population stock in the northern Gulf of Mexico. The notable exception would be an oil spill occurring at a time and place where marine mammals are concentrated or a spill that would adversely affect the habitats or habitat component (e.g., important prey species) essential to the well-being of any marine mammal species or population stock in the northern Gulf. There is no information on the distribution of cetaceans prior to oil and gas exploration and development in the northern Gulf of Mexico. The present distribution patterns of both large and small cetaceans may already reflect displacements in response to the expansion of OCS activities into deepwater areas.

Small numbers of marine mammals could be killed or injured by chance collision by OCS-related vessels or by eating indigestible trash, particularly plastic items, accidentally lost from OCS-related facilities or vessels. Few lethal impacts are expected. Deaths caused by structure removals are not expected because of existing mitigation measures. The evidence on whether anthropogenic noise has or has not caused long-term displacements of, or reductions in, marine mammal populations is inconclusive. Contaminants in waste discharges and drilling fluids could indirectly affect marine mammals through food-chain biomagnification. Biological impact of any mortality would depend, in part, on the size and reproductive rates of the affected stocks (e.g., whether the species is listed as endangered), as well as the number, age, and sex of animals affected.

Sea Turtles

The density of sea turtles and the chance of contact with deepwater activities appear to be less than on the shelf for all but leatherback turtles. Deepwater activities are unlikely to have long-term adverse effects on the population size and productivity of any sea turtle species in the northern Gulf of Mexico. The notable exception would be an oil spill occurring at a time and place where sea turtles are concentrated or a spill that would adversely affect the habitats or habitat components (e.g., important prey species) essential to the well-being of any sea turtle species in the northern Gulf. There is direct evidence that turtles have been seriously harmed by oil spills.

Sea turtles could be impacted by the degradation of water quality resulting from operational discharges, helicopter and vessel traffic, noise, brightly lit platforms, explosive structure removals, oil spills, oil-spill response activities, and trash and debris lost from OCS-related facilities or vessels. Most deepwater OCS activities are expected to have sublethal effects (behavioral effects, and nonfatal exposure to or intake of OCS-related contaminants or debris). Contaminants in waste discharges and drilling fluids might indirectly affect sea turtles through food-chain biomagnification; there is uncertainty concerning the possible effects. Chronic sublethal effects (e.g., stress) resulting in persistent physiological or behavioral changes and/or avoidance of impacted areas could cause declines in survival or productivity and result in either acute or gradual population declines. Few lethal impacts are expected. Lethal effects are most likely to be from chance collisions by deepwater-related service vessels and ingestion of plastic materials. Deaths caused by platform removal operations are not expected because of existing mitigation measures. Contact with or consumption of chemical products or diesel might seriously harm individual turtles, thereby possibly seriously impacting the sea turtle population. Biological impact of any mortality would depend, in part, on the size and reproductive rates of the affected stocks (e.g., whether the species is listed as endangered), as well as the number, age, and sex of animals affected.

Fishing and Fisheries

Operations resulting from oil and gas development in deepwater areas of the Gulf of Mexico have the potential to cause some detrimental effects on fisheries and fishing practices. Activities such as offshore discharge of drilling fluids and produced water are expected to cause negligible impacts and to not affect commercial fisheries deleteriously. Factors such as production platform emplacement, underwater OCS impediments, explosive platform removal, and accidental oil spills could cause greater impacts on fisheries and fishing practices. However, the actual effects from these potential impact-producing factors are expected to be inconsequential. At the expected level of effect, the resultant influence on fisheries should be indistinguishable from natural population variations.

Air Quality

Air pollutants from an OCS facility can impact other OCS facilities, fishermen, mariners, cruise ship passengers, marine mammals, sea turtles, birds, and, to a lesser extent because of dispersion, the onshore environment.

Flaring/Burning: The MMS regulations do not allow approval of flaring/burning operations that have significant impacts on air quality. The established review process at the flare/burn request stage should continue to be effective in identifying the potentially significant flare/burn requests.

Class I Area: Preliminary work to inventory emission sources (accomplished as part of the Breton Aerometric Monitoring Program) indicates that stationary OCS sources will not be the major contributor to any exceedance of the allowable increase in SO_2 levels (i.e., will not play a large role in consuming the SO_2 increment) in the Class I area. Although cumulative OCS NO_x emissions do exceed the 1-$\mu g/m^3$-threshold in some areas within 100 km of the Breton National Wilderness Area, this level includes both baseline (existing) and incremental (additional) emissions.

Hazardous Air Pollutants (HAP=s): The MMS currently lacks a regulatory framework for requiring control of HAP emissions. Insufficient information exists to quantify the BTEX emissions from OCS operations. The information that is available, specifically that glycol still vents are the primary point source of BTEX emissions in the United States and that the majority of the OCS glycol still vents are uncontrolled, indicates that potentially substantial quantities of BTEX are being emitted. Limited information about the types, quantities, and locations of chemicals transported, stored, and used by deepwater facilities makes it difficult to quantify potential impacts that might be associated with accidental releases of chemical products. Information is lacking on any control devices planned or in-place to mitigate any accidental releases of chemical products. Current information indicates that the impacts would be relatively small or of short duration because of the relatively small size of most reported tanks. An exception to this could be a rupture of a supply pipeline near to or on shore; such a release could impact onshore air quality.

Ozone: Reanalysis of the Gulf of Mexico Air Quality Study data for the 8-hr averaging period indicates substantial contributions to onshore concentrations from OCS sources. Once the redesignation, based on requirements of the September 1997 ozone NAAQS, occurs in September 2000, steps may be needed to control emissions of ozone precursors. A subsea blowout in deep water could generate substantial quantities of VOC=s and, correspondingly, ozone for an extended period.

Hydrogen Sulfide: H_2S is the only HAP for which MMS requires a contingency plan. Combining the very low density of non-OCS-related people in the deepwater areas and the very low frequency of H_2S accidents, statistically less than one non-OCS-related person would likely be affected by an accidental release of H_2S.

Archaeological Resources

The greatest potential impact on an archaeological resource as a result of deepwater activities would be from contact between an OCS offshore activity (platform/structure installation, drilling rig emplacement, pipeline installation, or dredging project) and a historic shipwreck. OCS activities could contact a shipwreck because of incomplete knowledge on the location of shipwrecks in the Gulf. Although this occurrence is not probable, such an event would result in the disturbance or destruction of important historic archaeological information. Other activities associated with deepwater activities are not expected to impact historic archaeological resources.

Impacts from an oil-spill contact on historic coastal sites would be temporary and reversible.

Water Quality

Deepwater activities are expected to incrementally increase support activities and the expansion or construction of support bases. The impacts resulting from this growth are common to all OCS support facilities (point-source waste discharges, runoff, dredging, and vessel discharges) and not specific to deepwater activities. Moderate, short-term, water quality degradation may increase at a few support base locations expected to grow as a consequence of deepwater activities (including Corpus Christi, Galveston, and Port Fourchon). Existing onshore waste disposal practices may change. If synthetic-based drilling fluids (SBF) and associated cuttings cannot be disposed of offshore, temporary storage and onshore disposal may result in some localized contamination at onshore bases and commercial waste-disposal facilities. Additionally, prohibiting the discharge of cuttings containing SBF could increase the use of oil-based drilling fluids that will eventually have to be treated and disposed of onshore, thus aggravating water quality problems currently being faced at some existing commercial onshore disposal sites.

The probability of deepwater-related spills occurring and contacting coastal waters is very low, and generally, because of the distance from shore, deepwater spills are not expected to cause impacts different than from spills from shallow water operations. Some deepwater operations have the potential to result in very large oil spills that, even after weathering, could remain on the sea surface long enough for a substantial quantity to reach coastal waters. There are two deepwater areas from which a larger volume of oil may reach coastal waters and coastal habitats than volumes expected from spills occurring on the shelf. This would be due to a combination of greater size of deepwater spills, the areas' proximity to the shoreline, and projected oil spill trajectory paths. These areas are off the Mississippi Delta and off southern Texas. During September through April, the western Gulf of Mexico has a well-developed westward coastal current from Louisiana to Texas waters. Under the physical oceanographic and meteorological conditions during this period, the risk of a deepwater spill contacting the nearest shore line may be extremely low; the higher risks of contact may displaced to areas farther from the spill source. Shuttle tankering of oil from deepwater operations has the potential to result in spills that could impact coastal waters in a very short time period if the spill were to occur near port.

Because studies have yet to be conducted on how discharge plumes under varying oceanographic conditions impact sediments surrounding deepwater discharge sites, the fate of deepwater operational waste discharges cannot be accurately predicted. The types of discharges in deep water will be the same as those on the shelf, the volume of discharges from deepwater locations will typically be greater than in shallow sites, and the number of deepwater discharge sites will be fewer. In addition, the volume of water available for dilution of discharges will be greater. The impacts caused by deepwater discharges are not anticipated to be consequential. Because information on potential impacts to chemosynthetic communities is limited, MMS is proposing an NTL that will prohibit industry from locating discharge points for drilling muds and cuttings within 330 m (1,000 ft) of a feature or area that could support high-density chemosynthetic communities.

The potential effects of SBF are related to their deposition and degradation on the seafloor. The plume resulting from SBF-wetted cuttings, as compared with the discharge of water-based muds and cuttings, should have less water-column effects because the SBF does not disperse in the water column.

More extensive and frequent use of some chemical products to enhance throughput of the oil and gas is anticipated in deepwater because of the temperatures and pressures encountered at the seafloor. Spills of some chemicals may pose a more serious threat to marine water quality than do oil spills. Limited information is available about the types and amounts of chemicals being used in deepwater operations or about the potential impact of such spills.

Coastal Habitats

Most deepwater-related impacts on coastal habitats are largely indistinguishable from those generated by other OCS Program activities.

The probability of deepwater-related spills occurring and contacting coastal habitats is very low; however, deepwater operations have the potential to result in oil spills on the OCS that are larger than those analyzed in previous EIS's. Even after weathering and dissipation, very large spills could deliver greater volumes of oil into coastal habitats than spills that have been previously analyzed. Tankering of oil from deepwater operations also have the potential to result in large OCS oil spills closer to or directly in coastal habitats. Such spills could heavily oil wetlands, waterways, and beaches. Impacts of such oil contact include irreversible wetland loss and large reductions in habitat productivity for an extended period of time. These impacts would be more severe in areas with highly organic soils and where other environmental stressors are involved, such as in Louisiana.

Deepwater-produced oils may contain high asphaltene concentrations. Spills of such oil may permanently cover water bottoms and wetlands, thereby presenting the first notable and serious OCS impact to submerged vegetation, oysters, and other benthic organisms in coastal habitats and to navigation. Impacts include depositing an impenetrable and nondispersing asphaltic concrete over benthic environments, rendering them nonproductive. Viscous oils and related concretes can also form obstructions in navigable waterways. Such spills may also greatly increase the occurrence and volume of tar on barrier beaches and in other coastal habitats around the Gulf. There, tar is an environmental nuisance as well as a financial drain on industries such as trawling and recreational use of beaches.

Socioeconomic Resources

Employment projected to occur in association with Gulf deepwater activities is expected to be filled primarily by persons already engaged in OCS oil- and gas-related jobs and by unemployed and underemployed persons living in the area. The coastal counties and parishes of Texas and Louisiana should provide the greatest support and, hence, incur the greatest potential impacts. Inasmuch as local residents will take some of these jobs, including high-paying positions, positive effects should occur. Given the present amount of OCS-related jobs along the Gulf Coast, there should be only minor workforce fluctuations. Population throughout the region of influence will increase, but at markedly different rates, which may or may not be causally related to deepwater activities. Some importation of skilled labor may be required. Social and cultural problems typically associated with migration may occur but should be minor. Several different possible scenarios may result in the siting of new supporting onshore facilities, with their concomitant economic and environmental implications, near low-income or minority populations. Existing onshore facilities may be expanded to handle additional work requirements.

Economic and logistic considerations, as well as local zoning and permitting requirements, drive the choice of where to site onshore facilities. There should not be disproportionately high or adverse human health or environmental effects on minority or low-income populations. Lack of information, however, on potential locations of future onshore infrastructure makes it impossible to dismiss potential disproportionate impacts.

Suggested Mitigation Measures for Further Evaluation

Many of the issues identified for this deepwater EA have been analyzed in previous NEPA documents and, in some cases, mitigating measures were developed through the NEPA process. Many of the mitigation measures have been established through MMS operating regulations or Notices to Lessees (NTL=s). Some of the mitigation measures are applied on a project-specific basis. Established mitigation measures are identified in the description of deepwater activities (Chapter II) and discussed in the environmental consequence analyses (Chapter IV).

All of the suggested new mitigation measures in this EA are environmentally viable. Subsequent to the completion of this EA, each mitigation measure will be evaluated for technological and economic viability, expected benefits, and potential impacts. Measures that are found to be environmentally, technologically, and economically viable and offer net environmental benefits will be recommended for implementation. Implementation may be through MMS operating regulations (30 CFR 250, 30 CFR 251, and 30 CFR 254), NTL=s, or project-specific requirements.

Suggested Research and Information Synthesis

This EA identifies opportunities for additional research to enhance our understanding of deepwater issues. Identification of these information needs is not meant to imply that these needs are so critical that decisions on deepwater activities would have to cease. Rather, they are intended to identify information that will enhance and improve the analyses and help develop and refine mitigation measures.

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PREFACE

This Deepwater Environmental Assessment (EA) addresses oil and gas exploration, development, and production activities in water depths greater than 1,000 ft on the Gulf of Mexico Outer Continental Shelf (OCS). The concept of using the National Environmental Policy Act (NEPA) process to evaluate potential impacts unique to Gulf of Mexico OCS deepwater activities was presented and adopted at an MMS Deepwater Strategy meeting in October 1997. The Deepwater EA was initiated in January 1998, with completion expected within the year. The EA received final approval through all levels of MMS management more than two years later.

In the meantime, several of the original objectives of preparing the EA have been met. Floating production, storage, and offloading (FPSO) systems were identified as proposed new technology to the Gulf of Mexico, with potentially significant impacts. Through cooperative efforts with the industry group DeepStar, an Environmental Impact Statement (EIS) on FPSO's was initiated in May 1999. The potential impact of seismic surveying on marine mammals was identified as an issue of increasing controversy. An EA specifically addressing seismic surveying and other geological and geophysical exploration activities was initiated in June 1999. A mitigation measure has been developed to reduce the potential for impacts to chemosynthetic communities from seafloor discharge of drilling muds and cuttings and from the discharge of cuttings associated with the use of synthetic drilling fluids. Notice to Lessees and Operators (NTL 98-11) is being modified to include a 1,000-ft buffer zone around all deepwater well sites. As the NTL goes through the formal review and implementation process, this mitigation is being applied on a site-by-site basis.

Since the completion of the text, many deepwater studies identified in the EA have been funded, are in the procurement process, or are included in the Environmental Studies Program Strategic Plan for funding in the near future. Sections of the EA describing issues, available and needed information, and current studies have been reviewed and updated where appropriate.

Since the EA was more than two years in preparation and review, many of the statistics within the document end with calendar year 1997 information. Projections for the years 1998 and 1999 have not been included. Statistical information for these years is available in the recently released MMS report *Deepwater Gulf of Mexico: America's Emerging Frontier* (OCS Report MMS 2000-022).

A Decision Document was prepared for NEPA decisions based on this EA (Appendix A). In addition, a series of decision papers have been prepared or are being prepared to address NEPA, non-NEPA, technical, and policy issues. These decision papers outline options to address several issues identified via the EA and document decisions on MMS's approach to addressing specific issues.

CHAPTER I

PURPOSE AND NEED

I. PURPOSE AND NEED

The western and central portions of the northern Gulf of Mexico constitute one of the world's major oil and gas producing areas, and have proved a steady and reliable source of crude oil and natural gas for more than 50 years. The pace of exploration and development in the deepwater (water depths greater than 1,000 ft [305 m]) Gulf of Mexico (Figure I-1) has accelerated rapidly in the last few years. In water depths exceeding 1,000 ft, the use of conventional, bottom-founded (fixed) platforms quickly becomes uneconomic. As new discoveries are made in progressively deeper water, technologies continue to evolve to meet technical, environmental, and economic needs of deepwater development.

The Minerals Management Service (MMS) is mandated to manage the development of Outer Continental Shelf (OCS) oil and natural gas resources, while also ensuring safe operations and protection of the human and natural environment. To meet these objectives, MMS is using the National Environmental Policy Act (NEPA) process as a planning and management tool. This environmental assessment (EA) on deepwater oil and gas activities will assist in managing these activities and in assuring appropriate environmental reviews. A Notice of Availability and a summary of the findings of the EA will be published in the *Federal Register*.

Action

The action addressed in this EA encompasses projected oil and gas exploration, development, and production operations in the deepwater areas of the Gulf of Mexico OCS during the 10-year period 1998-2007. The action also includes activities that support deepwater operations.

Need

The OCS Program was established by the Outer Continental Shelf Lands Act (OCSLA). The benefits of producing oil and natural gas from the OCS include helping to meet national energy needs and generating royalties on production that flow into the U.S. Treasury. Why have exploration and development activities accelerated in the deepwater Gulf of Mexico and why at this time? Several of the factors that have contributed to the recent surge in deepwater activities are the following:

- development of new deepwater drilling, development, and production technologies;
- discovery of major hydrocarbon fields, some with very high flow rate wells;
- development of three-dimensional (3D) geophysical surveying and interpretation technologies;
- passage of the Deep Water Royalty Relief Act (DWRRA); and
- the opportunity to lease recently terminated lease blocks.

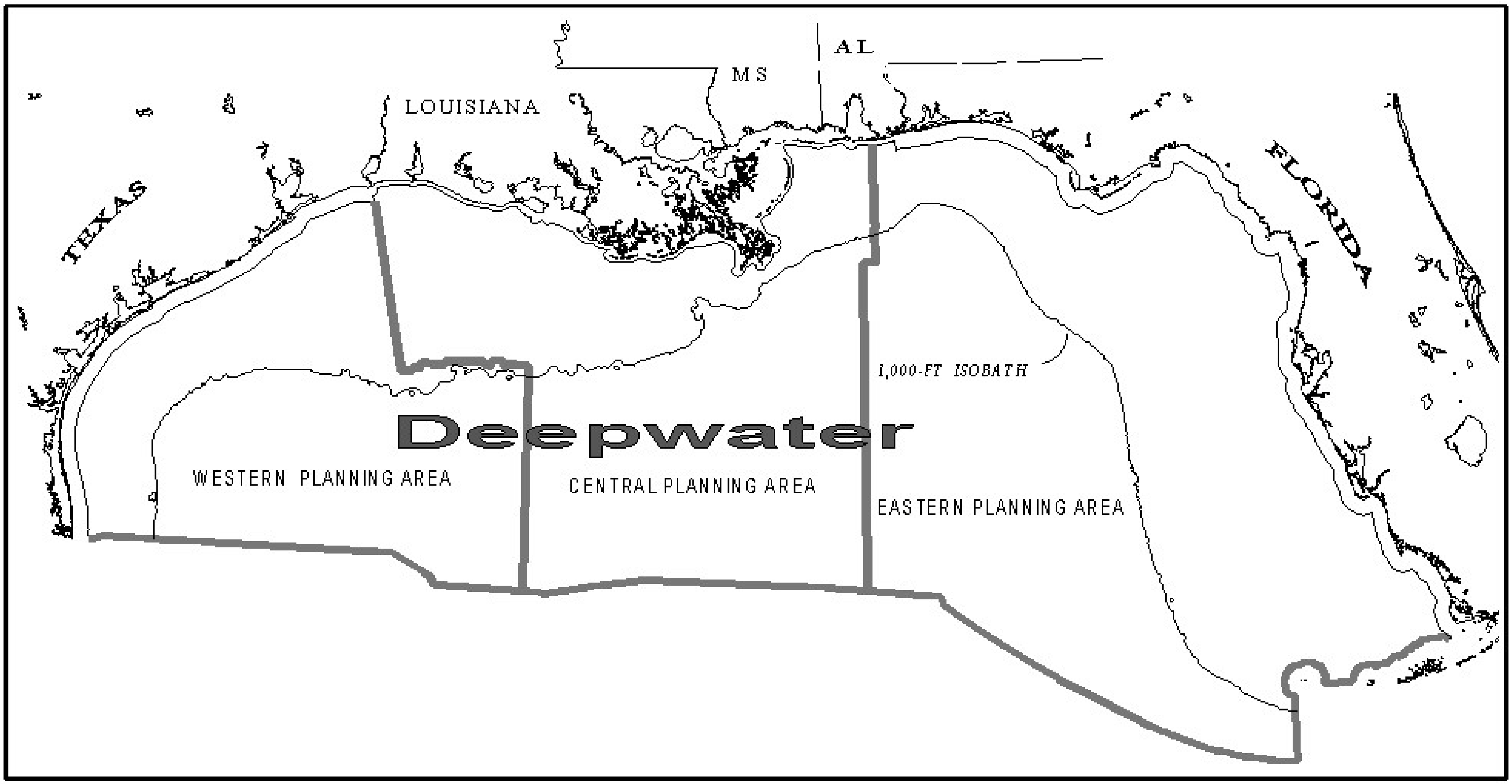

Figure I-1. Deepwater Area of the Gulf of Mexico Outer Continental Shelf (Deep water is defined by the 1,000-ft isobath.)

Objectives

The MMS=s specific objectives in this document are the following:

- ensure that the oil and gas activities in the deepwater Gulf of Mexico occur in a technically safe and environmentally sound manner;
- determine which deepwater activities are substantially different from those associated with conventional operations and activities on the continental shelf;
- determine which deepwater activities are substantially the same as those associated with conventional operations and activities on the continental shelf;
- identify and evaluate potential impacts from OCS deepwater operations and associated support activities and infrastructure;
- develop, for further consideration, measures to mitigate impacts from deepwater activities on the marine, coastal, and human environments;
- identify potential research or studies related to deepwater activities and environmental resources that will support a more comprehensive or detailed impact assessment or will help develop or refine mitigation measures; and
- provide a summary document on deepwater technologies, activities, and impacts for reference in future NEPA documents.

Decisions to be Made

The MMS will make several decisions based on the findings of the EA:

- determine which aspects or components of deepwater operations and activities potentially impact the marine, coastal, or human environments of the Gulf of Mexico OCS and adjacent coastal areas;
- determine which aspects or components of deepwater operations and activities are adequately addressed by current NEPA analyses (Gulf of Mexico OCS Lease Sale EIS=s and/or plan-specific or programmatic NEPA reviews);
- determine if further NEPA analysis is needed to evaluate potential impacts not covered by current NEPA analyses;

Scoping Summary

Scoping is defined by NEPA as an early and open process for determining issues to be addressed in a NEPA document and analysis. The MMS has actively sought information and data on the technologies, risks, potential impacts, issues, and concerns related to deepwater activities in the Gulf of Mexico. The scoping opportunities listed below are discussed in more detail in Chapter V.

- August 1, 1996BThe Call for Information and Nominations (Call) and the Notice of Intent (NOI) to Prepare an Environmental Impact Statement (EIS) for the proposed 1998-2002 Central Gulf of Mexico lease sales was published in the *Federal Register*.
- January 29, 1997BThe Call and NOI to Prepare an EIS for the proposed 1998-2001 Western Gulf of Mexico lease sales was published in the *Federal Register*.
- April 1997BThe MMS and the industry group DeepStar jointly sponsored a workshop to gain a better understanding of floating production, storage, and offloading (FPSO) technology and the scope of operations around the world. The proceedings of this workshop are published as OCS Report MMS 98-0019 (Regg, 2000).
- April 1997BThe MMS Environmental Studies Program and Louisiana State University (LSU) hosted a AWorkshop on Environmental Issues Surrounding Deepwater Oil and Gas Development@ (Carney, 1998). The results of the workshop are reflected in the procurement of 10 studies specifically devoted to deepwater studies issues.
- June 1997BPublic hearings on the Draft EIS for proposed 1998-2002 Central Gulf of Mexico lease sales were held in Houma and New Orleans, Louisiana, and in Mobile, Alabama.
- October 1997BPublic hearings on the Draft EIS for proposed 1998-2001 Western Gulf of Mexico lease sales were held in Austin, Corpus Christi, and Houston, Texas, and in New Orleans, Louisiana.
- February 1998BAnnouncement of the preparation of the EA was published in the *Federal Register* on February 23, 1998.
- June 1999BPublic scoping meetings for the EIS on the potential use of floating production, storage, and offloading (FPSO) systems in the deepwater areas of the Western and Central Planning Areas of the Gulf of Mexico OCS were held in Corpus Christi, Houston, and Beaumont, Texas, and in Lake Charles and New Orleans, Louisiana.

Issues Identified

The issues addressed in this EA are those identified through the scoping opportunities listed above or those identified by MMS as warranting consideration. Many of these issues have been analyzed in previous NEPA documents. Many of the issues below are related to impact-producing activities or risk factors and are addressed in the description of deepwater activities in Chapter II. Most of the issues below are addressed in the environmental consequences analyses in Chapter IV.

Issues Related to Technology, Operations, and Operational Environment

- timing and scale of deepwater operations
- deepwater facility decommissioning and site clearance

- deepwater pipelaying and pipeline technologies
- wetlands impacts due to increasing numbers of pipeline landfalls
- unsupported pipeline spans (e.g., fisheries conflicts)
- alternative transportation of produced fluids
- disposition of produced gas
- use of centralized host facilities
- historic archaeological resources (shipwrecks)
- ordnance disposal areas
- geologic hazards
- deepwater seismic surveying operations

Issues Related to Accidental Release of Oil

- chemical composition of deepwater crude oils
- fate and effects of deepwater oil spills
- fate and effects of oil released by loss of control of a subsea well
- fate and effects of oil spills related to tankering
- fate and effects of oil spills related to barging
- storage of large volumes of oil at deepwater structures
- oil spill contingency planning and response capabilities

Issues Related to Chemical Products

- types and toxicities of chemical products used for deepwater drilling and production
- usage and discharges of chemical products
- risk of spills of chemical products
- fate and effects of large-volume, chemical-product spills

Issues Related to Water and Sediment Quality

- areal extent of seafloor contamination from surface discharge of drilling muds and cuttings
- fate and effects of synthetic drilling muds introduced into the marine environment
- potential impacts of increased dredging to support deepwater activities

Issues Related to Air Quality and Emissions

- emissions associated with deepwater operations
- emissions from extended well testing and well cleanup operations
- emissions associated with increased support services (e.g., service vessels and anchor-handling vessels)
- emissions related to oil and oil-product transfer operations
- consumption of the Class I Area maximum allowable increments

Issues Related to Impacts on Biological Communities

- potential impacts on benthic communities (including chemosynthetic communities), marine mammals, sea turtles, and fish resources
- potential impacts on essential habitats

Issues Related to Socioeconomic Impacts

- accommodating larger support vessels
- increased demand for freshwater and other consumables
- increased economic and industrial activity in the coastal zone
- additional service vessel and helicopter traffic
- increased use of coastal infrastructure, including traffic on existing roadways
- competition with other port users
- in-migration of workers
- potential for boom/bust economic cycle

- increased demand for multipurpose ports
- potential locations of additional onshore service bases
- safety of the deepwater workforce
- multiuse conflicts with commercial and recreational fisheries
- transboundary effects
- environmental justice

Resource Topics

The analyses of potential impacts and environmental consequences are presented under the following resource topics:

- chemosynthetic communities
- nonchemosynthetic communities
- marine mammals
- sea turtles
- fishing and fisheries
- air quality
- archaeological resources
- water quality
- coastal habitats
- socioeconomic resources
- transboundary effects

Suggested Mitigation Measures for Further Evaluation

Many of the issues identified above have been analyzed in previous NEPA documents and, in some cases, mitigating measures were developed through the NEPA process. Many of the mitigation measures have been established through MMS operating regulations or Notices to Lessees (NTL=s). Some of the mitigation measures are applied on a project-specific basis. Established mitigation measures will be identified in the description of deepwater activities and discussed in the environmental consequences analyses.

All of the suggested new mitigation measures in this EA are environmentally viable. Subsequent to the completion of this EA, each mitigation measure will be evaluated for technological and economic viability, expected benefits, and potential impacts. Measures that are found to be environmentally, technologically, and economically viable and offer net environmental benefits will be recommended for implementation. Implementation may be through MMS operating regulations (30 CFR 250, 30 CFR 251, and 30 CFR 254), NTL=s, or project-specific requirements.

Some potential mitigation measures suggested during the preparation of this document have been eliminated from further consideration. These measures and a very brief statement of the reasons for their elimination are given below.

Limiting the maximum amount of oil that can be stored at an offshore facility was eliminated because such a limitation could restrict the use of drilling ship=s hull storage capabilities in support of extended well testing and could restrict an operator=s ability to respond to operational incidents. Such a restriction would also eliminate consideration of the potential use of floating production, storage, and offloading (FPSO) systems as a development option (an EIS is being prepared specifically on the potential use of FPSO=s in the Gulf of Mexico).

Limiting the maximum amount of chemical products that can be stored at an offshore facility was eliminated because such a limitation could restrict an operator's ability to develop a reservoir effectively, to ensure well and pipeline flow, and to respond to operational incidents. In addition, secondary impacts could result from more frequent transport of smaller amounts of chemical products.

The use of ship-based observers to provide real-time mitigation (airgun shutdown), as well as collection of data regarding responses of marine mammals to seismic surveys, is not operationally feasible as a mitigation measure. Visual identification of marine mammals is not possible at night and may not be possible in poor weather or high sea conditions. Restricting seismic operations to periods of visibility for marine mammal observers would require multiple start-up/deployment, which could increase potential impacts from noise, fuel use, engine emissions, and multiuse conflicts.

Aerial surveys are limited in their usefulness as a mitigation measure in conjunction with seismic surveys in the Gulf of Mexico. Given the variability of distribution of marine mammals, a relatively long-term, fine-grained baseline of sighting data would need to be established before changes in distribution due to a single seismic survey could even be detected. In addition, small aircraft with limited flight range could not be used effectively in deepwater areas far from shore. In general, aerial surveys are effective for information gathering and monitoring rather than for mitigation.

Suggested Research and Information Synthesis

This EA identifies opportunities for additional research to enhance our understanding of deepwater issues. Identification of these information needs is not meant to imply that these needs are so critical that decisions on deepwater activities would have to cease. Rather, they are intended to identify information that will enhance and improve the analyses and help develop and refine mitigation measures.

CHAPTER II

DEEPWATER ACTIVITIES IN THE GULF OF MEXICO

II. DEEPWATER ACTIVITIES IN THE GULF OF MEXICO

The deepwater Gulf is, at present, the most active province for hydrocarbon exploration in the United States OCS. The outlook for deepwater exploration and development should remain strong considering the recent large field discoveries, technological advances, the continuing rig conversions and construction to meet demand, and the benefits of deepwater royalty relief.

This chapter describes the current and projected offshore infrastructure, activities, and disturbances associated with deepwater exploration, development, and production that could affect the biological, physical, and socioeconomic resources of the Gulf of Mexico area. Exploring for, developing, producing, and transporting deepwater hydrocarbon resources require a complex and interrelated series of operations. The process begins with prelease geological and geophysical exploration under MMS permit; continues through leasing of offshore blocks, postlease seismic surveying operations, drilling of exploration wells, drilling of development wells, installation of production facilities, ongoing production operations, and transport of produced hydrocarbons via pipeline or vessel; and ends with the removal of production facilities and site clearance. Procurement and transport of personnel, equipment, and supplies needed to maintain these operations are an integral part of the process.

The scenario assessed in this EA includes existing, planned, and projected deepwater exploration, development, production, and support activities in the Gulf of Mexico OCS for the years 1998-2007. The scenario was developed to provide a framework for the analysis of potential impacts associated with deepwater operations. The MMS has prepared a series of technical papers that provide a summary description of the different types of structures that may be employed in the development and production of hydrocarbon resources in the deepwater areas of the Gulf of Mexico. These papers are published in one MMS report (Regg, 2000). A 10-year period was chosen for the analysis because rapidly changing technologies make projections beyond that timeframe very uncertain. Industry plans for the next five years are fairly well known. Projections for the five years beyond that are based on extrapolations of known activity levels and on the expected availability of additional support infrastructure (e.g., new drilling vessels). Activity levels and technological advancements beyond 10 years are not reasonably foreseeable and were not projected for this assessment. The 10-year scenario includes all anticipated deepwater activities, regardless of when the lease was issued. The only exception to this is an anticipated acceleration of exploratory drilling activities in 2005-2007 as a large number of leases approach the expiration of their initial lease terms. The scenario is presented as a set of ranges of exploration and development operations and supporting activities. These projections are best estimates based on existing and planned activities, current trends, and projections of these trends into the reasonably foreseeable future. To ensure that the technological descriptions are accurate and that the activity projections are reasonable, two industry groups, DeepStar and the Offshore Operators Committee, were asked to review and comment on these portions of the scenario.

Deepwater is a relative term; the definition of deepwater depends on who is doing the defining and what the definition is in relation to. For most of this document deepwater is defined as greater than1,000 feet or 305 m. For resources estimation and royalty relief purposes, deepwater is defined as greater than 656 feet or 200 m. The following sections on exploration history, geology, hydrocarbon potential, and geologic hazards use the 200-m definition for deepwater.

A. Hydrocarbon Exploration History

Technological advances have allowed exploration in the Gulf of Mexico to move gradually from the nearshore, shallow-water areas off Louisiana to leases in water depths exceeding 2,300 m (about 7,500 ft). To date, most of the producing wells that are off continental the shelf are located on the continental slope in water depths ranging from 200 to 400 m (656-1,312 ft) (Figure II-1). It is common for the leasing activity on the continental slope to precede by several years the lessees' ability to drill and develop. Often bids in frontier areas (on unproven "wildcat" objections) are based on the belief that technology will be available in the near future to more clearly define and develop potential prospects. Advances in seismic data acquisition, processing, and interpretation have reduced the risks inherent to exploration in frontier areas. Enhancements in development and production techniques (e.g., spar, TLP, and subsea completions) for deepwater fields, coupled with the large volume of hydrocarbons and extremely favorable production rates, determine the long-term viability of the deepwater OCS.

The first well drilled in the deeper waters of the continental slope was spudded by Atlantic Richfield in November 1974 on Mississippi Canyon Block 148 in a water depth of 212 m (696 ft). The well not only encountered economically viable hydrocarbons, but proved the feasibility of drilling in water depths greater than 200 m (656 ft). An additional 1,677 wells were spudded (Figure II-2) in the water depths greater than 200 m since the drilling of that first well more than 25 years ago; more than half of these wells were drilled in the last eight years. In August 1998, Texaco and Chevron began drilling their AGamera@ prospect in 2,353 m (7,718 ft) water depth. This is the current Gulf of Mexico water depth drilling record.

For water depths greater than 1,000 ft (305 m), about 10 percent of the leased tracts have been drilled to date. As of January 2000, there were 106 discoveries with 42 fields producing in water depths greater than 1,000 ft (305 m) (Figures II-3 and II-4). Deepwater development took a large leap forward when Shell commenced production from its Cognac Field (Mississippi Canyon Block 194), set in 312 m (1,024 ft) of water, in August 1979. More than 80 wells have been drilled in this field, which has current cumulative production in excess of 230 million barrels of oil equivalent (MMBOE). In 1997, Shell commenced production through subsea completions in 1,625 m (5,300 ft) of water from their Mensa Field (Mississippi Canyon Block 731), setting a new water depth record for subsea production that has been subsequently broken by Petrobras in waters off Brazil.

Hydrocarbon reserves in deepwater fields can be designated as proved or unproved. The MMS defines proved reserves as those quantities of hydrocarbons that can be estimated with reasonable certainty to be commercially recoverable from known reservoirs and under current economic conditions, operating methods, and government regulations. Proved reserves must have either facilities operational at the time of the estimate to process and transport those reserves to market, or a commitment or reasonable expectation to install such facilities in the future. Unproved reserves are those quantities of hydrocarbons that can be estimated with some certainty to be potentially recoverable from known reservoirs, assuming future economic conditions and technological developments. As of the end of 1996, the remaining proved reserves in the Gulf OCS in water depths greater than 200 m are 2.196 billion barrels of oil equivalent (BBOE) with unproved reserves estimated at 1.374 BBOE by MMS.

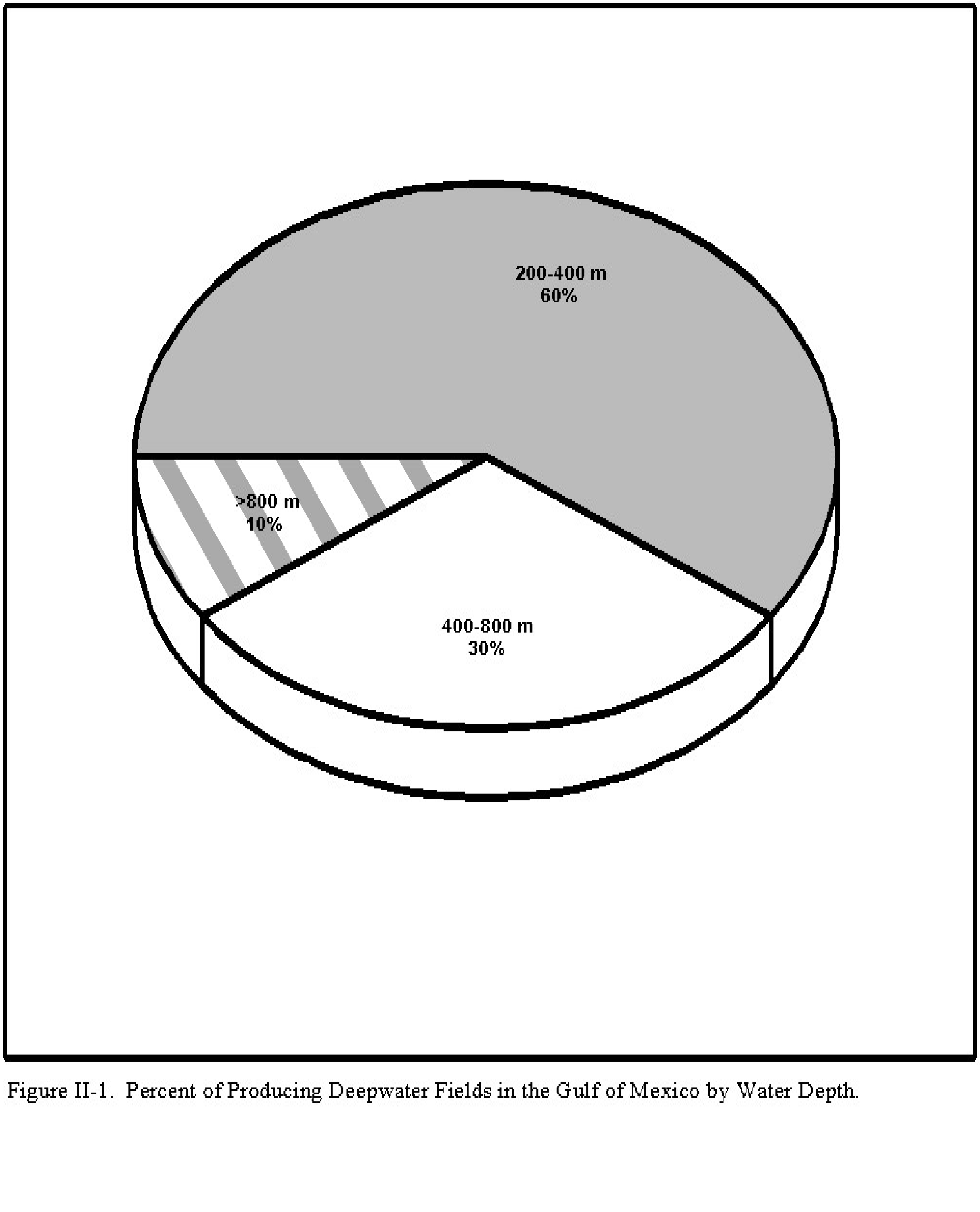

Figure II-1. Percent of Producing Deepwater Fields in the Gulf of Mexico by Water Depth.

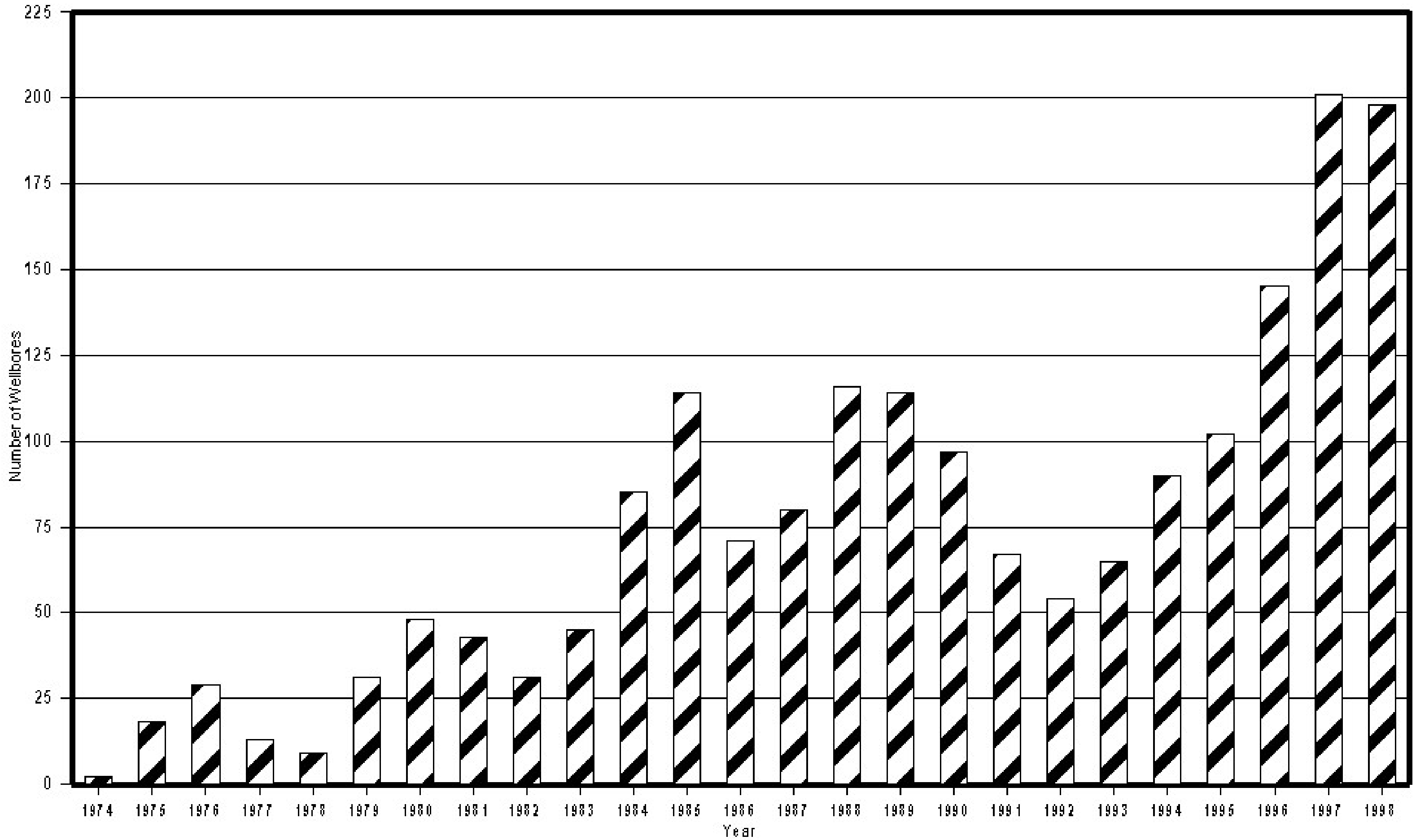

Figure II-2. Number of Wellbores Spudded in Water Depths Greater than 200 Meters by Year.

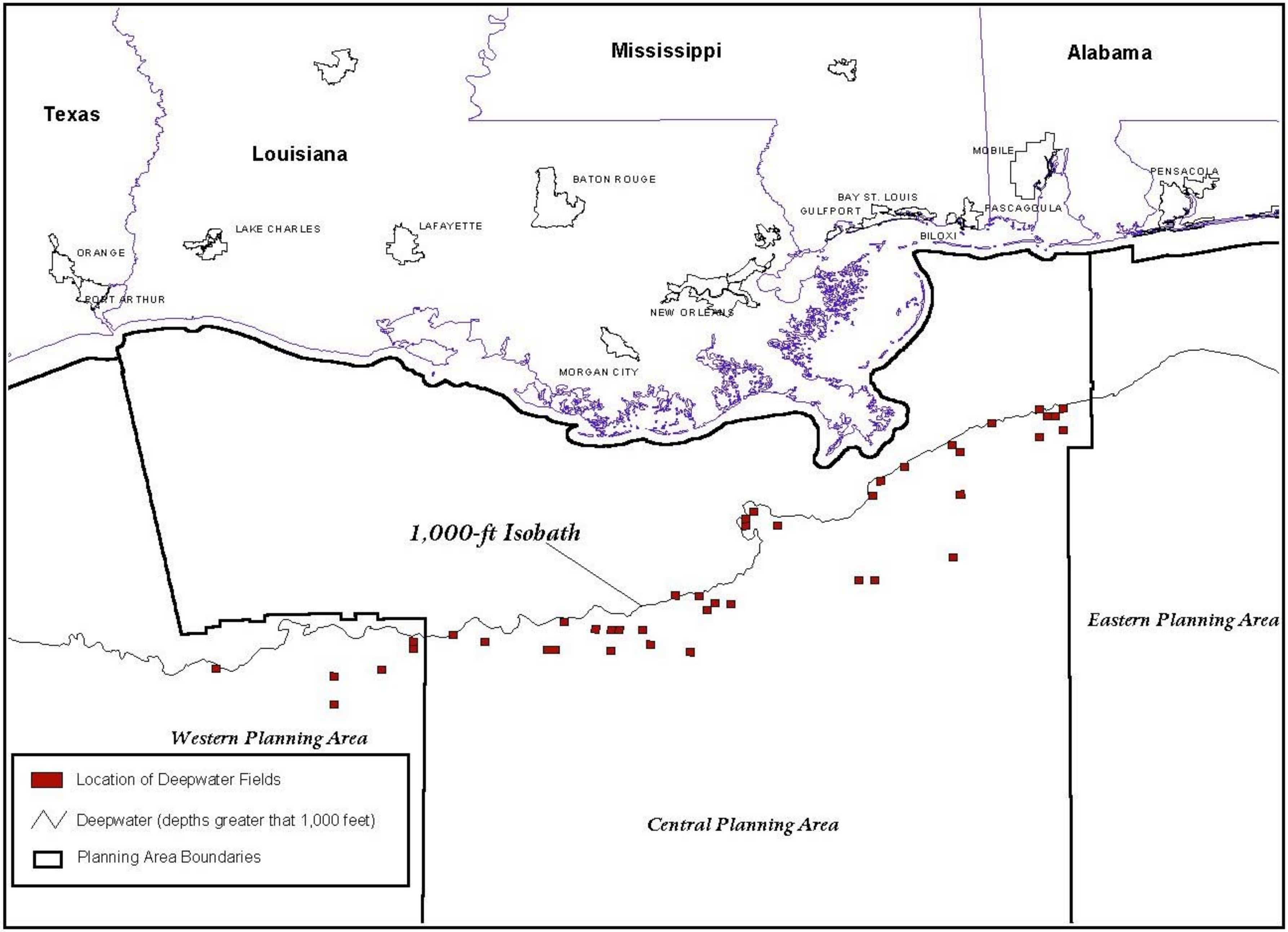

Figure II-3. Deepwater Fields Producing as of January 2000.

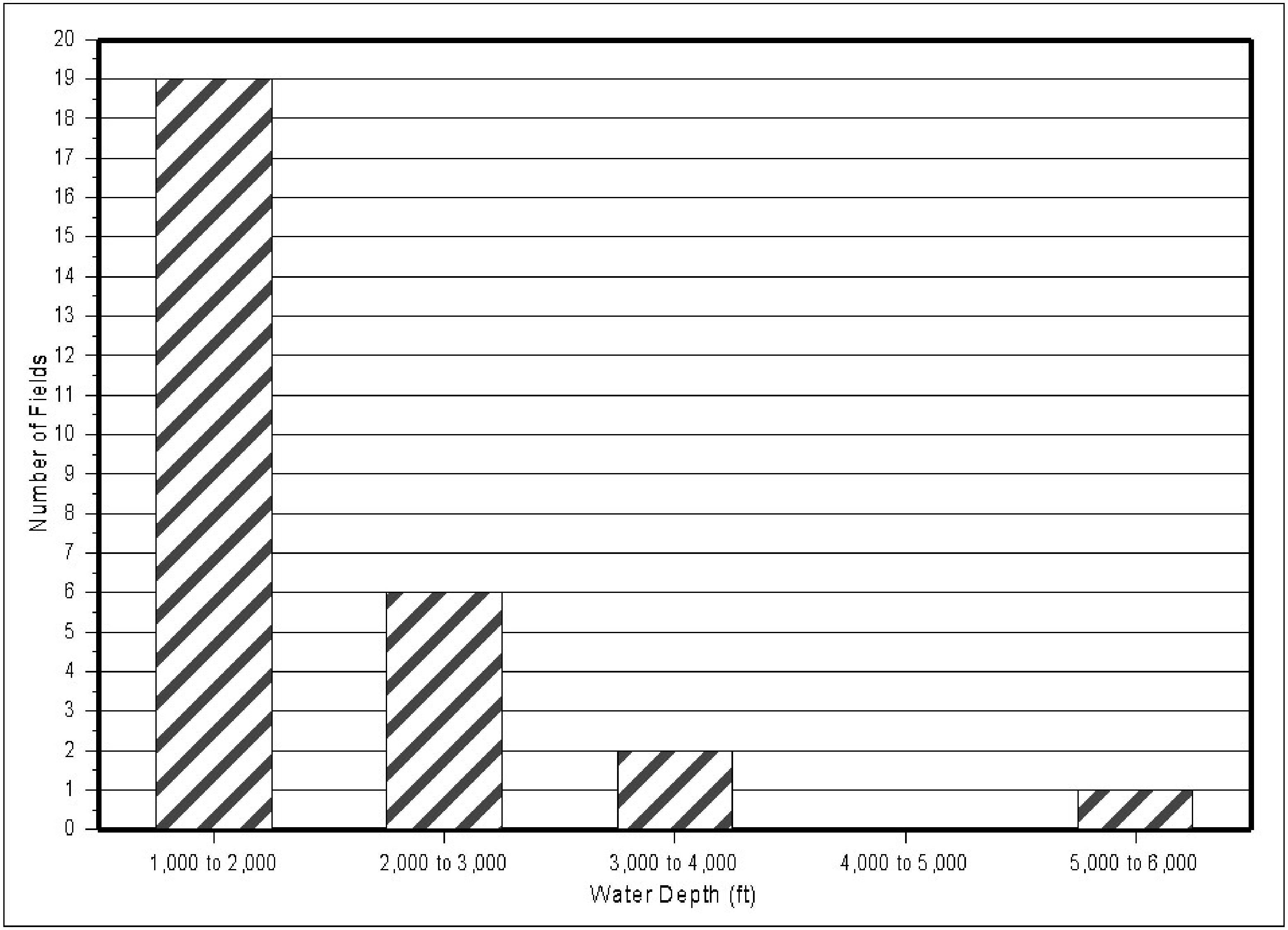

Figure II-4. Number of Producing Fields in the Gulf of Mexico by Water Depth.

B. Seismic Surveying Operations

Geophysical seismic surveys are performed to obtain information on surface and near-surface geology and on subsurface geologic formations. Low-energy, high-resolution seismic surveys collect data on surficial geology used to identify potential shallow geologic hazards for engineering and site planning for bottom-founded structures. They are also used to identify environmental resources such as chemosynthetic community habitat. High-energy, deep-penetration, common-depth-point (CDP) seismic surveys obtain data about geologic formations greater than ten thousand meters below the seafloor. The two-dimensional (2D) and three-dimensional (3D) CDP data are used to map structure features of stratigraphically important horizons in order to identify potential hydrocarbon traps. They can also be used to map the extent of potential habitat for chemosynthetic communities.

Seismic surveying operations in deep water are generally no different than surveying on the shelf. Typical seismic surveying operations tow an array of airguns (the seismic sound source) and a streamer (signal receiver cable) behind the vessel 5-10 m below the sea surface. The airgun array releases compressed air into the water column creating an acoustical energy pulse. Acoustic (sound) signals are reflected off the subsurface sedimentary layers and recorded near the water surface by hydrophones spaced within streamer cables. These streamer cables are often 3 mi or greater in length. Vessel speed is typically 4-7 knots (about 4 2 -8 mph) with gear deployed.

The 3D seismic surveying enables a more accurate assessment of potential hydrocarbon reservoirs to optimally locate exploration and development wells and minimize the number of wells required to develop a field. State-of-the-art interactive computer mapping systems can handle much denser data coverage than the older 2D seismic surveys. Multiple-source and multiple-streamer technologies are used for 3D seismic surveys. A typical 3D survey might employ a dual array of 18 guns per array. Each array might emit a 3,000-in^3 burst of compressed air at 2,000 pounds per square inch (psi), generating approximately 4,500 kilojoule (kJ) of acoustic energy for each burst. At 10 m from the source, the pressure experienced is approximately ambient pressure plus 1 atmosphere (atm). The streamer array might consist of 6-8 parallel cables, each 6,000-8,000 m long, spaced 75 m apart. A series of 3D surveys collected over time (four dimensional or 4D seismic surveying) is used for reservoir monitoring and management (the movement of oil, gas, and water in reservoirs can be observed over time).

Developing technologies that may provide additional detail on the geology and fluids beneath the seafloor might be appropriate for use in the deepwater areas of the Gulf and might include seafloor cables, multicomponent seafloor cables, vertical cables, marine vibrators, and combinations of multiple vessels, source arrays, and streamers.

C. Drilling Activities

To date, there have been approximately 1,200 wells drilled in water depths equal to or deeper than 305 m (1,000 ft) in the Gulf of Mexico. Approximately 90 percent of all deepwater wells drilled have been in the Green Canyon, Mississippi Canyon, and Viosca Knoll Areas of the Central Planning Area and the Garden Banks Area of the Western Planning Area.

Deepwater exploration strategies appear to target potential oil accumulations. Most of the deepwater prospects developed to date have been the oil-prone discoveries. Despite this, there have been some large natural gas discoveries in the deepwater areas of the Gulf. Shell=s Mensa project in approximately 1,615 m (5,300 ft) of water successfully demonstrated deepwater drilling and production subsea system feasibility for both oil and gas deepwater operations. The MMS expects more development of deepwater natural gas prospects in the future.

Deepwater drilling activities are expected to increase in the Western Gulf in the East Breaks, Garden Banks, Alaminos Canyon, and Keathley Canyon Areas. Projections are that 30-35 percent of the deepwater drilling activities during the next ten years could occur in these areas.

An increase in the rate of exploratory drilling is expected to occur around 2005-2007 as approximately 2,000 deepwater leases near the end of their initial lease terms. These leases will expire (and be re-offered for lease) unless the lessees initiate exploratory drilling operations, the leases are made part of an approved exploration or development unit, or the MMS grants the lessees a suspension.

Most drilling activities in the deepwater portion of the Gulf will be undertaken by floating drilling rigs (FDR's). Today, the fleet of FDR's for deepwater operations comprises drillships and semisubmersibles (Figure II-5). New drillships are relatively self-sufficient and may stay at sea for extended periods of time. Support vessels will replenish fuel, food, drilling supplies, and other essentials to the rigs. Normally, helicopters are used to transport crews to and from the FDR's.

The worldwide mobile drilling fleet is composed of approximately 40 semisubmersibles and drillships. Of these, seven rigs are capable of drilling in water depths of greater than 1,500 m (5,000 ft). The worldwide utilization rate for deepwater rigs is 100 percent. By the year 2001, it is estimated that there may be 20-25 deepwater drilling rigs worldwide capable of drilling in water depths of up to 3,600 m (12,000 ft).

During the first quarter of 1998, there were approximately 25 mobile deepwater rigs working in the Gulf of Mexico. Three of these rigs have ultra-deepwater capabilities. Of the 20-25 ultra-deepwater rigs expected worldwide by the year 2001, 50-70 percent (10-18) are projected for deployment to the Gulf of Mexico.

Drilling vessels use two types of stationkeeping systemsBdynamic positioning and catenary anchors. Most drillships use dynamic positioning (DP) systems. The advantages of DP are mobility, independence from tugs and anchor-handling vessels, and relatively quick setup time. The DP systems use computers, global positioning systems, and thrusters to ensure relatively precise location of the FDR.

Many semisubmersibles are held on location by an array of catenary anchors. Systems with eight anchor moorings are commonBtwo anchor points from each Acorner.@ Each mooring component is usually composed of an anchor, anchor chain, and wire rope leading back to the winches on the semisubmersibles. Anchored FDR's require assistance from seagoing tugs and anchor-handling vessels to establish their position or to change location. Each anchor must be positioned and emplaced by an anchor-handling vessel.

Larger anchors and longer anchor chains/mooring lines are expected for operations in deep water as compared to operations on the shelf. The length or Ascope@ of each mooring line may be 5-7 times the water depth. The areal extent of the impact zone of the anchor system, or Afootprint,@ is expected to be greater for an operation that employs anchoring in deep water. The size and shape of the footprint depend on a variety of factors. In addition to water depth, factors influencing the footprint include the anchor deployment pattern, precision of navigation with the anchor handling vessel when placing the anchor, length of drag before the anchor is set, current and weather conditions (especially storms), composition of the anchoring system (e.g., chain followed by wire line, piggy-backed anchors), and scheduled movement of the FDR for nearby well patterns. The seafloor impact zone associated with an anchored FDR will encompass a much larger area than that of a dynamically positioned FDR.

Mooring systems are also evolving. Taut leg mooring systems associated with suction piles or vertical leg anchors are improving stationkeeping capabilities and reducing the area of potential impacts from setting and retrieving anchors. The assessment of impacts from the anchor moorings is best addressed in the site-specific environmental evaluations conducted by MMS with each exploration or development plan. To adequately assess potential impacts at the site of proposed

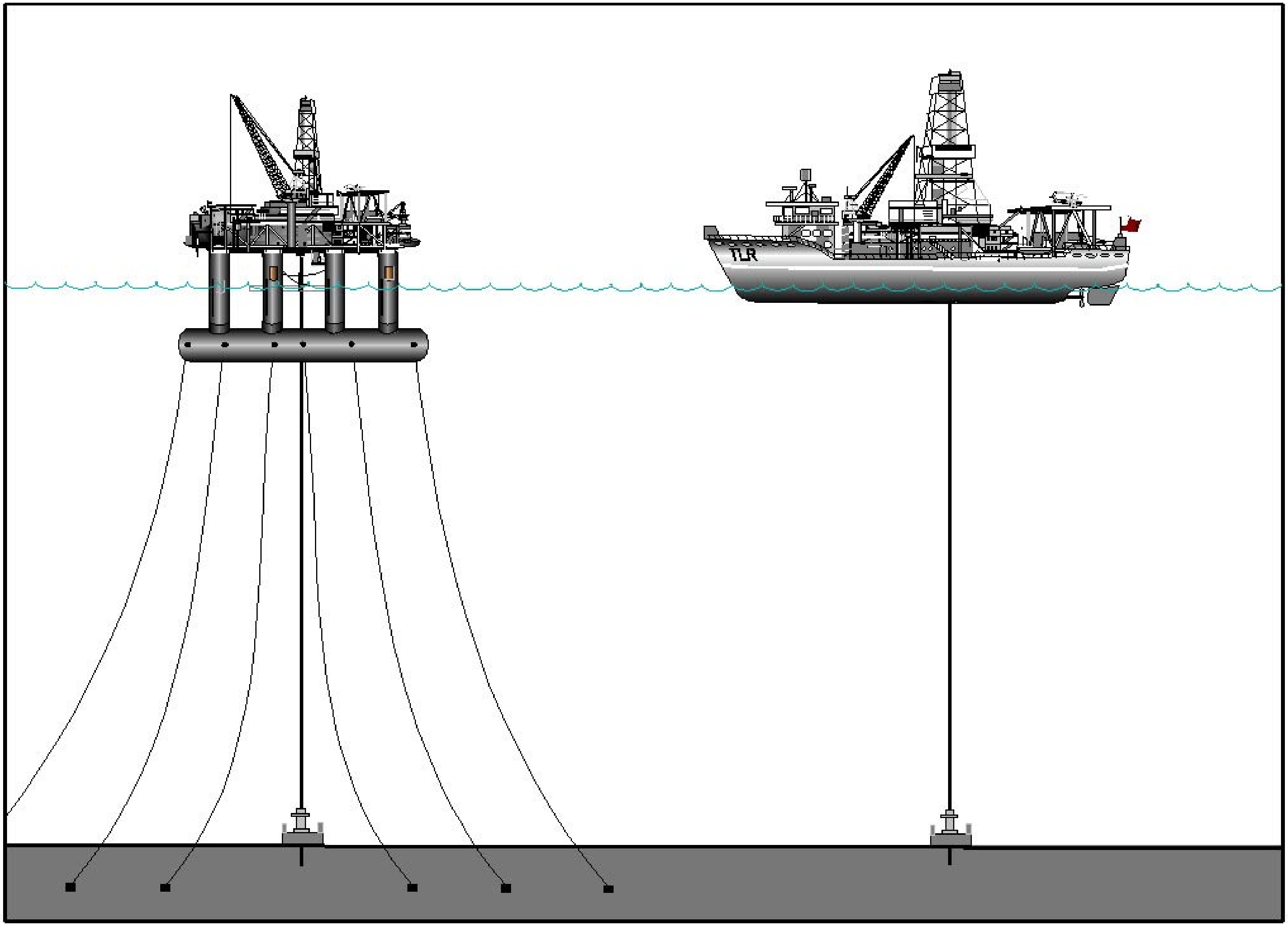

Figure II-5. Deepwater Drilling Vessels--Semisubmersible and Drillship.

operations, high-resolution geohazards survey data must be collected over the entire area of potential bottom disturbance, which includes the entire potential scope of the mooring system.

Most deepwater surface facilities currently installed in the Gulf of Mexico can support a platform drilling rig. Industry statements indicate a general trend to use smaller surface facilities to develop deepwater fields, 15-20 mobile drilling rigs are projected for the approximately 100 production facilities projected for deep water by 2007. Mobile drilling rigs present potential impacts to sensitive seafloor resources; site-specific review and clearance would help avoid such impacts.

Historical data indicate that the ratio of exploratory to development wells drilled ranges from two to four (i.e., 2-4 exploratory wells are drilled for each development well). Table II-1 shows the range of anticipated well starts by year over the next 10 years. Projections include both infill (drilling of new wells within existing fields) and step out (drilling of new wells adjacent to existing fields to test the extent of the reservoir) drilling.

Table II-1

Projected Deepwater Wells SpuddedB2000 through 2007

Year	Total	Exploration	Development
2000	170-200	130-150	40-50
2001	180-210	135-150	45-60
2002	180-210	135-150	45-60
2003	180-210	135-150	45-60
2004	200-230	150-165	50-65
2005	230-250	170-185	60-75
2006	250-275	185-200	65-75
2007	250-275	185-200	65-75

These projections are based on several assumptions about future drilling activities.

The time required to drill an exploratory well is typically 70-90 days, 40-60 days for a development well, including completion of the well. Some wells may take up to 120 days to complete.

Well testing and other types of evaluations could extend the time the drilling rig is at a given location.

As more rigs become available, the amount of time deepwater rigs are available to perform well remediation activities will increase. In 2003-2007, it is assumed that up to 20 percent of each drilling rig=s time will be spent doing remediation work.

During 1998-1999, 25-35 rigs were operating on the Gulf OCS, 30-40 rigs are expected during 2000-2002, and up to 50 rigs during 2003-2007.

Deepwater drilling activity is expected to increase during 2005 through 2007, as about 2,000 deepwater leases approach the expiration of their initial lease term.

Projections in the table include drilling new wells within existing fields (infill drilling) and new wells adjacent to existing fields to test the extent of the reservoir (step out drilling).

Constraints to increased drilling levels may be the operating budget of companies, available personnel for the new rigs, and the availability of resupply vessels.

The depths of these projected wells obviously depend on the depths of the specific target horizons within the individual prospects. Projections from historical data and geophysical information suggest the distribution shown in Table II-2.

Table II-2

Projected Percentage of Wells by Well Depth Range

Percentage of Wells	Well Depth Range (ft) Below Mudline	Average Depth (ft) Below Mudline
20	< 8,000	6,000
60	8,000-20,000	14,000
20	> 20,000	22,000

The hole and casing sizes of these wells will depend on the geology and engineering considerations at each well site. Table II-3 presents the parameters of a typical deepwater well. Well returns will be taken at the seafloor during the early casing points within the well.

Table II-3

Projected Hole and Casing Sizes and Length of Hole Section for a Typical Deepwater Well in the Gulf of Mexico Region

Hole Size (in)	Casing Size (in)	Length of Hole Section (ft)
36	36	Jetted; 160-300; returns to seafloor
26	20	900-1,600; returns to seafloor
20	16	1,000-2,000; returns to seafloor
17	13	1,900-5,000; returns to surface*
12.25	9	5,000-8,000; returns to surface*
9.875	7	6,500-8,500; returns to surface
8.5	5.5 or liner	2,400-4,000; returns to surface

*The use of synthetic drilling fluid could start at this casing point.

Synthetic Drilling Fluid

The base constituents in synthetic-based drilling fluids (SBF) are synthesized organic compounds that are mixable in water. Two of the most common types of SBF are composed of esters and poly-alpha olefins. Esters are derived from reacting vegetable fatty acids with various alcohols. Poly-alpha olefins are purified, short-chained hydrocarbons that are chemically treated to attach the chains together (polymerized) to form longer-chained hydrocarbons.

The SBF have downhole performance characteristics similar to those of oil-based drilling fluids (OBF) and both offer advantages over traditional water-based drilling fluid (WBF) in certain circumstances. For example, SBF have higher lubricity in the wellbore compared to WBF. The SBF and OBF may also endure more hostile downhole conditions (e.g., heat, pressure, H_2S). Penetration rates may be substantially faster, which may be a substantial economic advantage to the operator by shortening the time on location to drill a well.

Synthetic- or oil-based drilling fluids are generally not used for the entire depth of the well. In a typical deepwater well, WBF are used for the upper portion of a well with a change to an SBF below the 16-in or 13-in casing points at a depth of 2,000 m or more. The SBF are used to prevent possible hydrate formation in the wellbore during drilling operations. The SBF also offer advantages when used through the prospective production horizons, i.e., SBF are less likely than WBF to interact within the production horizons because their physical and chemical makeup is similar to the fluids within the hydrocarbon-bearing zone. This characteristic makes well cleanup prior to production easier and more effective.

Operators have economic incentive to conserve synthetic drilling fluids. The cost of 12 lb/gal mud weight SBF ranges from $180-280 per barrel compared to WBF at $10-26 per barrel. The SBF are typically Arented@ from a mud company, and operators pay a premium for any volume that is lost. Therefore, the equipment for solids control and fluid recovery for SBF wells tends to be more efficient than for other operations.

Suggested Research and Information Synthesis

Field studies to determine the distribution, dispersion, residence time, and toxicity levels of discharged synthetic-based drilling fluids and cuttings would help refine current mitigation measures and help identify any additional mitigation measures.

Riserless and Mudlift Drilling

The initial portion of all wells drilled from floating drilling rigs is conducted under Ariserless" conditions. This involves the discharge of sediments at the seafloor during drilling of the upper portion of the well. On deepwater drilling projects, operators have extended the portion of the well normally drilled riserless to a depth of approximately 2,000 ft below the mudline. After the casing is set, the subsea blowout preventer (BOP) and riser system are installed and drilling returns come to the surface for separation and treatment.

In a traditional deepwater drilling scenario, a 21-in marine riser is connected to the BOP stack after the initial casings are run and cemented in a well. Drilling fluid is pumped down the center of the drill pipe to the drill bit. The drilling fluid and cuttings then return to the surface using the riser as a conduit. The drill cuttings, sand, and silt are removed and the drilling fluid is recirculated down to the drill bit. Well solids (drill cuttings, sand, and silt) wetted with drilling fluid are discharged overboard, if they meet USEPA NPDES requirements.

AMudlift drilling@ operations allow the drilling returns to be diverted at the subsea BOP and transported to the surface via a marine umbilical or return line. In most of these operations there will be no marine riser. Gas lifting, drilling fluid density reduction, or submarine pumping may be included in the system to facilitate circulation of the returns to the surface. Some mudlift systems are devising partial solids separation for discharge at the seafloor.

Figure II-6 depicts three deepwater drilling scenarios to illustrate these operations.

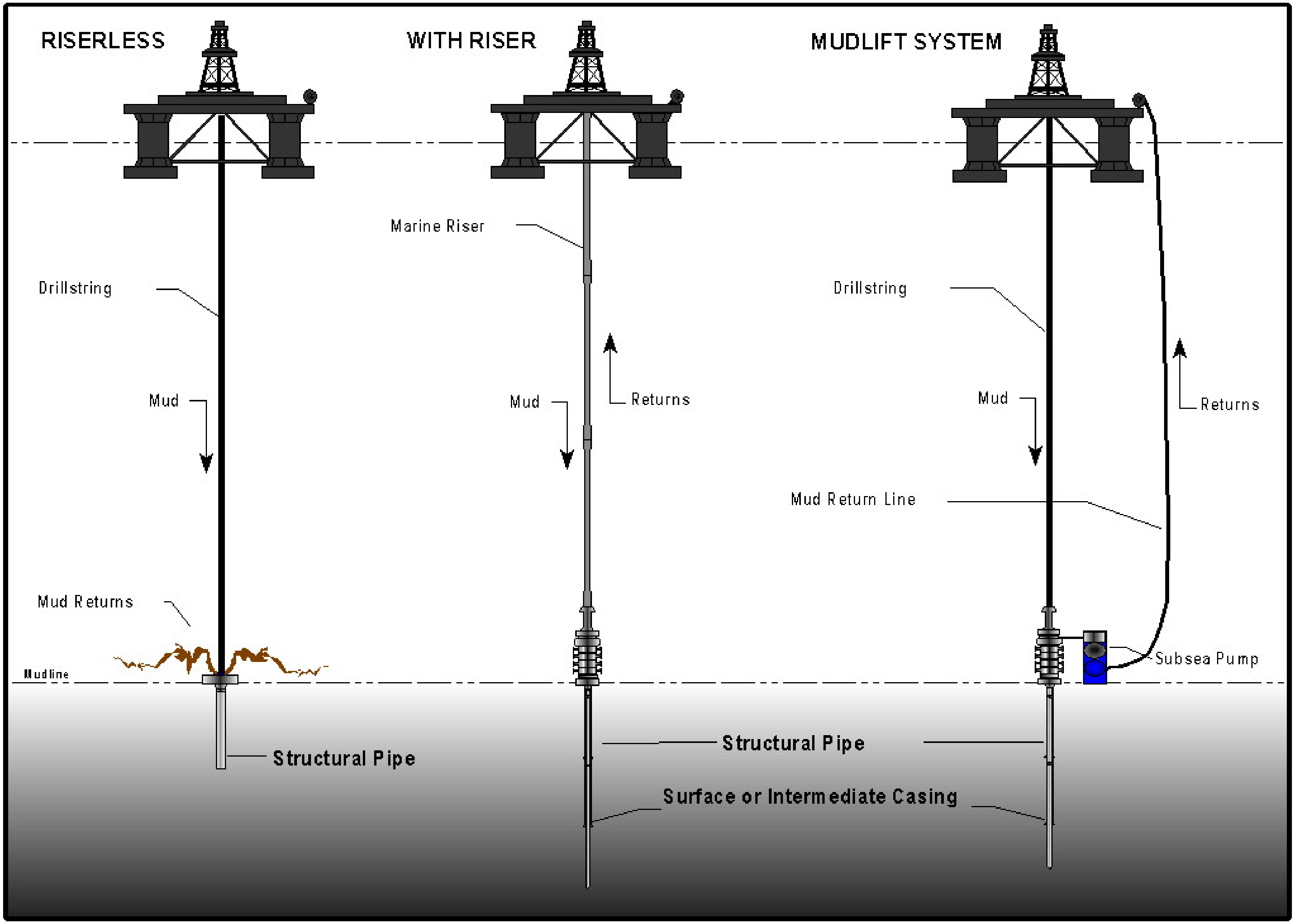

Figure II-6. Riser Options for Deepwater Drilling.

Suggested Research and Information Synthesis

Field studies to determine the distribution and dispersion of muds and/or cuttings discharged at the seafloor during pre-riser and riserless drilling operations would help refine current mitigation measures and help identify any additional mitigation measures.

Blowouts

Blowouts occur when improperly balanced well pressures result in the sudden, uncontrolled releases of fluids from a wellbore or wellhead. Blowouts can occur during any phase of offshore operations: exploratory drilling, development drilling, completion operations, production, or workover operations. However, these events are relatively rare. From 1971 to 1995, there were 24,237 well starts. Exploratory drilling operations had 49 blowouts (frequency of 0.00202) while development drilling resulted in 45 blowouts (frequency of 0.00186) (USDOI, MMS, 1994 and 1997a). Only 100 bbl of oil/condensate were spilled in 1992 from two events associated with exploratory drilling activities. The condensate spill resulted from a blowout when the well unexpectedly encountered a shallow, overpressured gas reservoir. Typically, Ablowout@ refers to loss of control associated with the target reservoir. No spills have occurred associated with development drilling operations.

For the same 25-year span, blowouts from production, workovers, and completion operations were lower in number than from drilling operations: 18 blowouts occurred during production, 29 during workovers, and 10 during completions (USDOI, MMS, 1994 and 1997a). Accounting for all sources of blowouts gives an average of 7 blowouts per 1,000 well starts.

Of the 24,237 well starts from 1971 to 1995, 901 (3.7%) were drilled in water depths greater than 1,000 ft. No major blowouts have occurred in the Gulf=s deepwater areas. Many of the wells expected in deep water will have well control equipment located at the seafloor. Water depths may complicate well control operations. Of particular concern is the ability to stop a blowout once it has begun. The availability of rigs capable of drilling in similar water depths, riser components, and associated deepwater drilling equipment may be limited. The MMS is considering a rulemaking establishing the operator=s responsibility for assuring the MMS of the accessibility and availability of an intervention drilling rig.

In the event a blowout occurs and the surface facilities are damaged enough to preclude well re-entry operations, a relief well may be needed to regain control of the situation. Drilling an intervention well could take anywhere from 30 to 90 days (Regg, 1998; Stauffer, personal communication, 1998; McCarroll, personal communication, 1998). The actual amount of time required to drill a relief well will depend upon a variety of factors including the complexity of the intervention, the location of a suitable drilling rig, the type of operations that must be completed in order to release the rig (e.g., may need to run and cement casing before the rig may be released), and any problems mobilizing personnel and equipment to the relief well site. It is estimated that the entire intervention effort for a blowout could range from 60 to 120 days (Regg, 1998; Stauffer, personal communication, 1998; McCarroll, personal communication, 1998). This estimate assumes that the depth of the intervention well will be approximately 10,000 ft (3,048 m) subsurface. The oil and gas industry has speculated that because the deepwater sediments are relatively unconsolidated, a deepwater blowout may stop flowing in several days to a few weeks as failure of a portion of the bore hole, called Abridging over,@ blocks the flow. The increased hydrostatic pressure at these water depths will contribute to failure of the wellbore and cessation of uncontrolled well flow.

Should a surface blowout occur at a deepwater facility (for example from a wellhead on the production deck of a TLP), spill response is expected to resemble that of a similar event in shallow water. Complications could arise because of the increased distance from shore and potentially greater spill rates. Well control efforts for a surface blowout in deep water are expected to take approximately 60 days.

Further investigation is needed before the consequences of a blowout in deep water can be fully evaluated. Information is limited on the chemical behavior, phase changes, transport, and physics of the rising plume, given the temperature and pressure encountered in deep water. An MMS-funded modeling effort showed that hydrates might form from some of the gaseous components in a blowout fluid (S.L. Ross Environmental Research Ltd., 1997). Ross modeled the fate of the release of 30,000 bbl of oil per day and 60 mmcf of gas per day during a deepwater blowout for two extreme cases. In the first case, a bubble plume was assumed to form. Gas bubbles can create a pumping action that results in the development of a rising plume of gas, oil, and water to the surface at velocities that can override the effects of the prevailing water currents. In this scenario, for water depths ranging from 300 to 750 m (984 to 2,461 ft), not enough of the gas was converted to hydrate or dissolved to prevent the formation of a bubble plume. This blowout scenario assumed that the released gas pumped the oil, gas, and water to the surface. In the second case, all of the gas was assumed to convert to hydrate with no bubble or gas plume forming. This scenario assumed a blowout in water depths greater than 900 m (2,953 ft). Rapid conversion of all of the gas to hydrate is expected to occur in blowouts at this water depth; oil is expected to eventually rise to the water surface because of its buoyancy. A more detailed investigation is needed to validate the results of this preliminary study.

The International Association of Drilling Contractors (IADC) and the OOC recently published Deepwater Well Control Guidelines (IADC/OOC, 1998). The guidelines are designed to assist the drilling industry in planning and conducting operations in deepwater areas around the world. The guidelines are structured into five chapters: Well Planning, Well Control Procedures, Equipment, Emergency Response, and Training. Each chapter provides the recommended practices and procedures for a given situation or condition. The guidelines are derived from the knowledge and experience gained by the drilling industry in conducting operations in deepwater areas. Though the guidelines are intended for worldwide use, many of the examples are based on the Gulf of Mexico operations.

Well Intervention

Intervention into a wellbore is generally for recompletion, workover, or well-control purposes. A recompletion is usually a scheduled event to change the production interval in a well from its existing depth. Workover operations are usually unscheduled events performed on an Aas needed@ basis. Well-control problems are usually emergency situations. An operator=s actions are focused on regaining control of the situation, stopping the well from flowing, and returning the well to production.

As operators move into deeper water, some of the newly designed deepwater production systems may not be capable of accommodating a conventional platform drilling rig on their decks. Deepwater structures are being designed to minimize the size, load capacity, and complexity of the facility to control costs. As a result, interventions in subsea wells will likely require a floating drilling rig, specially designed workover rig or equipment (limited capabilities), or a specialized intervention vessel. If a floating drilling rig is used, operations would be similar to mobilizing for a drilling activity, except the length of time on location (10-30 days) is expected to be less than that for drilling a new well (70-90 days). If a floating drilling rig is involved in intervention work, it is not available for exploratory or development drilling. This may be a critical factor for operators in the current Atight@ rig market until more floating drilling rigs become available. By 2003-2007, as much as 20 percent of the floating drilling rig fleet=s time may be expected in intervention operations.

The emergency nature of a well-control intervention may require the assistance of a second floating drilling rig. If the loss of well control damages the rig on location, another floating drilling rig would have to suspend its current operations to move to the intervention site to begin remedial operations. If the current operations of the secondary rig are critical to the safety and protection of the resources and the environment (e.g., running and cementing casing in the well), the response time may be delayed. The responding rig must have capabilities similar to those of the rig under distress. The responding rig may need additional supplies and possibly additional equipment for its intervention role. With the limited number of floating drilling rigs available in the Gulf, intervention operations will require cooperation among the operators and service companies involved in deepwater activities. The MMS is aware of the potential problem and has met with deepwater operators to encourage them to reach an agreement for mutual assistance in case of emergencies.

Industry well-control experts continuously work to improve the understanding of needs, processes, and existing capabilities. One notable effort was the IADC/OOC Deep Water Well Control Task Force. The group addressed well planning, well-control procedures, equipment, emergency response, and training. The findings and recommendations from the Task Force can be found in their October 1998 report (IADC/OOC, 1998). The MMS participated in the Task Force at the steering committee level.

D. Production Facilities and Operations

After initial exploration wells discover recoverable quantities of hydrocarbons, delineation wells may be drilled so that the areal extent and characteristics of the reservoir may be better determined. With the corporate decision to produce the potential hydrocarbons, production facilities can be designed and fabricated. However, production facilities cannot be installed until operators have received all of the necessary regulatory approvals. The average development cycle time (discovery to first production) for deepwater projects has been approximately 72 years. The cycle time is strongly dependent on the availability of infrastructure and support services, as well as on development of equipment and technology. Efforts are underway by operators to reduce this cycle time. As technology and techniques for deepwater operations are proven successful, the cycle time may be reduced to 3-4 years. As an example, operators are seeking to reduce the developmental cycle time by minimizing the size and complexity of deepwater structures and by minimizing the fabrication time. The use of floating production, storage, and offloading (FPSO) systems is another strategy under consideration to reduce the cycle time and fabrication costs.

As of January 13, 2000, there were 42 deepwater producing fields in the Gulf of Mexico. In addition, there were 64 discoveries, either under construction or at the planning/evaluation stage of development. Table II-4 lists the field name, location, operator, water depth, date of first production, and the type of development system employed or planned for each field. The distribution by map area of all known deepwater fields is shown in Table II-5.

Almost 90 percent of the currently producing fields are concentrated around the Mississippi River Delta area in the Green Canyon, Mississippi Canyon, and Viosca Knoll Areas. These fields were developed with an assortment of production facilities including fixed platforms, floating facilities, and subsea developments tied back to host facilities. AHost@ facilities are surface facilities that receive production from subsea developments or other facilities for separation, processing, and/or treatment of the hydrocarbons prior to transport to shore. Host facilities also control well and production equipment for subsea developments or unmanned surface facilities.

Table II-4

Deepwater Production and Discoveries

Field	Area/Block	Operator	Water Depth (ft)	Production Start-up	Type of Development
Deepwater Fields Producing as of January 13, 2000					
Alabaster	MC 397	Exxon	1,059	1992	Fixed
Allegheny	GC 254	British-Borneo	3,186	1999	TLP/Subsea
Amberjack	MC109	BP Amoco	1,029	1991	Fixed
Angus	GC 113	Shell	2,045	1999	Subsea
Arnold	EW 963	Marathon	1,800	1998	Subsea
Auger	GB 426	Shell	2,860	1994	TLP
Baldplate	GB 260	Amerada Hess	1,641	1998	Compliant Tower
Bullwinkle	GC 62	Shell	1,353	1989	Fixed
Cognac	MC 194	Shell	1,025	1979	Fixed
Cooper	GB 388	EEX	2,190	1995	FPS
Diamond	MC 445	Kerr-McGee	2,095	1994	Subsea
Dulcimer	GB 367	Mariner	1,120	1999	Subsea
EW 1006	EW 1006	Walter	1,884	1999	Subsea
Gemini	MC 292	Texaco	3,393	1999	Subsea
Genesis	GC 205	Chevron	2,597	1999	Spar
Jolliet	GC 184	Conoco	1,720	1989	TLP
Lena	MC 281	Exxon	1,018	1983	Guyed Tower
MC 441	MC 441	EEX	1,520	1993	Subsea
Macaroni	GB 602	Shell	3,600	1999	Subsea
Marlin	VK 915	BP Amoco	3,236	1999	TLP
Mars	MC 807	Shell	2,940	1996	TLP/Subsea
Mensa	MC 687	Shell	5,376	1997	Subsea
Morpeth	EW 965	British-Borneo	1,630	1998	TLP/Subsea
Neptune	VK 826	Kerr-McGee	1,930	1997	Spar
Oyster	EW 917	Marathon	1,200	1998	Subsea
Penn State	GB 216	Amerada Hess	1,450	1999	Subsea
Pompano I	VK 989	BP Amoco	1,290	1994	Fixed
Pompano II	MC 28	BP Amoco	1,865	1995	Subsea
Popeye	GC 116	Shell	2,000	1996	Subsea
Ram-Powell	VK 956	Shell	3,214	1997	TLP
Rocky	GC 110	Shell	1,785	1996	Subsea
Seattle Slew	EW 914	Tatham	1,019	1993	Subsea
Shasta	GC 136	Texaco	1,040	1995	Subsea
Spirit	VK 780	Shell	1,040	1998	Fixed
Stellaria	GC 112	Shell	2,045	1999	Subsea
Tahoe	VK 783	Shell	1,500	1994	Subsea
Thor	VK 825	Kerr-McGee	1,720	1998	Subsea
Troika	GC 244	BP Amoco	2,721	1998	Subsea
Typhoon	GC 236, 237	Chevron	2,000		Mini TLP
Ursa	MC 809	Shell	3,916	1999	TLP
VK 862	VK 862	Walter	1,043	1995	Subsea
Zinc	MC 354	Exxon	1,478	1993	Subsea
Deepwater Fields Not Producing as of January 13, 2000					
Anstey (East)	MC 607	BP Amoco	6,680	1999	Subsea
Atlantis	GC 699	BP Amoco	6,133		
Bison	GC 166	Exxon	2,518		
Black Widow	EW 966	Mariner	1,850		Subsea
Boomvang (East)	EB 688	Reading & Bates	3,737		
Boomvang (North)	EB 643	Reading & Bates	3,688		
Brutus	GC 158	Shell	2,877	2001	TLP
Conger	GB 215	Amerada Hess	1,500	2000	Subsea

Field	Area/Block	Operator	Water Depth (ft)	Production Start-up	Type of Development
Coulomb	MC 657	Shell	7,500		
Crazy Horse	MC 777, 778	BP Amoco	6,050		
Crosby	MC 899	BP Amoco	4,452		
Diana	EB 945	Exxon	4,500	2000	Spar
Diana (South)	AC 65	Exxon	4,800	2000	Subsea
Europa	MC 935	Shell	3,870	2000	Subsea
Fuji	GC 506	Texaco	4,243	2001	FPSO
GB 254	GB 254	Chevron	1,920		
GC 72	GC 72	Mobil	1,655		Subsea
GC 228	GC 228	Texaco	1,638		
Glider	GC 248	Shell	3,300	2000	TLP
Gomez	MC 755	Union Pacific	3,000	2001	Spar/TLP
Grand Canyon	GC 141	Conoco	1,715		
Habanero	GB 341	Shell	2,000		
Herschel	MC 522	Shell/BP Amoco		2003	Subsea
Herschel South	MC 520	Shell/BP Amoco	6,739	2003	Subsea
Holstein	GC 644, 645	BP Amoco	4,390		
Hoover	AC 25, 26	Exxon	4,785	2000	Spar
King	MC 84	BP Amoco	5,500	2001	Subsea
King	MC 764	Shell	3,250	2000	Subsea
King Kong	GC 472	Conoco	3,817	2000	Subsea
King=s Peak	DC 133	BP Amoco	6,530	2001	Subsea
Knight	GB 372	Santa Fe	1,740		
Ladybug	GB 409	Texaco	1,355		
Leo	MC 502, 503, 546	British-Borneo	2,500		
Llano	GB 386	EEX	2,300	1999	Subsea
MC 26	MC 26	BP Amoco	1,272		
MC 243	MC 243	Conoco	3,100	2000	
MC 443	MC 443	Walter	2,095	1999	Subsea
MC 533	MC 533	Walter	1,000	1999	Subsea
MC 837	MC 837	Walter	3,900	1999	Subsea
Mad Dog	GC 826	BP Amoco	6,560		
Madison	AC 24	Exxon	4,856	2002	Subsea
Marshall	EB 949	Exxon	4,500	2002	Subsea
Matterhorn	MC 243	Elf Exploration	2,830		Mini TLP/Subsea
Metallica	MC 911	BP Amoco	7,000	2004	
Mica	MC 167, 211	Exxon/Mobil	4,350	2001	
Mickey	MC 211	Exxon/Mobil	4,356		
Mirage	MC 941	Vastar	3,927		Subsea
Morgus	MC 942	Shell	3,960	2002	
Mosquito Hawk	GB 269	Texaco	1,102		
Nakika	MC 383	Shell/BP Amoco	5,759	2000	Monohull FPS
Narcissus	MC 630	Texaco	4,250		
Neptune	AT 574	BP Amoco	6,220	2001	
Nile	VK 914	BP Amoco	3,535	2001	Subsea
Nirvana	MC 162	BP Amoco	3,414	2001	
Petronius	VK 786	Texaco	1,754	2000	Compliant tower
Pluto	MC 718	Mariner/BP Amoco	2,828	2000	Subsea
Poseidon	GC 691	BP Amoco	4,489		
Prosperity	VK 742	Texaco	1,000		
Salsa	GB 171	Amerada Hess	1,076		
Sorano	GB 516	Shell	3,153	2001	Subsea
Sunday Silence	EW 958	Flextrend	1,450	2001	Mini TLP
Toro	GC 69	Shell	1,465	2000	
Virgo	VK 823	Elf Exploration	1,130	1999	Fixed
Zeus	MC 941	Exxon	3,905		

Several innovative designs for production facilities are expected to be introduced into the Gulf of Mexico during the next decade. These include variations of spars, TLP=s, mini-TLP=s, etc. The Morpeth mini-TLP has been installed in the Gulf of Mexico. Two other mini-TLP=s are under construction. Other existing systems and technologies are expected to be adapted for use beyond their current applications. This will be based on experience, technical evaluations, modeling, and analyses as the technology matures.

Table II-5

Deepwater Discoveries by Map Areas

Map Area	Number of Discoveries
Mississippi Canyon	34
Green Canyon	19
Garden Banks	13
Viosca Knoll	11
Ewing Bank	7
East Breaks	3
Alaminos Canyon	2
DeSoto Canyon	1
Atwater Valley	1

An estimated 50-60 deepwater projects are likely to be under development or producing by the year 2007. The Ahigh case@ estimate is 90 deepwater developments by 2007. This is an estimate based on current trends in oil prices, discovery rates, and well flow rates; any estimate would change considerably if any or all of these factors changed drastically. The complexity of these projects will range from one-well subsea developments to large multiwell developments associated with different floating production systems, fixed structures/platforms, and subsea facilities. Table II-6 shows the projected number of deepwater development Astart-ups@ by year and the type of development systems for the projects.

Table II-6

Projected (Estimated) Number of Deepwater Developments (AStart-ups@) by Year

	Type of Development Systems						
Year	Subsea	TLP	Spar	Fixed	FPU	FPSO	Total
2000	5	1	3		1		10
2001	4		2			1	7
2002	7	1	1	1			10
2003	7	1	1			1	10
2004	7	1		1	1		10
2005	8		1			1	10
2006	7		1	1	1		10
2007	7	1			1	1	10

A summary description of the different types of structures that may be employed in the development and production of hydrocarbon resources in the deepwater areas of the Gulf of Mexico is provided in a separate MMS technical report (Regg, 2000). The papers provide an overview of each type of production structure, a technical description of the various components, and the operational processes including installation, maintenance, and operational activities. The papers also provide technical information on how the various components interface with the environment. The technical information in the papers provides a basis for comparison of new or unfamiliar systems with known and evaluated systems. This will be particularly beneficial for evaluating the technical, safety, and environmental issues associated with systems for which there is little Gulf of Mexico experience but some knowledge of the technology based on applications and experience elsewhere.

Three general types of development and production systems are currently deployed in the deepwater Gulf of Mexico. These include fixed structures (e.g., conventional fixed platforms and compliant towers), floating production systems (e.g., TLP=s, spars, and semisubmersible-based FPS=s), and subsea systems. See Figure II-7 for a depiction of these systems and the ranges of water depths expected for each system.

Fixed Structures

Conventional fixed platforms consist of a jacket, one or more decks, and Atopsides@ equipment such as separators, pumps, treaters, and manifolds systems. The jacket is composed of welded steel tubulars and is secured to the seafloor by piles that are driven into the bottom. Once the jacket is secured and the deck is installed, surface facility modules are added for drilling, production, and crew accommodations. Large barge-mounted cranes are employed to install the jacket, deck, and modular components. Technology and economic considerations tend to limit conventional fixed platforms to water depths of generally less than 1,500 ft (457 m).

Compliant towers are similar to conventional fixed platforms; however, compliant towers can yield to sea and wind forces in a manner similar to floating structures. The jacket portion of the tower is smaller in dimensions (both in cross-sectional size of the jacket structure and in the footprint on the seafloor) than that of a fixed platform. The towers tend to be more linearly shaped rather than the characteristic pyramidal shape of the conventional fixed structure. Compliant towers may have buoyant sections in the upper portion of the jacket. The towers are fixed to the seafloor by a base template that is secured by piles driven into the sea bottom. Mooring lines from the jacket to the seafloor may limit movement of the tower (guyed-tower design). Compliant towers are considered likely candidates for a water depth range of 1,000-3,000 ft (305-914 m).

Floating Production Systems

There are several different types of floating production systems (FPS=s) that have been or are projected to be installed in the Gulf of Mexico. A tension-leg platform (TLP) is a buoyant structure that is held in place by a specialized mooring system. The mooring system is a set of vertical steel legs or tendons held in tension by their attachment to a seafloor template and to a buoyant hull. The TLP may resemble a semisubmersible drilling unit above the waterline. Installation begins by driving piles through one or more templates or foundations on the seafloor. Then the legs/tendons are attached to both the template and buoyant hull. The design dampens vertical motions but allows for some horizontal movements. The surface facilities are similar to those of fixed structures.

A semisubmersible-based floating production system, commonly referred to as an FPS, is similar to a TLP except the structure uses a typical catenary anchored mooring system for its stationkeeping operations. Some semisubmersible drilling rigs have been converted to FPS=s by removing some drilling equipment, making modifications to the structure, and installing conventional Atopsides@ production equipment to their decks.

A spar is a deep-draft, floating, caisson-shaped structure that is hollow (similar to a very large buoy). It is composed of a buoyant hull, moorings, and surface facilities. The distinguishing feature

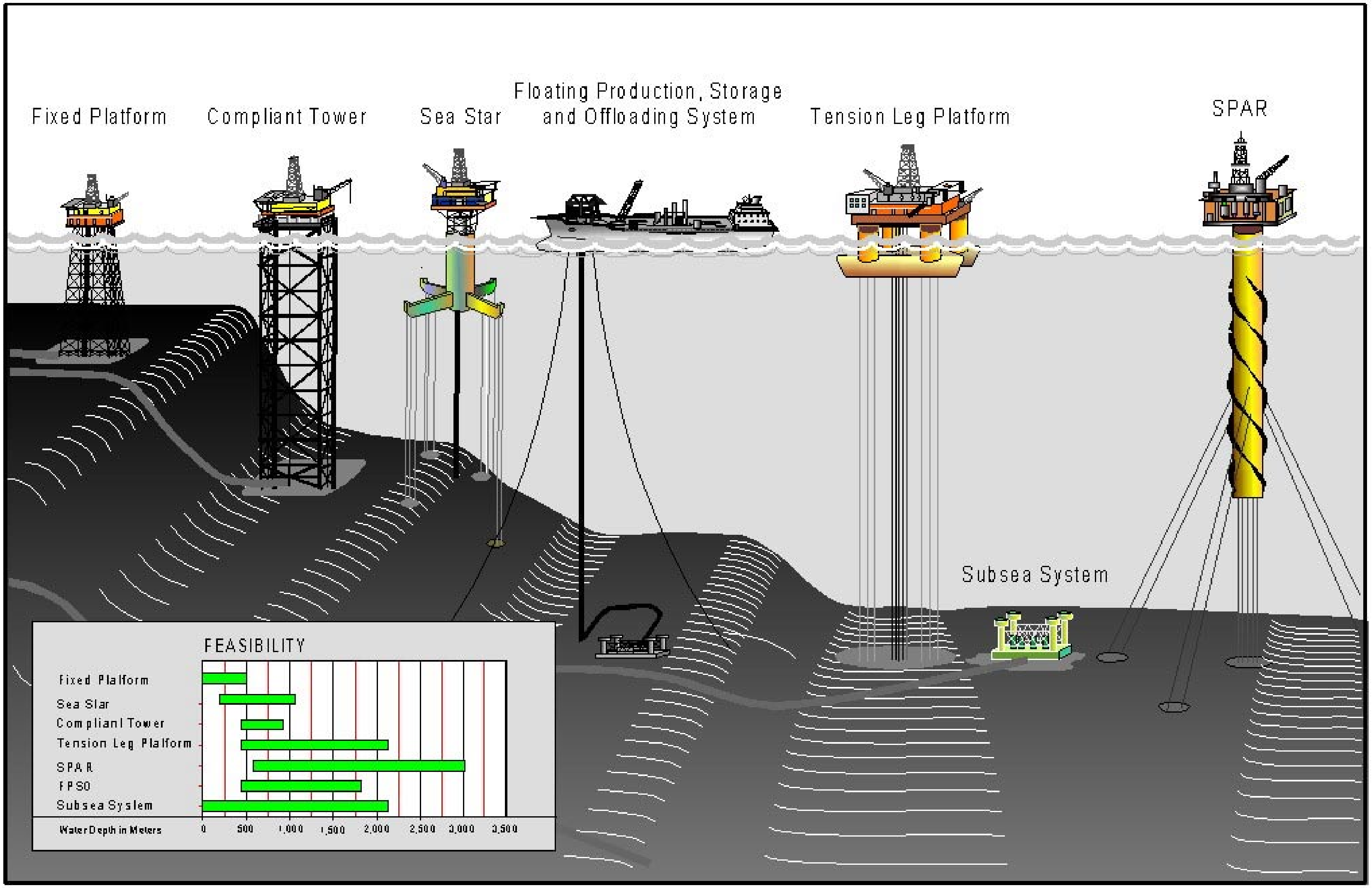

Figure II-7. Deepwater Development Systems in the Gulf of Mexico.

of a spar is its deep-draft hull, which produces more favorable motion characteristics when compared with other floating concepts. Approximately 90 percent of the structure is below the waterline. The resulting low motion and the protected centerwell provide an excellent configuration for deepwater operations. Spars rely on a traditional anchored mooring system to maintain their positions at sea.

Floating Production, Storage, and Offloading Systems

Floating production, storage, and offloading (FPSO) systems have been traditionally ship-shaped (although not necessarily) facilities that produce, process, and store liquid hydrocarbons at an offshore location. FPSO=s are viable through a wider range of water depths than other floating production systems. Gulf of Mexico FPSO=s are expected to be moored with conventional anchoring systems. Subsea production systems will be used in association with FPSO=s. The surface production facilities on an FPSO are similar to those associated with other offshore production facilities. Produced oil will be stored within the hull of the FPSO. The hull may be single-hulled, double-sided/single-bottomed, or double hulled. Produced oil will be offloaded to shuttle tankers or ocean-going barges for transport to shore. Any natural gas produced from the reservoirs serviced by an FPSO will be pipelined to shore. Storage of extremely large volumes of produced liquid hydrocarbons (500,000 to 2.3 million barrels of oil), offloading OCS crude to shuttle tankers, and transport of OCS crude by surface vessels are operational aspects that will be new to the Gulf of Mexico OCS.

Some of the unique pieces of equipment found on FPSO=s include the turret mooring system and the swivel stack. The turret mooring system allows the vessel to weathervane around its moorings. The swivel stack serves to transfer hydrocarbons and utilities (control fluids, electrical conductors, chemical inhibitors, etc.) between the FPSO and the subsea production equipment.

Offshore Platform and Structure Requirements and Operator=s Severe Weather Response

The MMS Operating Regulations address requirements for platforms and structures on the OCS in 30 CFR 250 Subpart I. In addition, all platforms or structures to be installed in water depths greater than 122 m (400 ft) are subject to the Platform Verification Program. The API Recommended Practices (API RP 2A and API RP 2FPS) provide further guidance and are incorporated by reference into these regulations.

Data on the operational environment are an integral part of the design, installation, and operation of offshore structures. These data include such factors as wave heights and periods, currents, vertical distribution of wind and gust velocities, water depth, storm and astronomical tides, marine growth, and air and sea temperatures. Offshore structures are designed and constructed to withstand the environmental conditions and loads expected at the site as well as the severe weather conditions that may be expected in the Gulf.

When severe weather conditions approach offshore structures, operators implement their operations curtailment and personnel evacuation plans. As a storm approaches, operators begin a phased response that may ultimately require the structure=s wells and production equipment to be temporarily shut in and the structure=s personnel to be evacuated.

Subsea Systems

Subsea systems are multi-component seafloor systems that allow the production of hydrocarbons in water depths where installation of conventional fixed or bottom-founded structures would not be feasible. A typical subsea development system might include several subsea wells, a central manifold, umbilicals, jumpers, and flowlines.

Umbilicals are used to control remote subsea equipment from a supporting surface facility or Ahost.@ Typically, an umbilical is composed of a bundle of (1) hydraulic or electric well control lines that activate components on the subsea tree, downhole devices, and other subsea equipment such as valves on subsea manifolds; and (2) small well treatment lines (usually one-inch or less) that may transport flow assurance and/or inhibiting chemicals to the subsea well. Generally, low volumes are associated with the small well control and supplemental injection lines. Traditional impacts from anchor damage or damage from ground-founding operations are unlikely in deepwater. Another source of potential damage comes from pipeline activities. New deepwater pipeline installations may be routed around umbilicals or the two lines may be vertically separated to preclude damage.

In deep water, subsea developments may be located many miles away from the supporting surface facility. Well production is transported from the subsea well head to the host facility via a Atie back@ flowline. As development moves into even deeper waters, existing deepwater facilities may become hosts for more distant or deeper water facilities.

The full Awell stream@ (oil, gas, and produced water) from a subsea well will flow to the host facility for processing. Equipment located on the host facility will control the operation of subsea wellheads via electrical and/or hydraulic umbilicals. Specialized treatment fluids may be stored on the host facility for use in maintaining flow assurance through subsea production equipment. These treatment fluids may include chemicals for hydrate control, corrosion control, and/or special inhibitors for paraffins and asphaltenes. These fluids are delivered to the subsea equipment through dedicated lines in the control umbilical or through specialized pipelines.

Since production in the flowlines is subject to ambient conditions of cold temperatures, and high pressures, hydrate, asphaltene, and wax formation in the lines remains a concern for operators. The MMS and others are sponsoring research to determine how to prevent these precipitates from forming in subsea flowlines and how to reinitiate production if they do inhibit or preclude flow. Chemical injection appears to be the method of choice. Methanol and various types of glycols have been used to inhibit hydrate formation.

Intervention into a wellbore may be needed for recompletion, workover, or well-control purposes. For subsea systems, floating drilling rigs or specialized intervention vessels will be required for these operations.

Chemical Usage in Offshore Operations

A variety of chemical products are stored and used for a number of different purposes during offshore oil and gas operations. Some are used in specific treatment processes and others are used in general Ahousekeeping@ procedures (Hudgins, 1989). Chemical products are used during production operations, in gas processing, and to enhance flow through pipelines. The types of chemical products include corrosion inhibitors, emulsifiers, demulsifiers, drag-reducing agents, pour-point depressants, well stimulation and workover chemicals, hydrate inhibitors, antifoaming agents, scale inhibitors, biocides, coagulants, and many more substances. Many of these chemicals are only used to reduce or mitigate some type of operating condition. Other chemicals are used routinely and their volumes are expected to be low because they are recycled (e.g., triethylene glycol used in gas dehydration). Some of these chemicals may be added periodically; others are used only during infrequent operations (e.g., injection of chemicals at startup or shutdown in a process). Some chemicals are continuously injected (metered) into a process or at transfer points to control well or flow conditions. A wide range of additives is now used in workover fluids and drilling fluids. These specialty chemicals can have a major impact on well performance and resource recovery. Some production systems would be considered inoperable without these specialty chemicals.

The use of some chemicals has increased in order to operate in the deepwater environment safely and economically. Subsea production systems may require more extensive and frequent use of chemical products to maintain flow and to inhibit the formation of waxes, hydrates, corrosion, and asphaltene in the flowlines. Deposition of complex and heavy organic compounds from petroleum can cause blockages in the oil reservoir, in the well, in the pipelines, and in the oil production and processing facilities. The types of compounds deposited can include asphaltene, resin, flocculated material, diamondoids, clatherates, gas hydrates, paraffins/microcrystalline waxes, salts and oxides, sulphur, mercaptans, and organometallic compounds. Deposition of heavy organic compounds is not necessarily related to the percentage of asphaltic material measurable in crude oil. Rather, their formation is strongly influenced by complex relationships between the various hydrocarbon fractions occurring in crude oil, the thermodynamic influences of the deepwater environment, the addition of oil treatment chemicals, and flow conditions within the flowline. Maintaining flow in deepwater pipelines is made more difficult by the cold temperatures and high ambient pressures found at the seafloor and because of the long distance between wellheads and the surface facilities.

The volume of chemical products needed may dictate the method of transporting the chemicals to the offshore. Chemical products may be transported by supply or service vessels in DOT-approved tanks or in tanks integrated into the hull of the vessel. The volume of one DOT tank can range from 12 to 143 bbl. Multiple DOT tanks may be needed for an application. These tanks are routinely lifted from the supply vessel to the facility and stored prior to being connected to their process application inlet. Large quantities (thousands of barrels) of routinely used chemicals are more likely to be conveyed via pipeline or barge. Tank barges may transport as much as 10,000-15,000 bbl. Chemical transfers will involve hose and pipe connections from the hull of the supply vessel or barge to onsite storage at the offshore facility. Many chemical products are routinely stored for long periods at shore bases or at offshore facilities.

E. Pipelines

Historically, pipelines have been the primary mode of transporting liquids and gases from subsea well sites to OCS production facilities, between OCS production facilities, and from OCS production facilities to onshore facilities. Transportation-related issues associated with deepwater development are discussed in an MMS technical report (Regg, 2000). The paper summarizes pipeline installation methods, spanning, methods for maintaining flow assurance, and alternative transportation options.

For many deepwater applications, pipeline systems, called gathering lines, transport production from remote subsea well sites to surface processing facilities. These pipelines are usually small in diameter because they transport production from only one or a few wells. Pipelines may also connect a minimal surface structure at a deepwater well site to its supporting host facility. A minimal surface structure may contain well test equipment or Afree-water knockout@ equipment to remove water from the production stream. Removal of the water reduces the possibility of hydrate formation in the pipeline.

Rights-of-way (ROW) are granted for pipelines that are off the operator=s lease or unit. These ROW pipelines are also called transmission lines, trunklines, or sales pipelines. These lines are generally larger diameter pipelines that transport production from several fields after the hydrocarbons have undergone separation and treatment. The destination for ROW pipelines is either another offshore facility for further treatment or refinement of the hydrocarbons or a shore facility for storage.

The operating environment for deepwater pipelines is different from the operating environment of pipelines on the shelf. Deepwater pipelines face higher hydrostatic pressures, colder water and sediment temperatures, different physical stresses during installation, effects from loop currents or eddies during installation or operation, greater amounts or rates of flow assurance chemicals, possibly higher flow rates, greater span (length of pipelines above the seafloor) distances, rugged seafloor topography, and technical challenges to monitoring and repair operations.

Pipeline installation methods for deepwater pipelines may be different from methods used on the shelf. The AJ@ lay and bottom tows installation methods are unique to deep water. Deepwater pipelines may also be installed using dynamically positioned lay barges rather than the traditional anchored systems. While dynamic positioning eliminates the environmental effects from anchoring, air emissions may increase due to combustion of fuel to power positional thrusters.

As of April 1998, there were approximately 26,600 mi of pipeline on the Gulf=s seafloor. Most of these pipelines support shelf and near-shelf facilities; a small percentage supports deepwater operations. During the period 1990-1995, the growth in deepwater pipeline activities fluctuated through a range of 2-19 percent of all pipelines installed in the Gulf of Mexico. A dramatic increase occurred in the years 1996 and 1997, with deepwater pipeline installations being 34 and 46 percent, respectively, of all pipelines installed in these years. Figure II-8 shows the percentage of deepwater pipeline miles installed compared with the total number of miles of pipelines installed in the Gulf of Mexico from 1990 to 1997. Approximately 58 percent of all existing deepwater pipeline miles installed from 1990 to 1997 were installed during the two-year period of 1996-1997. Deepwater pipeline Amiles installed@ are expected to range from 300 to 500 mi per year through the year 2007. (This projection does not include the installation of replacement pipelines on the shelf to support deepwater operations.) To date, producers have installed most of the deepwater pipelines. However, pipeline transmission companies have shown a willingness to extend their systems into deeper waters.

The chemical composition of the produced hydrocarbons and the available carrying capacity of existing pipelines are two factors influencing the need for additional pipelines for deepwater development activities.

Several oil and gas pipeline systems to shore are projected in this scenario based on the location and number of expected developments during the next decade. These pipeline systems are likely to be built with excess capacity to allow for additional field tie-ins.

Pipeline inspections and repairs in deep water offer some challenges to the industry. Remotely-operated vehicles (ROV=s) will most likely be involved at great water depths. High hydrostatic pressures, low ambient temperatures, darkness, and requirements to move or operate large/heavy components make ROV operations difficult. Bundled pipelines and umbilicals may also complicate ROV operations. Distant infrastructure make logistical support and emergency response more time consuming and complicated. Currently, there are few ROV=s with capabilities for water depths greater than 1,000 ft (305 m). Advancements in ROV technology and capabilities are expected to evolve to facilitate deepwater pipeline inspections and repairs. Mohr=s Deepwater Pipeline Technology Conference paper gives a reasonable comprehensive discussion of deepwater pipeline repair (Mohr, 1998).

Subsea spills may occur from deepwater pipelines as a result of leaking or damage. There are many technical and environmental questions related to detection of deepwater pipeline leaks, hydrocarbon movement in the water column, formation of hydrates at the leak site, and spill treatment and/or cleanup. Research is ongoing to enhance the ability to detect a seafloor pipeline leak in deep water, to stop the spill source once it is detected, and to ensure pipeline integrity in the long term.

Operators who develop deepwater prospects evaluate all transportation options prior to making decisions on whether to install new pipelines to shore. An alternative to installing new pipelines is to increase the carrying capacity of the existing pipeline system to accommodate new production from deep water. Additional carrying capacity for existing pipelines may be accomplished by increasing the maximum allowable operating pressure (MAOP) within the line (requires MMS

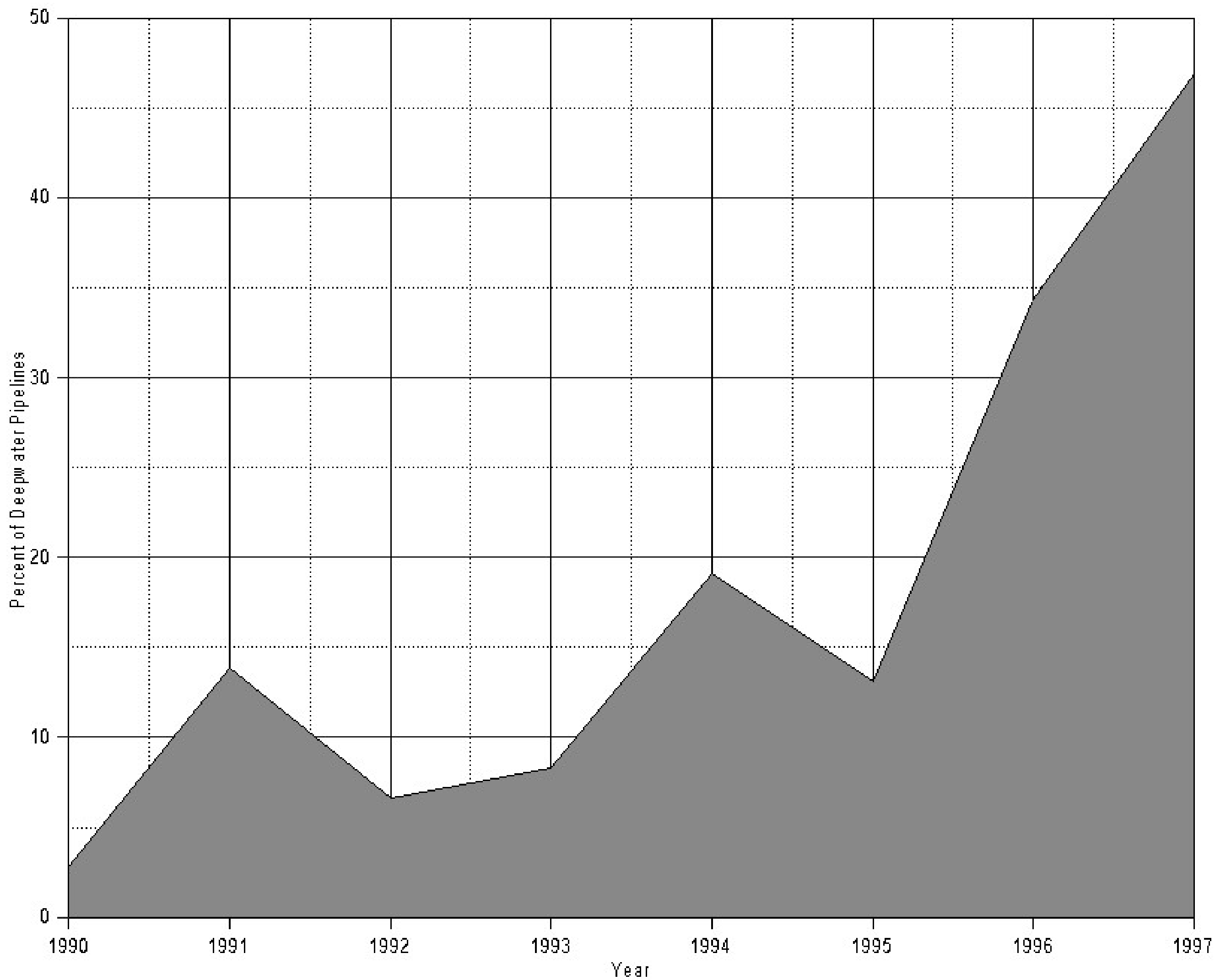

Figure II-8. Percentage of Deepwater Pipeline Miles Installed Compared to Total Pipeline Miles in the Gulf of Mexico from 1990 to 1997.

evaluation and approval) or by adding flow-enhancing chemicals into the pipeline. Other transportation options are discussed in Chapter II.F. below.

F. Alternative Transportation Options for Produced Hydrocarbons

Barging Operations

Limited barging operations, mostly associated with well testing operations, are anticipated from deepwater activities. Some new drillships have liquid hydrocarbon storage capabilities that range from 100,000 to 500,000 bbl. If the storage capacity of these vessels is used, e.g., for an extended well test or limited first production, the liquid hydrocarbons will be offloaded to a shuttle tanker or large ocean-going barge for transport to another facility or to shore. Offloading procedures will adhere to U.S. Coast Guard regulations (33 CFR Subchapter O--Pollution) and be under the direction of the Captain of the vessel. Sea state and meteorological conditions will limit offloading operations.

Barging operations associated with extended well tests are expected to occur only once during the development of a field. Storage of liquid hydrocarbons and subsequent barging may be a viable alternative for facilities developing gas fields with limited amounts of liquid hydrocarbons. Barging may also serve as an interim measure to transport liquids until a pipeline can be emplaced.

Tankering

The scenario for this EA projects 2-4 FPSO facilities operating in the Gulf of Mexico in the next 10 years. Each FPSO would be supported by one or more shuttle tankers with an expected cargo capacity of 500,000 bbl of oil. For an assumed production rate of 100,000 BOPD, offloading operations would occur approximately every five days. The liquid hydrocarbons would likely be transported to Gulf Coast ports in Texas and Louisiana, or to the Louisiana Offshore Oil Port (LOOP). Offloading and surface transport of OCS-produced oil will be new to the Gulf of Mexico.

Lightering from super tankers to shuttle tankers and offloading from FPSO=s to shuttle tankers are similar operations. The USCG=s Deepwater Port Study (USDOT, CG, 1993) provides information about lightering operations and Gulf Coast ports. This study provides controlling water depths for selected Gulf Coast ports that might support shuttle tanker operations (Table II-7).

Disposition of Associated Natural Gas

Natural gas associated with production of liquid hydrocarbons (oil-well gas) may present a dilemma for some deepwater projects that are located far from the existing pipeline infrastructure. This is of particular concern when the produced hydrocarbon liquids are to be tankered or barged and the associated natural gas production does not economically warrant the installation of a gas pipeline.

There are several technological options for handling associated natural gas: (1) transporting the natural gas via pipeline; (2) reinjection of the natural gas into a reservoir for future production; (3) flaring or venting of the gas; or (4) conversion of the gas into a transportable liquid. As conservation of the natural gas resources is a primary concern for MMS, requests for reinjection or flaring/venting of associated gas would be evaluated by MMS on a case-by-case basis. The MMS has approved flaring of limited volume and duration to allow for well testing, well unloading, and other infrequent, short-term events. Natural gas liquefaction, conversion to methanol, or conversion to syncrude are emerging technologies for marine applications. The plants involve complex processing equipment and are currently considered too large for most offshore FPS installations. There is a low probability that these facilities would be operational in the field within the next decade.

Table II-7

Controlling Water Depth for Selected Gulf Coast Ports
that Might Support Shuttle Tanker Operations

Primary Port/Waterway	Secondary Port/Waterway	Controlling Water Depth (ft)
Lake Charles, La.		40
Lower Mississippi River, La.	Baton Rouge	40
	Mississippi River	40
	New Orleans	32
	Mississippi River to Gulf of Mexico	35
	Mississippi River Entrance	45
	Inner Harbor Navigation Channel	30
Freeport, Tex.		34
Corpus Christi, Tex.		47
Galveston, Tex.		42
Texas City, Tex.		35
Houston, Tex.	Southern Pacific Ship Channel	42
	Turning Basin	37
Port Arthur, Tex.	Sabine Pass Channel	42
	Port Arthur Harbor	40
Beaumont, Tex.		40

Source: U.S. Dept. of Transportation, Coast Guard, 1993.

This study also provides data on the average size of lightering vessels at selected Gulf Coast ports (Table II-8). The OCS-related shuttle tankers are expected to be of a similar size.

Table II-8

Average Size of Lightering Vessels at Selected Gulf Coast Ports

Port	Average Size Lightering Vessel (in deadweight tons)
Lake Charles, La.	74,000
New Orleans, La.	82,000
Freeport, Tex.	62,000
Corpus Christi, Tex.	81,000
Port Arthur-Beaumont, Tex.	75,000
Galveston-Houston, Tex.	65,000

Source: U.S. Dept. of Transportation, Coast Guard, 1993.

G. Decommissioning Operations

Decommissioning operations are expected to undergo technical evolution similar to that seen with other deepwater technologies. Production from most of the current deepwater structures has not started to decline to a level that approaches the economic threshold for commercial operations. One deepwater structure in the Gulf of Mexico has been decommissioned; Placid's Green Canyon Block 6 structure was removed and reused at Garden Banks Block 388.

Delays in decommissioning some of the major deepwater facilities are expected. Major facilities may be tied into and support additional fields. Some facilities are expected to remain in place, becoming host or hub facilities providing production support for other fields. Operation of some deepwater facilities will be sustained through infield drilling activities to maintain production.

The MMS requires all operators to submit a decommissioning proposal for review prior to initiating abandonment operations. The proposal must detail the operator's plans to sever and remove all wells, structures, and equipment from the terminated lease(s). Current decommissioning requirements do not vary with water depth. Lessees are required to remove all structures and related underwater obstructions within one year after the termination of their lease (Section 22 of the lease). In addition, lessees must verify that the location has been cleared of all obstructions (30 CFR 250.702, 250.704, and 250.913).

For all deepwater decommissioning operations, some functions will be common to all types of structure removal activities. All wells must be plugged and abandoned in accordance with 30 CFR 250, Subpart G. All pipelines and umbilicals used with subsea wells and equipment are required to be cleaned, capped, and may be abandoned in place. If production risers are used at the facilities, they are expected to be removed and taken to shore for salvage.

Initial development of deepwater prospects in the Gulf used large fixed structures (such as Cognac). These platforms were assembled by stacking structural components on one another to form the jacket. Decommissioning operations for these structures will most likely require dismantling the jackets into components. Lift barge capabilities, such as hook load and derrick height limitations, will be constraining factors.

Mid-water severing operations are likely for the larger fixed structures. For example, the length of the jacket portion of compliant towers may require mid-water cuts to remove the jacket in segments. Other alternatives include conversion to a rigs-to-reefs project, or toppling in place and abandonment. Any mooring associated with the tower would be removed.

Foundations for tension-leg structures may include tendon templates secured to the seafloor with multiple large-diameter (72- to 96-in) piles. Severing these anchor piles will be a technological challenge at deeper water depths. Decommissioning of the structure's long tendons will be another challenge. To be physically manageable, these tendons will have to be removed in pieces or abandoned in place. The hulls of these structures are expected to be removed from the field and salvaged or reused at another location.

Decommissioning floating production structures, such as spars or FPSO's, will involve removing the hull for salvage or reuse. Removal of a spar hull will be complicated by its very deep draft (600+ ft in the water column). Several spar-based projects have proposed onsite abandonment. Moorings for these structures would also be removed. The FPS's held in place by large diameter piles will share some of the challenges facing tension-leg structure decommissioning operations.

Subsea development decommissionings will have the operators retrieving subsea production trees and well jumpers. Other seafloor structures such as manifolds and templates will be retrieved or abandoned in place.

The National Marine Fisheries Service (NMFS) developed a Biological Opinion, pursuant to Section 7 of the Endangered Species Act, regarding the removal of certain oil and gas platforms and other structures in the Gulf of Mexico when explosives are used during decommissioning operations. The conditions to protect endangered and threatened species set forth in this Ageneric@ opinion pertain to the type and size of explosive charge used, detonation depth below the mudline, number of charges per structural grouping, staggering of detonations, and use of qualified observers. Limitations in the generic NMFS consultation were designed prior to the rapid expansion of leasing and activities into deep water. The generic consultation currently limits explosive charges to no more than 50 lbs. This quantity of explosive may not be sufficient for the larger deepwater structures. If larger charges are required, an operator would have to seek an individual Section 7 Consultation with NMFS.

The NMFS Opinion also contains an Incidental Take Statement (ITS). The purpose of the ITS is to authorize the incidental taking of listed protected species during explosive decommissioning operations. The applicant must adhere to specific terms and conditions contained within the ITS.

H. Associated Impact-Producing Factors

Operational Waste Discharged Offshore

The major operational wastes generated during deepwater operations are expected to be the same as those in shallower waters (discussed fully in USDOI, MMS, 1997b and 1998), although differences are expected in the volumes of the wastes being generated, the amounts and composition of additives contained in the wastes, and the disposal options for the wastes when overboard discharge is not allowed. Wastes generated by the OCS oil and gas industry are discharged offshore if they are covered by and meet the requirements of a U.S. Environmental Protection Agency (USEPA) National Pollutant Discharge Elimination System (NPDES) permit. The USEPA recently finalized NPDES permit requirements that have a direct bearing on how industry operating in deep water will dispose of its wastes. These new requirements are discussed under each waste type described below.

Drilling Fluids and Cuttings

The major source of contamination to the marine environment from drilling operations is the discharge of drilling fluids (also known as drilling muds) and cuttings. There are three differences in the use and discharge of drilling fluids and cuttings associated with deepwater operations: the extensive use of synthetic-based drilling fluids (SBF), an increase in the volume of cuttings discharged prior to installation of the riser, and the use of new Ariserless@ drilling technology using Amudlift@ systems in place of risers.

Synthetic-based Drilling Fluids

In the Gulf of Mexico, 75 percent of all wells in Gulf of Mexico deepwater are drilled using synthetic-based drilling fluids (SBF) for portions of the well (USEPA, 1999). To date, no oil-based drilling fluids (OBF) are used in the deepwater due to the potential of spills, and due to higher performance requirements (USEPA, 1999). It is expected that 90 percent of all wells drilled in deep water will use SBF to drill a portion of the total hole depth. Chapter II.C. provides a description of SBF and further information on SBF use practices. In general, synthetic muds are not being discharged directly; because of their high cost, most SBF are recycled. Only SBF adhering to cuttings are being discharged.

The existing USEPA, Region 6, NPDES Permit effluent limits and monitoring protocols for muds and cuttings are not applicable to SBF operations. Because the SBF are hydrophobic and any formation oil adheres tightly to the SBF discharged with cuttings, the static sheen test and visual observation of a sheen may not detect any formation oil contamination of the cuttings (Daly, 1997). The USEPA=s current toxicity monitoring methodology for muds and cuttings is not applicable to SBF. The current methodology determines the toxicity of the dissolved and suspended particulate phase of discharged muds and cuttings on shrimp and minnows and thus applies to the effect of dispersed mud in the water column; SBF do not disperse in the water column. To resolve this, the USEPA, headquarters office, recently proposed Effluent Limitation Guidelines for drill cuttings discharged with SBF (USEPA, 1999). This effort involved extensive data collection efforts and a detailed evaluation of the available data acquired. The USEPA worked closely with industry working groups and with other Federal agencies, especially the MMS. The proposed requirements include testing for polynuclear aromatic hydrocarbons (PAH), sediment toxicity, biodegradation rate, and formation oil for all cuttings (USEPA, 1999). The USEPA projects that their regulations will reduce the discharge of SBF by 11.7 million pounds annually. Finalization of the regulations is expected to take a year or more. The USEPA Region 6, which covers all operations in the Gulf of Mexico west of the Mississippi River, has already published a proposed modification to their permit to incorporate the Guidelines once they are finalized. The USEPA Region 4, which covers all operations in the Gulf of Mexico east of the Mississippi River, has already banned the discharge of SBF and cuttings wetted with SBF.

There is limited information on the environmental effects from the discharge of SBF-associated cuttings. In general, the area and intensity of impact from drilling discharges of water-based muds are proportional to the dispersal of the discharged plume and the deposition potential of the discharge. In contrast, discharges of cuttings with adhering SBF do not disperse easily into the water column and sink rapidly as a mass to the seafloor. Thus, the primary potential environmental impacts are to benthic communities. Adverse effects occur due to the organic loading. Rapid biodegradation of the SBF-wetted cutting piles causes high biochemical oxygen demand. Industry, USEPA, MMS, and others are conducting research efforts to examine possible impacts from SBF. Several screening surveys funded by industry and USEPA (Fechhelm et al., 1999; CSA, 1998) have already taken place. The unpublished results, reviewed by the MMS, indicate that benthic fauna were impoverished within 100-200 m from the well site, with some effects observed out to 500-1,000 m, with recovery occurring within one to two years.

These impacts must be weighed against the environmental benefits of the use of SBF=s. Compared to the discharge of other muds and cuttings, the discharge of SBF cuttings has reduced water-column effects and physical seabed burial effects (Burke and Veil, 1995; Daly, 1997). Benthic toxicity tests indicate lower aquatic toxicity than diesel and conventional mineral oils. Also, a smaller volume of SBF than of other muds is needed to drill a well, thus producing less waste. Allowing the discharge of SBF may reduce non-water quality environmental impacts. Prohibiting the use of SBF may increase the use of OBF. All OBF and cuttings must be hauled to shore and disposed of at commercial oil-field disposal sites. Thus, disallowing the use of SBF may increase the volume of OBF that must be treated and disposed of onshore, which may contribute to the water pollution concerns currently being faced at the commercial onshore disposal sites, and may affect land use through additional disposal sites. Compared to the zero discharge option, the USEPA estimates that allowing the discharge of SBF will reduce emissions of air pollutants by 450 tons per year, decrease fuel use by 29,000 bbl per year of oil equivalent, and reduce the generation of oily drill cutting wastes requiring off-site disposal by 212 million pounds per year.

At present, MMS is funding (1) a literature review that will summarize existing information on environmental impacts and frequency of use of SBF and (2) a risk assessment. The MMS has plans to participate in a joint industry seabed survey to determine the effects of discharges of SBF=s on sensitive bottom habitats.

Discharges of WBF and Cuttings at the Sea Surface

Seafloor disturbances from the surface discharge of drilling fluids and cuttings are depth dependent (de Margerie, 1989). Accumulations of drill cuttings in 400-m water depth have been identified extending from the wellbore in finger-like projections to an average of 450 m (the maximum being about 610 m) (Nunez, personal communication, 1994). The sidescan-sonar records indicate that the cuttings were distributed in thin accumulations less than 0.3 m thicknesses. It is uncertain whether these accumulations include only those cuttings deposited at the seabed during the initial drilling of the well or also those discharged at the surface. Discharged drilling fluids and cuttings are expected to be distributed across broader areas of the seafloor with greater water depth and to be generally distributed in thinner accumulations than in shallower areas on the continental shelf. Contaminate levels in deep-sea sediments from drilling discharges are expected to be extremely low. Smothering and toxic effects from these thin accumulations are expected to be much less than documented at shallower sites. These accumulation characteristics have not been verified; studies have not been conducted to determine how and if waste plumes impact sediments surrounding deepwater discharge sites under varying oceanographic conditions.

Discharges of Drill Cuttings at the Seafloor

Muds and cuttings are discharged at the seafloor during drilling prior to installation of the riser, during riser disconnect, and during well abandonment and plugging. The initial portion of all wells drilled from floating drilling rigs is conducted under Ariserless@ conditions with the cuttings being discharged at the wellbore and being deposited directly on the seafloor. In deepwater, operators have extended the portion of the well normally drilled riserless to a depth of approximately 2,000 ft below the mudline. The volumes of these discharges that would be deposited on the seafloor are not known and information on the potential effects is limited.

Riserless and Mudlift Drilling

After the casing is set, the subsea blowout preventer (BOP) and riser system are installed and drilling returns come to the surface for separation and treatment. In a traditional deepwater drilling scenario, a 21-in marine riser is connected to the BOP stack after the initial casings are run and cemented in a well. Drilling fluid is pumped down the center of the drill pipe to the drill bit. The drilling fluid and cuttings then return to the surface using the riser as a conduit.

AMudlift@ operations allow the drilling returns to be diverted at the subsea BOP and transported to the surface via a marine umbilical or return line. In most of these operations, there will be no marine riser. Gas lifting, drilling fluid density reduction, or submarine pumping may be included in the system to facilitate circulation of the returns to the surface. Some mudlift systems are devising partial solids separation for discharge at the seafloor.

Produced Waters

Produced water constitutes the largest single source of material discharged into the Gulf during normal oil and gas production operations. Produced water (also known as production water or produced brine) is the water from the oil and gas extraction process. Produced water includes formation water, injection water, and various chemicals. Formation water (also called fossil or connate water) from the permeable sedimentary rock strata comprises the bulk of produced water. Injection water is used to enhance oil recovery (secondary oil recovery) and may break through into the oil formation and flow into the production well.

In order to develop oil and gas at the cold temperatures and high ambient pressures encountered in deep water, more extensive and frequent use is anticipated for a number of chemical compounds to enhance flow and to treat the production stream (Chapter II.D.). Often these chemicals end up in the produced-water waste stream. For example, approximately 19 percent of the offshore production chemicals used on platforms in the North Sea are discharged to the ocean in treated produced water, including more than 50 percent of the emulsifiers, surfactants, oil-removing agents, and scale inhibitors (Neff, 1997). For other treating chemicals, less than 20 percent of the amounts used are discharged with produced water. The NPDES permit requires sampling of the produced-water waste stream for toxicity testing. Samples for monitoring produced-water toxicity are collected after the addition of any substances, including seawater that is added prior to discharge, and before the flow is split for multiple discharge ports.

The industry consortium DeepStar projects that oil and gas produced in deep water will most likely be piped from subsea completions through multiphase flowlines to surface processing facilities (DeepStar, 1994). These processing facilities will separate and process the production streams into oil, gas, and water, and then discharge the produced water. It is expected that there will be fewer produced water discharge sites in deep water but larger discharge volumes at the each site. The recently finalized USEPA NPDES permit has removed the limitations on discharge rates. Toxicity testing protocols are adjusted to ensure that the larger volumes of produced water discharges will not exceed water quality criteria.

Some operators may consider installing mini-facilities located at the sea surface above their subsea developments. This production option would allow the use of initial separation equipment. The separation equipment could remove produced water prior to sending the remaining well stream to the Ahost@ production facility. Under these circumstances, much smaller volumes of produced water per facility would be discharged, i.e. produced water discharges would occur at the subsea development site and less discharged at the host facilities. Produced water could be contaminated with hydrate inhibitors or other chemicals and may require specialized treatment prior to discharge.

Recent industry models of produced-water discharges of 7,000 and 11,000 bbl/day predict that the produced-water plumes would not penetrate deeper than 30 m into the water column, even under weak density stratification (Smith, written communication, 1995). Modeled produced-water plumes reach neutral buoyancy rapidly, limiting further vertical plume dispersion. Therefore, large volumes of produced water discharged from surface facilities are not expected to impact water depths greater than 100 m. Likewise, no seafloor contamination from produced-water discharges is expected below the 100-m water depth interval.

Other Waste Discharges

In the newly promulgated general NPDES permit for Region 6 (west of the Mississippi River), USEPA set standards for a new discharge classification--the discharge of chemically treated seawater and freshwater. As discussed earlier, industry is expected to use large volumes of treatment chemicals to produce hydrocarbons from deepwater reservoirs. Biocides, corrosion inhibitors, or other treatment chemicals may be added to seawater and freshwater for a variety of purposes, not all unique to deep water. Some of the discharges proposed by industry are large (nearly 2 million gallons per day) or may contain pollutants that are toxic at concentrations as low as 3 Fg/l (USEPA, 1998). Compliance by operators with toxicity limitations should prevent adverse environmental effects.

All other minor waste discharges are permitted by USEPA and are expected to be rapidly assimilated and dispersed in sea water. No impacts are expected to result from these minor discharges.

Suggested Research and Information Synthesis

A series of field studies to determine the following information would help refine existing mitigation measures and develop additional mitigation measures to protect sensitive bottom features:

- Distribution, dispersion, residence time, and toxicity levels of surface-discharged, synthetic-based drilling fluids and/or cuttings wetted with SBF;
- Distribution, dispersion, and residence time of surface-discharged WBF and cuttings; and
- Distribution, dispersion, and residence time of muds and/or cuttings discharged at the seafloor during pre-riser and riserless drilling operations.

Development of a dispersion model that can estimate the vertical transport of produced water, WBF, SBF, and associated cuttings would enhance our ability to project dispersion and potential seabed deposition. The model would support design of mitigation measures based on potential areal and time-function extent of sediment contamination, sediment toxicity, benthic changes, biodegradation, and bio accumulation. Field research may be needed to develop the model and to verify the model outputs. Some of the information that will support development of such a model is already being gathered through MMS, USEPA, and industry research initiatives.

Trash and Debris

Oil and gas operations on the OCS generate solid waste materials made of paper, plastic, wood, glass, and metal. Operations in deep water are not expected to generate substantially different types or amounts of waste than those associated with comparable operations on the shelf. Some personal items, such as hardhats and personal flotation devices, are accidentally lost overboard from time to time.

The MMS regulations, USEPA NPDES permits, USCG regulations implementing MARPOL 73/78 Annex V, and the Shore Protection Act prohibit the disposal of any trash and debris into the marine environment, call for the development of waste management plans, and require precautions to prevent careless loss of solid waste or debris from offshore facilities or during transport. Generally, galley, operational, and household wastes are collected and stored on the lower deck near the loading dock in large covered containers. Service vessels transport these containers to shore for disposal of the wastes in approved landfills. Food wastes are allowed to be ground up into small pieces and disposed of overboard.

Over the last several years, offshore operators have employed waste reduction and improved waste-handling practices to reduce the amount of trash that could be lost into the marine environment. Improved waste-management practices include: substituting reusable ceramic cups and dishes for those made of styrofoam; recycling offshore waste; and transporting and storing supplies and materials in bulk and in reusable containers, when feasible. These practices have resulted in a marked decline in the accidental loss of trash and debris throughout Gulf of Mexico offshore oil and gas operations.

Air Emissions

The OCS activities that use any equipment that burns a fuel, that transports and/or transfers hydrocarbons, or that results in accidental releases of petroleum hydrocarbons or chemicals will cause emission of air pollutants. Some of these pollutants are precursors to ozone, which is formed by complex photochemical reactions in the atmosphere. The criteria pollutants of concern from OCS activities are nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2), volatile organic chemicals (VOC), and particulate matter. The USEPA=s Compilation of Air Pollutant Emissions Factors (AP-42) does not currently contain a breakout of the different fractions of particulate matter for all source categories. Since the total particulate loading is less than the most restrictive loading allowed for any fraction, it is reasonable to assume that the impacts from any fraction would be less than the total impact. Since the total is below the allowable levels, then the fractions must also be below the allowable levels. All references to particulate matter in this document are to total suspended particulate (TSP) and not to PM_{10} or $PM_{2.5}$.

Deepwater platforms are generally farther from shore and less densely spaced than operations on the shelf. Equipment for deepwater operations is usually larger and more powerful than that used in shallower waters and therefore a source of greater emissions. As emissions from deepwater activities are transported shoreward by prevailing winds, they are additive with emissions generated by OCS operations on the continental shelf, additive both in the OCS and within the coastal counties and parishes.

When comparing the emissions from large host facility operations supporting multiple subsea developments with the emissions from separate smaller platforms for each field, several competing factors come into play. The table below shows some of the expected differences.

Host Facility Servicing Subsea Developments	Conventional Facilities for Each Field
--- one host production facility -- support vessels for one surface facility -- larger and fewer pieces of production equipment centrally located -- less total emissions, but the emissions are concentrated near the host facility -- less emissions along support vessel transportation routes and at support vessel bases -- fewer OCS construction days -- greater likelihood of voluntary use of emission control devices or of more efficient production equipment because of space, economic, and managerial considerations	-- multiple production platforms and caissons -- support vessels for multiple surface facilities -- smaller pieces of production equipment scattered over a larger area -- more total emissions dispersed over the area of development -- more emissions along support vessel transportation routes and at support vessel bases -- more OCS construction days

Host facilities tend to be concentrated point sources of emissions scattered along the continental shelf break. Since the production equipment is centrally located, it is larger in size. The generators and compressors involved are typically more likely to be turbine driven rather than natural gas reciprocating engines. Small turbine engines are not that common and are expensive; however, turbines are efficient, reliable, and cleaner-burning. Also, as the volume of hydrocarbons handled increases, VOC control equipment becomes more cost effective as the volume of recovered saleable hydrocarbons offsets the cost of the control equipment.

Having smaller but more numerous facilities scattered throughout the area is generally considered better, if you are a neighbor to the facilities. But the benefit of scattering the platform emissions is more than outweighed by the increase in nearshore and onshore emissions coming from the increased support vessel usage needed to support these multiple facilities. Vessel emissions typically well exceed those of the production equipment for OCS oil and gas exploration and development activities.

The MMS has neither generated average platform emissions nor collected an inventory of existing platforms to use as a basis for computing the proposed emissions. The MMS is in the process of trying to gather such information. As a result of this information gap, the analyses of the emissions in this document are based on (1) generalizations drawn from multiple plans (Note: In plans, the company is required to submit a Aworst-case@ estimate of emissions.); (2) specific data from individual plans or applications; and (3) generalizations drawn from the emissions inventory collected in 1992 for the Gulf of Mexico Air Quality Study (Note: there were very few data collected from deepwater operations in this inventory; therefore, these generalizations would likely underestimate average deepwater operations).

Of particular concern for deepwater operations are emissions associated with flaring during testing of high-rate wells and with well cleanup operations. These operations involve burning large volumes of liquid and/or gaseous hydrocarbons. A common contaminant of these hydrocarbons is sulfur, and the resulting emissions can contain SO_2 emissions rates high enough to be of concern.

Evaporative losses and emissions from tanker/barge loading and unloading also need to be evaluated. Increased volumes of liquids are projected to be transferred between vessels during well testing and cleanup operations, and associated with FPSO offloading operations.

Hydrocarbon spills typically generate large quantities of VOC emissions, which correspondingly can generate large quantities of ozone. It is assumed that emissions of air pollutants from surface-based oil spills essentially cease after three days. The duration of a subsurface-released spill could be much longer than the duration of a surface-based slick. Emissions from the subsurface spill would continue from the time the oil first reaches the surface until approximately three days after the oil stops surfacing.

Noise

Noise is associated with seismic surveying, drilling activities, production structures, pipeline installation, and support service traffic (e.g., helicopters and support boats). Sound from these activities can be transmitted through both air and water, and may be continuous or transient. The intensity level and frequency of the sound are highly variable, both between and among the various sources. The level of underwater sound depends on receiver (biological, mechanical, or electronic) depth below the sea surface and altitude above the seafloor, aspect (from which direction the sound is coming at the receiver), and strength of the sound source. Operations in deep water are not expected to generate different types, frequency, or intensity of sounds than those associated with comparable operations on the shelf.

The sound generated during seismic surveys is intermittent, with pulses (Gales, 1982). Airgun arrays produce noise pulses generally less than one second in duration with very high peak levels (higher than the continuous sound levels associated with any ship or industrial activities); however, the short duration of each pulse limits the total energy. Levels are expected to be less than 200 dB at distances beyond 90 m from the source (Gales, 1982). Pulses are often detectable at $\geq$ 100 km from the seismic ship, and in deep water may be detected at $\geq$ 1,000 km away (Richardson and Würsig, 1997). Most energy in seismic pulses is below 200 Hz; baleen whales communicate at frequencies mostly below 3 kHz, which is likely to overlap with dominant frequencies produced by the seismic airguns. High-frequency noise produced during seismic surveys may overlap with frequencies used by toothed dolphins and could possibly cause disturbance (Goold and Fish, 1998). Marine vibrators, which may also be used as the sound source for deepwater seismic surveying, have a lower peak-power output than airguns.

Drilling operations often produce noise that includes strong tonal components at low frequencies, including infrasonic frequencies in at least some cases. Drilling noise from semisubmersibles is not particularly intense and is strongest at low frequencies, averaging 10-500 Hz (Richardson et al., 1995). Sound levels are generally higher near drillships than near semisubmersibles (Richardson et al., 1995). From a semisubmersible, sound and vibration paths to the water are through either the air or the risers, in contrast to the direct path through the hull of a drillship.

Machinery noise generated during the operation of production structures can be continuous or transient, and variable in intensity. These levels vary with type of platform and water depth. Underwater noise from the floating facilities used in deep water is expected to be relatively weak because of the small surface area in contact with the water and the placement of machinery on decks well above the water.

Aircraft and vessel support also introduce noise into the marine environment. Sound generated from helicopter and service-vessel traffic is transient in nature and extremely variable in intensity. Helicopter sounds contain dominant tones (resulting from rotors), generally below 500 Hz (Richardson et al., 1995). Water depth and bottom conditions strongly influence propagation and levels of underwater noise from passing aircraft. Lateral propagation of sound is less in deep water than in shallow water. Helicopters, while flying offshore, generally maintain altitudes above 700 ft during transit to and from the working area and an altitude of about 500 ft while between platforms. Helicopters in transit to deepwater platforms will generally maintain higher altitudes for fuel conservation during the long trip, although refueling stops will likely be needed.

Service vessels transmit noise through both air and water. The primary sources of vessel noise are propeller cavitation, propeller singing, and propulsion; other sources include auxiliaries, flow noise from water dragging along the hull, and bubbles breaking in the wake (Richardson et al., 1995). Propeller cavitation is usually the dominant sound source. The intensity of sound from service vessels is roughly related to ship size, whether the ship is laden or not, and speed. Large ships tend to be noisier than small ones, and ships underway with a full load (or towing or pushing a load) produce more noise than unladen vessels. Noise increases with ship speed. Sounds from support vessels range from 400 to 7,000 Hz at 120-160 dB (USDOC, NMFS, 1984). Broadband source levels for most small ships (about 180-275 ft, or 55-85 m, long) are about 170-180 dB re1*m*Pa (Richardson et al., 1995).

I. Sour Oil and Gas, and Sulfurous Oil in the Gulf of Mexico

Sulfur may be present in oil as elemental sulfur, within hydrogen sulfide (H_2S) gas, or within organic molecules, all three of which vary in concentration independently. Although sulfur-rich petroleum is often called Asour@ regardless of the type of sulfur present, the term Asour@ should properly be applied to petroleum containing appreciable amounts of H_2S, and Asulfurous@ should be applied to other sulfur-rich petroleum types. The matrix below summarizes concerns related to sour gas, sour oil, and sulfurous oil.

Sour oil and gas occur sporadically throughout the Gulf of Mexico OCS (currently, about 65 total sites), but principally offshore the Mississippi Delta. Examination of industry exploration and production data show that H_2S concentrations vary from as low as fractional parts per million (ppm) in either oil or gas to as high as 650,000 ppm in the gas phase of a single oil well near the Mississippi

Delta. The next highest concentrations of H_2S are in the range 20,000-55,000 ppm in some natural gas wells offshore Mississippi-Alabama. There is evidence that oil in the deep Gulf is sulfurous, but deepwater gas fields to date contain extremely low H_2S (< 2 ppm) and are not considered Asour@ by any engineering or environmental criterion.

	Petroleum Category		
Concern Category	Sour Natural Gas	Sour Oil	Sulfurous Oil
Engineering	Equipment and pipeline corrosion	Equipment and pipeline corrosion	N/A
On-Platform Industrial Hygiene	Irritation, injury, and lethality of leaks	Irritation, injury, and lethality from outgassing of spilled oil	Irritation, injury, and lethality from exposure to sulfur oxides produced by flaring (See Chapter IV.F. (Air Quality) for an extended discussion.)
Off-Platform General Human Health and Safety	Irritation, injury, and lethality of leaks	Irritation, injury, and lethality from outgassing of spilled oil	Irritation, injury, and lethality from exposure to sulfur oxides produced by flaring (See Chapter IV.F. (Air Quality) for an extended discussion.)
Ecosystem Impacts	Irritation, injury, and lethality of leaks	Outgassing can increase or complicate oil-spill impacts	N/A

J. Support Activities and Infrastructure

Region of Influence

Figure II-9 shows the relation of deep water and the shoreline of the Gulf Coast States. One can see readily that distances to deep water vary markedly. The distance combined with channel depth dictates which ports are the most attractive locations for deepwater support activities. Table II-9 lists U.S. ports along the Gulf of Mexico with projected channel depths of 20 ft or more. These ports are assumed to be capable of accommodating deepwater support activities. There are 28 such ports, including 4 in Florida. Given the State of Florida=s opposition to oil and gas activities and the fact that appropriate existing ports in the other Gulf Coast States are, in most cases, closer to potential deepwater development, no Florida ports are expected to be used in support of deepwater OCS activities. Short distances to deep water and channel depths of 20 ft or more to accommodate larger service vessels were the two criteria used to select ports where deepwater support service centers will most likely be located and also where localized, community effects will be felt most strongly. Figure II-10 also shows a 50-mi radius surrounding each selected port. The American Automobile Association sets 50 mi as a standard, one-way commute. Table IV-5 translates that radius for each of the five port-centered regions into affected counties or parishes. Statistical data are more readily available and accurate at the county/parish level. Table IV-5 also gives the 1997 population estimates of each county or parish, subtotals for each state, and a grand total for the four-state region.

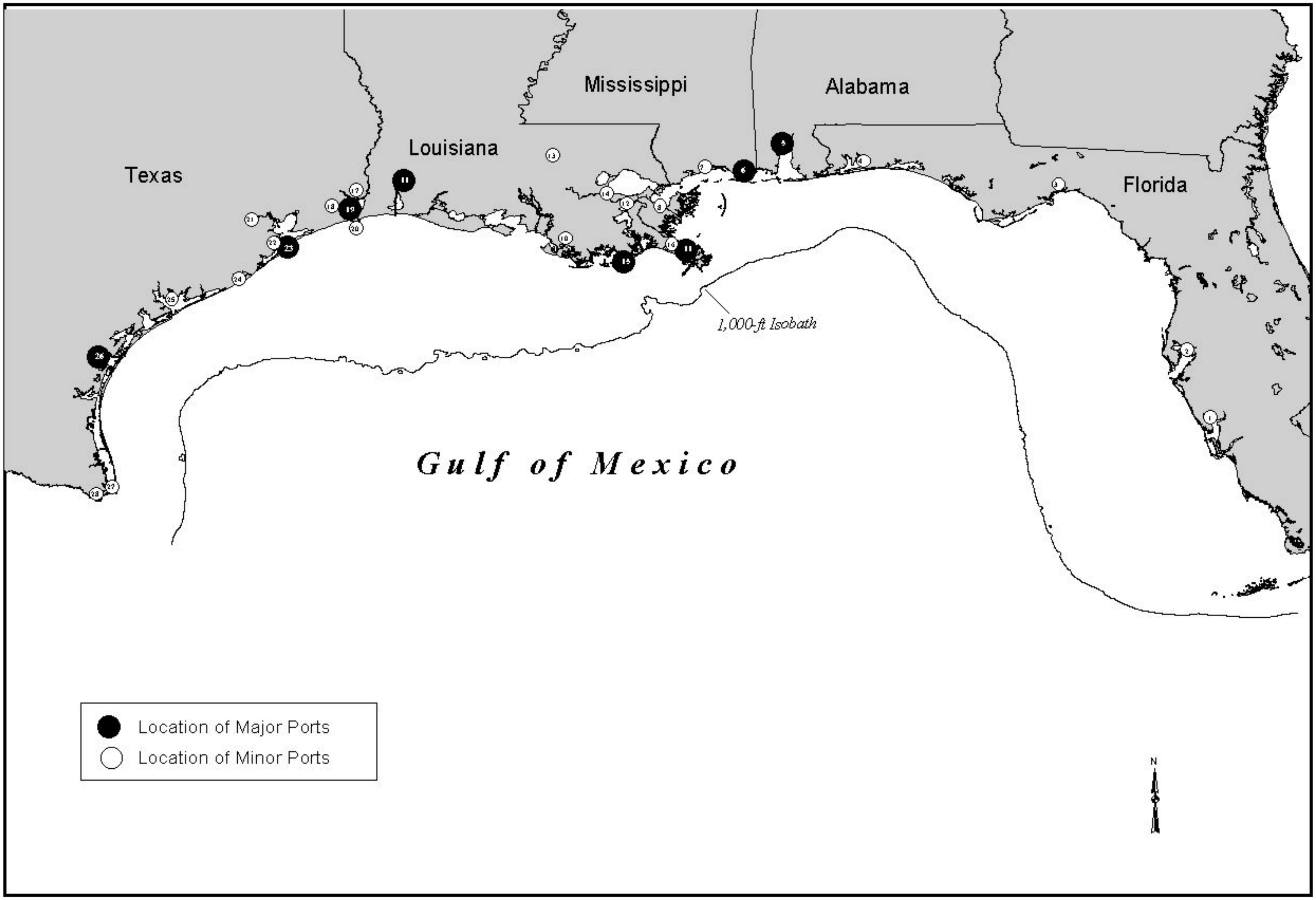

Figure II-9. Major Gulf of Mexico Ports (see Table II-9).

Table II-9

Major Gulf of Mexico Ports

Map ID*	Waterway/Port	County/ Parish	State	Maximum Project Depth (ft)	Distance to 300 Meters (mi)
1	Charlotte Harbor	Charlotte	Florida	32	165.38
2	Tampa Harbor	Hillsborough	Florida	45	145.95
3	Panama City Harbor	Bay	Florida	34	142.81
4	Pensacola Harbor	Escambia	Florida	35	57.13
5	Mobile Harbor	Mobile	Alabama	40	93.07
6	Pascagoula Harbor	Jackson	Mississippi	40	83.02
7	Gulfport Harbor	Harrison	Mississippi	32	92.56
8	Mississippi River Gulf Outlet	St. Bernard	Louisiana	38	79.35
9	Mississippi River Gulf Outlet via Venice	Plaquemines	Louisiana	16	36.77
10	"Atchafalaya River," Morgan City to Gulf of Mexico	St. Mary	Louisiana	20	106.82
11	"Calcasieu River and Pass, LA (Lake Charles)"	Calcasieu	Louisiana	42	161.04
12	Port of New Orleans	Orleans	Louisiana	45	88.50
13	Port of Baton Rouge	East Baton Rouge	Louisiana	45	145.32
14	Port of South Louisiana	St. John The Baptist	Louisiana	45	105.08
15	Port Fourchon	Lafourche	Louisiana	20	37.37
16	Port of Plaquemines	Plaquemines	Louisiana	45	58.95
17	Orange (Sabine River)	Orange	Texas	30	157.30
18	Beaumont (Neches River)	Jefferson	Texas	40	155.52
19	Port Arthur	Jefferson	Texas	40	138.01
20	Sabine Pass Harbor	Jefferson	Texas	42	131.47
21	Houston Ship Channel (Houston)	Harris	Texas	40	135.39
22	Texas City Channel (Texas City)	Galveston	Texas	40	107.46
23	Galveston Channel (Galveston)	Galveston	Texas	40	103.56
24	Freeport Harbor (Freeport)	Brazoria	Texas	38	82.36
25	Matagorda Ship Channel	Calhoun	Texas	38	83.31
26	Corpus Christi	Nueces	Texas	45	84.19
27	Brazos Island Harbor (Brownsville and Port Isabel)	Cameron	Texas	38	58.16
28	Brownsville	Cameron	Texas	38	73.62

*See Figure II-9.

Source: U.S. Dept. of the Army, Corps of Engineers, 1996.

Ports and Service Bases

This assessment focuses on coastal ports with federally authorized channel depths of 20 ft (6 m) or more (Figure II-9). Information on these ports is presented in Table II-10. Figure II-10 indicates the shortest distance from each selected port to the 1,000-ft isobath. The circles on Figure II-10 represent a 50-mi radius around each port, with 50 mi being regarded as an easy one-way commute for the local labor force.

Ninety percent of the current deepwater activity is occurring along the continental slope in the CPA and eastern WPA, offshore Louisiana (Viosca Knoll to Garden Banks). Port Fourchon is located in the center of this area of activity. Port Fourchon is one of the few Gulf ports that can accommodate the draft of fully laden deepwater vessels and should be ideally located for the next 10-25 years. Venice, Port Fourchon, and Morgan City currently service most of the deepwater activity. Galveston is expected to be the primary port supporting deepwater activity in the WPA. The projected development of deepwater lease blocks to the east of Viosca Knoll is expected to lead to the development of yet another deepwater service base located in the Eastern Gulf (e.g., Mobile Bay Harbor) (White, personal communication, 1998).

Port administrations are expected to promote, capture, and accommodate business generated by increased deepwater activities, as well as continuing support of offshore oil and gas activities in general, commercial and recreational fishing, and other shipping activities.

Service bases are shore facilities and associated businesses that load, store, and supply equipment and supplies needed at offshore work sites. They may also serve as transportation bases for offshore workers. Table II-10 lists the OCS-related service bases located along the Gulf Coast.

As OCS operations move into deeper waters, larger vessels with deeper drafts have been phased into service. Typically, these deeper draft vessels will not need channels with depths greater than 6-7 m (20-23 ft). Deepwater operations have increased activity levels at deepwater service bases, most of which have access channels deeper than about 5 m (16 ft). Not all deepwater service bases have access channels that are deeper than 5 m. Shallow-water service bases will continue to play a role in deepwater support.

Other service bases that can accommodate deepwater vessels include Port Isabel, Corpus Christi, Pelican Island, and Port Arthur, Texas; Lake Charles, Louisiana; and Theodore and Mobile, Alabama. Pensacola, Panama City, and Tampa, Florida, are not currently used to support OCS activities.

Service bases that are centers of deepwater activity at present are expected to continue as important centers. Some ports are expected to expand to attract and capture additional deepwater business. Expansion may involve deepening access channels, upgrading infrastructure, or adding attributes important for attracting deepwater and other offshore petroleum activities.

As deepwater activities increase off southern Texas, service bases in that area are projected to expand their support of those activities. Existing development patterns indicate that Port Aransas, Port O=Connor, and Galveston are the most likely service bases to capture this business. To support developing deepwater activities east of the Mississippi River, up to two additional service bases may be developed in the vicinity of Alabama and the Florida Panhandle.

Port expansions often generate conflicts with other coastal resource users located in the port and its vicinity. Such conflicts are discussed in Chapter IV.J. (Socioeconomic Resources). State coastal zone management programs are intended to resolve many of these conflicts.

Table II-10
Waterway Usage by OCS-Related Navigation

Coastal Areas	Waterway	Approximate OCS Usage	Service Base	Barge Terminal	Potential Shuttle Tanker Port Areas
TEXAS	Channel to Aransas Pass	< 10%	Aransas Pass Port Aransas		
	Brazos Santiago Pass	< 10%	Port Isabel		
	Corpus Christi Ship Channel	< 10%	Corpus Christi Ingleside	Corpus Christi	Corpus Christi
	Matagorda Ship Channel	< 10%	Harbor Island	Matagorda Island	
	Port Mansfield Cut	< 10%	Port Mansfield		
	Gulf Intracoastal Waterway	< 10%	Rockport Port O'Connor		
	Freeport Harbor Channel	< 10%	Freeport		Freeport
	Houston Ship Channel	< 10%	Channel View		Houston
	Texas City Channel	< 10%		Texas City	
	Galveston Channel	< 10%	Galveston Pelican Island		
	Matagorda Ship Channel	< 10%			
	Gulf Intracoastal Waterway	< 10%	Surfside		
	Sabine Pass Ship Channel	< 10%	Sabine Pass	Beaumont Nederland Port Arthur	
LOUISIANA	Calcasieu Ship Channel	< 10%	Cameron Lake Charles	Lake Charles	Lake Charles
	Freshwater Bayou	< 10%	Freshwater City Intracoastal City		
	Gulf Intracoastal Waterway	< 10%	Intracoastal City Louisa Weeks Island		
	Mermentau Navigation Channel	< 10%	Grand Chenier		
	New Iberia Canal	< 10%	New Iberia		
	Vermilion River	70%	Abbeville Erath		
	Bayou Teche	70%	Berwick		
	Atchafalaya R./B. Chene	30%	Bayou Boeuf Berwick Morgan City	Gibson	
	Bayou Black	50%	Gibson		
	Bayou Boeuf (not GIWW)	75%	Amelia Bayou Boeuf		
	Bayou Lafourche/Belle Pass	40%	Port Fourchon Leeville		
	Gulf Intracoastal Waterway	40%	Patterson	Gibson	
	Houma/Caillou/Terrebonne	30%	Cocodrie Dulac Houma Schriever Theriot		
	Wax Lake Outlet	< 10%		Calumet	
	Mississippi River	< 10%		Norco	Mississippi River Ports
	Barataria Waterway	< 10%	Grand Isle		
	Mississippi River	< 10%	Bell Chasse Empire Venice	Empire	
	Empire Waterway	20%	Empire	Empire	
	Miss. River Gulf Outlet	< 10%			
	Gulf Intracoastal Waterway	< 10%	Harvey		
MISSISSIPPI	Pascagoula/Bayou Casotte	< 10%	Pascagoula		Pascagoula
ALABAMA	Bayou LaBatre	< 10%	Bayou LaBatre		
	Gulf Intracoastal Waterway	< 10%	Dauphin Island		
	Mobile Bay	< 10%	Mobile Theodore		Mobile
	Theodore Channel	< 10%	Theodore		

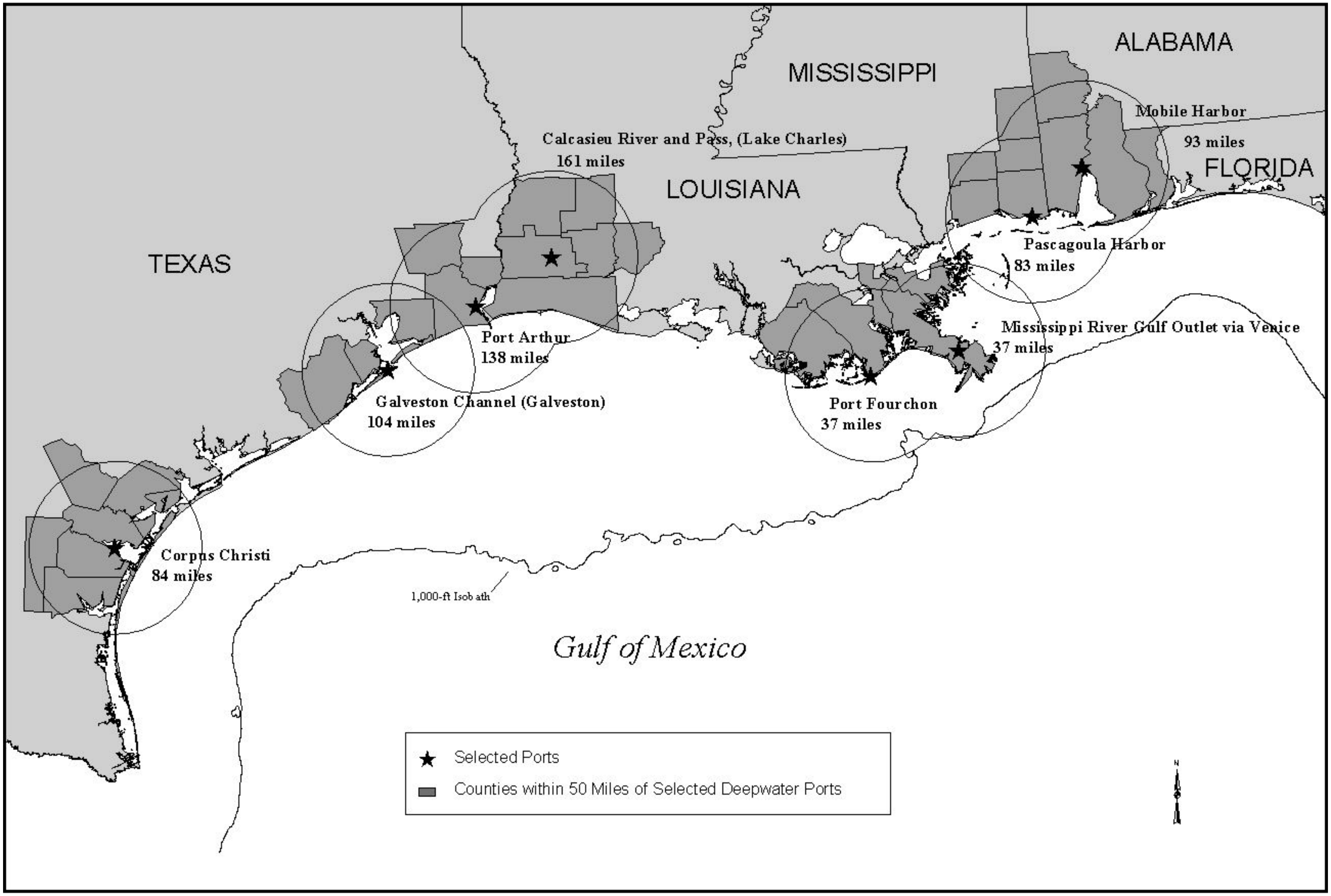

Figure II-10. Distance to Deep Water from Selected Ports.

Navigation Channels

Thirty-nine channels, with a cumulative length of approximately 3,650 km, along the Western and Central Gulf Coast are used in support of OCS activities. Canals, rivers, and bayous make up about 55 percent of the coastal navigation routes; the remaining length is composed of broad bays and sounds (derived from Turner and Cahoon, 1988; Wicker et al., 1989). Table II-10 lists the channels and indicates which channels provide access between these service bases and the Gulf. Typically, no channel deeper than 6-7 m (20-23 ft) will be needed to accommodate most of these deeper draft vessels, and some channels providing 4-5 m depths will continue to be used. Deeper drafts would be needed for transporting some large, prefabricated platform components.

The current system of channels is generally adequate to accommodate traffic generated by the future OCS deepwater activities. Future OCS and other traffic patterns on navigation channels will shift in accordance with local and regional economic, marketing, and managerial circumstances of ports and facilities.

Construction Facilities

Construction facilities include platform fabrication yards, pipeyards, and shipyards. Because of the large size of OCS structures, access to a navigation channel of appropriate width and depth is of prime importance to these facilities.

Components of deepwater production structures are fabricated worldwide and then are generally gathered at Gulf of Mexico facilities near major ports or on major navigation channels for assembly prior to transport to the offshore location. In the past, Abare bones@ topsides were transported to the offshore location where the wiring, plumbing, connecting, and finishing were completed. Today, topside construction is done almost completely onshore. Bigger skids and crane lifting capabilities have contributed to this change. Greater safety of onshore versus offshore work environment and lower costs for onshore work are also contributing factors.

At pipeyards, pipes are coated with metallic, inorganic, and organic materials to protect the pipe from corrosion and abrasion and to add weight to counteract buoyancy. Because of the environmental conditions encountered in deep water, pipes may require specialty coatings or are custom-made for specific applications.

Ten shipyards located at or near major ports or on major navigation channels along the Gulf Coast are known to support the petroleum industry. Worldwide, shipyards are modifying their facilities to accommodate the requirements of constructing the bigger vessels needed to support deepwater activities.

Over the past 10 years, many construction facilities in the Gulf coastal region have closed or have gone idle. With the resurgence of OCS activities in the Gulf, reactivation of some of these facilities and construction of new ones are occurring.

Oil Refineries

A refinery separates and processes the naturally occurring components of crude oil into marketable products. In the Gulf of Mexico, oil is either delivered directly to a refinery from the OCS via pipeline or barge, or it is first delivered to an oil terminal via pipeline or barge and then piped, barged, or trucked to a refinery. Deepwater oil may also be delivered to an oil terminal or storage facility via shuttle tanker. Because of the secondary transport of crude oil, deepwater-produced crude may be refined at any of the existing Gulf Coast refineries. Selection of a refinery is more dependent on the available capacity and capabilities of the refineries and economic terms than on location. Tables II-11 and II-12 show the location, number of refineries, and approximate production capacity of selected coastal refinery facilities that process at least some OCS crude. The current capacity of these refineries is approximately 6 MMbbl per day (Oil and Gas Journal, 1997); OCS crude accounts for about 20 percent of the operating capacity of these facilities (Rainey, 1992).

The MMS projects an increase in Gulf of Mexico OCS oil production from a production rate of 1.0 MMbbl per day in December 1996 to 1.7-2.0 MMbbl per day by the year 2002 (Melancon and Roby, 1998). Part of this increase is attributable to expected production from deep water. Due to legal and financial constraints, no new refineries are expected to be built to support OCS production, OCS oil will become a larger percentage of the throughput of existing refineries, existing refineries will expand their capacities, and some refineries that currently process only imported oil will begin handling deepwater crudes. For example, the newly refurbished and expanded refinery of TransAmerican at Norco, near LaPlace, Louisiana, has state-of-the-art technology and an expected capacity of 75,000 bbl per day of sour crude. This is phase one of upgrading operations to this facility. The investment of several billion dollars and is made partially on the basis of expectations of increasing production from the Gulf of Mexico OCS (Patton, personal communication, 1998).

Table II-11

Location, Number of Refineries, and Approximate Production Capacity of Selected Coastal Refinery Facilities

Location	Number of Refineries	Approximate Production Capacity (bbl per day)
Pascagoula, Miss.	1	295,000
Lake Charles, La.	2	530,000
Lower Mississippi River, La.	9	1,729,000
Freeport, Tex.	1	205,000[1]
Corpus Christi, Tex.	4	683,000
Port Arthur-Beaumont, Tex.	4	911,000
Galveston-Houston, Tex.	8	1,735,000

Source: Oil and Gas Journal, 1997.

[1] A 270,000-bbl-per-day expansion is expected for this facility to accommodate anticipated deepwater production in the western portion of the Gulf of Mexico.

Gas Processing Plants

Natural gas produced on the OCS is piped to a processing facility if processing is necessary; otherwise, the gas is transported via transmission lines for distribution to consumers. Gas processing plants remove impurities from raw gas to meet preset standards of the purchasing agent before the gas is commercially distributed. Some gas processing facilities simply remove any liquids (water and condensate) from the gas; others may Asweeten@ the gas by removing hydrogen sulfide and other compounds. Some processing plants also recover saleable natural gas liquids and products, such as butane, propane, and ethane from condensate, if these components are present in quantities that make extraction economically feasible. OCS gas accounts for 50-65 percent of the utilized capacity of the coastal gas processing plants.

Table II-12

Existing Coastal Infrastructure Related to OCS Program Activities in the Gulf of Mexico

	Coastal Subarea						
	Western TX	Eastern TX	Western LA	Central LA	Eastern LA	MS and AL	Total OCS Program
Refineries	3	13	4	4	3	1	28
Gas Processing Plants	9	12	13	11	6	5	56
Oil Pipeline Shore Facilities	5	10	24	14	20	1	74
Pipeyards	1	9	3	9	2	1	25
Platform Yards	5	1	7	18	8	6	45
Helicopter Hubs	6	6	8	8	4	1	33
Service Bases	8	6	8	12	6	4	44
Barge Terminals	2	4	1	3	1	0	11
Waste Disposal Facilities	8	2	3	4	0	2	19
Navigation Channels*	6	7	7	8	12	5	39
Pipeline Landfalls	3	26	64	50	60	11	214
Onshore Pipelines (km)	120	1,040	2,560	800	960	1,760	7,240

* Individual coastal subarea totals do not add up to the OCS Program total because some navigation channels span more than one subarea.

The MMS projects that gas production from the Gulf OCS may vary from a production rate of 14.14 Bcf per day in December 1996 to 12.43-17.54 Bcf per day in 2002 (Melancon and Roby, 1998). Any increase will be partially due to new deepwater development. Existing gas processing plants could be modified or expanded, or new facilities constructed, to accommodate the expected increase in natural gas production from deep water. Gas plants in the coastal zone (Table II-12) that are assumed to process OCS gas are operating at 60-90 percent capacity.

Disposal Sites for OCS Wastes

In the Gulf area, offshore oil-field wastes that are not discharged or disposed of onsite are brought onshore for disposal and taken to specially designated, commercial oil-field waste disposal facilities called Anonhazardous oil-field waste@ disposal sites or NOW sites. In Louisiana, there are 7 existing commercial oil-field waste disposal facilities that receive all of the types of wastes that would come from OCS operations; in Texas, there are 10 facilities; and in Alabama, there are 2 that are expected to continue servicing the OCS industry. Included in these numbers are two sites in Louisiana and one site in Texas that process naturally occurring radioactive material (NORM)-contaminated oil-field wastes. It is expected that all of the present commercial waste-disposal sites will continue to operate, using all currently permitted acreage.

Solid wastes may include oil-based drilling fluids and cuttings, production storage tank sludges, or produced oily sands and solids. At commercial waste-disposal facilities, solid wastes are usually put into pits, land treated, land farmed, or undergo a stationary treatment process to remove contaminants. Very often, however, the solid material is stored indefinitely onsite.

Liquid wastes brought onshore for disposal may include produced water; water extracted from sludge; or treatment, workover, and completion fluids waste that fail NPDES discharge limitations or requirements. Liquid wastes are usually transported to shore by barge or on tanks located on supply boats. Once onshore, the wastes are generally transported to commercial oil-field waste disposal facilities by vacuum truck or barge. At commercial waste-treatment facilities, liquid wastes are usually injected into disposal wells. As of February 1997, there are 94 disposal wells located in the Texas coastal zone and 17 in the Louisiana coastal zone.

Of particular concern with deepwater operations is the ultimate disposal of synthetic-based drilling fluids (SBF) and cuttings wetted with SBF. Because SBF are expensive, it is expected that they will be recycled. If onshore disposal is required for SBF cuttings, there will be different potential impacts associated with onshore disposal of the material. Drillers may switch to the lower cost oil-based mud as an alternative to using SBF. A possible increase in the use of oil-based muds may result and there may be onshore impacts associated with the disposal of these cuttings.

In addition to drilling and production wastes, trash and debris from the offshore oil industry operations are shipped onshore for disposal. These wastes may include mud bags, drums, crates, and a variety of domestic wastes. The OCS-generated trash and debris are disposed of at either municipal or industrial landfills. The OCS industry is expected to continue to develop better trash and debris recycling and disposal methods to reduce the volumes of these wastes that must be sent to landfills. Considering the growing problem with inadequate landfill capacities and that OCS operations will increase in the next few years, it is assumed that the expected levels of trash and debris transported from future OCS operations will contribute to the need for additional landfills.

Deepwater Service Vessels

Service vessels primarily used in deep water are offshore supply vessels (OSV), fast supply vessels, and anchor-handling towing supply/mooring vessels (AHTS) (White, personal communication, 1998). Other deepwater speciality service vessels include well stimulation vessels. The OSV=s and AHTS=s carry the same type of cargo (freshwater, fuel, cement, barite, liquid drilling fluids, tubulars, equipment, food, and miscellaneous supplies) but have different functions. The AHTS=s differ from the supply vessels by their deepwater mooring deployment and towing capabilities.

Type	Length (ft)	Draft (ft)	Speed (kn)	Crew
OSV	90-240	18-20	12-15+	8-10
Fast Supply Vessel	165	15	29	5
AHTS	220-276	16-22	15+	10-13
Other Service Vessels	~ 240			

There are currently 340 service vessels (155 ft or longer) operating in the northern Gulf. Each vessel makes an average of three round trips per week. This amounts to an average of 53,040 round trips per year for the entire service-vessel fleet in the northern Gulf, including deepwater trips. There are currently fewer deepwater trips than shelf trips because there are fewer deepwater operations and because some of the farthest deepwater operations are 200+ mi from port. Deepwater service vessels cruising at 12-14 kn (loaded) may reach distant deepwater sites within 10-18 hours. The nearest deepwater sites may be reached within 6-8 hours.

Deepwater OCS activities have resulted in an increased demand for service vessels and particularly for those qualifying for deepwater operations. Despite the recent lower price of oil, the service-vessel utilization rate remains high (approximately 85% for semisubmersibles and 80% for drillships Gulfwide (Offshore Data Services, 1999). The assets needed to drill, develop, and maintain the existing deepwater leases are currently in short supply.

Since 1997, the worldwide fleet of deepwater seismic vessels rose from 78 to 120 vessels (DeLuca, 1998). There are typically 5-6 seismic vessels operating in the northern Gulf at any given time (White, personal communication, 1998).

Costly daily rates are reflection of the shortage of logistical support in the northern Gulf. The cost of a supply vessel is roughly $9,000-$11,000 per day; semisubmersibles and drillships are approximately $200,000+ per day (Greenberg, 1998). A response to the need for deepwater logistical support was the 1997 order of 240 new supply, liftboat, utility, pushboat, towboat, tug, and AHTS vessels (WorkBoat, 1998). Eighty of the recent service-vessel orders for the Gulf are OSV (33%), a four-fold increase in newbuild orders since 1996. Forty of the vessels ordered are AHTS=s.

Most of the Gulf=s OSV=s were built in the 1970=s and were not designed to meet deepwater performance needs. Recent deepwater AHTS and OSV orders are a partial replacement of aging (20+ years old) vessels. New deepwater vessels will eventually incorporate most of the following specifications: improved hull designs (increased efficiency and speed), a passive computerized anti-roll system, drier and safer working decks, increased cargo capacity (water, cement, barite, liquid muds, etc.), increased deck cargo capability, increased cargo transfer rates to reduce the time and risk alongside structures (e.g., TLP), dual and independent propulsion systems, true dynamic positioning system, fuel and NO_x efficient engines, and Safety of Life at Sea (SOLAS) capability (WorkBoat, 1998; White, personal communication, 1998).

Helicopters

Helicopters will provide most of the personnel transportation for deepwater drilling and production activities. Normal offshore work schedules in deepwater activities involve two-week (or longer) hitches with crew changes on a weekly basis. Therefore, helicopters will travel to deepwater facilities at least once a week.

According to Neill Osborne (personal communication, 1998), chairman of the Helicopter Association International, the existing heliports in the coastal areas of Louisiana, Texas, and Alabama will be able to accommodate the expected increase in Gulf of Mexico helicopter activity anticipated over the next 10 years. The number of passengers has ranged between 3 and 3.5 million annually Gulfwide since 1992, with a gradual and steady increase evident since 1994 (Helicopter Safety Advisory Conference, 1996). Total takeoffs and landings have also increased since 1994, reaching over 1.6 million in 1996. The total number of helicopters in the fleet, however, has gradually declined from 626 in 1992 to about 500 at the beginning of 1998. In 1996, Air Logistics= fleet of 167 helicopters increased its utilization rate from 56 percent working to 75 percent working, which is near capacity since a number of craft are always in maintenance and are not available for service.

Helicopter services in the Gulf are provided primarily by three private companies (PHI, Air Logistics, and ERA), which contract services to offshore operators and the MMS. A few companies own and operate their own helicopters. Of the approximately 500 helicopters currently in service in the Gulf of Mexico, less than 10 percent are owned by oil companies. Increasing demand for helicopter services throughout the Gulf offshore area has led to helicopter companies expanding their fleets and hiring new personnel (Osborne, personal communication, 1998). Air Logistics alone hired 100 pilots and 50 mechanics in 1997 and is spending millions of dollars on equipment, training, parts, and new aircraft to prepare for the rising demand in offshore helicopter transport services increasingly influenced by deepwater exploration and development.

Helicopter refueling stations exist on many offshore platforms in the Gulf of Mexico and will be relied upon extensively in transporting workers and supplies to distant deepwater rigs and structures. Deepwater activities may stimulate the establishment of additional offshore refueling stations. At present, aircraft fuel is barged to these offshore refueling stations. Since more fuel is expected to be consumed by the helicopters because of the longer flight time to deepwater areas, larger volumes or more frequent barging of aircraft fuel are expected.

Employment

Given the present international configuration of the oil and gas industry, it is difficult to identify and evaluate the human components of deepwater exploration, development, and production activities. For example, a recent news item reported that a company with headquarters in Jackson, Mississippi, bought a French manufacturer for an undisclosed amount of cash. This purchase gives the parent company control over the fabrication of offshore oil rigs in Newfoundland and the U.S. Gulf Coast, plus two rig equipment manufacturing plants in France, plus ties to servicing and parts companies in 45 countries throughout the world (*The Times-Picayune*, 1998).

Deepwater oil and gas development has both local and regional employment implications. According to testimony given before the Senate Committee on Energy and Natural Resources (August 11, 1992) by the Assistant Secretary for Domestic and International Energy Policy and testimony before the Oceanography, Gulf of Mexico and OCS Subcommittee of the Merchant Marine and Fisheries Committee (September 14, 1993) by the President of the National Ocean Industries Association, for every $1 million invested offshore, 20 jobs are created. And for every 10 jobs created offshore, 37 jobs are created onshore. Full development costs for one deepwater field can exceed $1 billion, thereby creating as many as 20,000 new jobs. This includes direct, indirect, and induced employment. Many of these jobs will be distributed worldwide; most will be created in the Gulf coastal area. A typical TLP project in the Gulf of Mexico may create about 3,000 jobs (directly and indirectly involved in the project). About 60 percent of those jobs are in Louisiana and Texas. An average subsea project may employ about 400 employees at an estimated 25,700 person-days per project life. As with TLP projects, the majority of those employees are expected to reside in the Gulf of Mexico coastal region.

Drilling in deep water has special requirements in terms of both equipment and labor. An additional anchor boat may be required. Dynamically positioned drillships are needed both with multiple drilling crews and navigational personnel. Computerized machinery may require specialized operators. In recent years, equipment and labor availability have been limiting factors.

In general, MMS uses the following assumptions in projecting employment related to deepwater drilling activities: semisubmersibles can drill eight wells per rig per year with an average crew of about 150; and drillships can drill six wells per rig per year with an average crew of about 190. Not all of the rig=s crew will be onboard at the same time. Crews are rotated so one might expect that approximately 80-100 personnel would be on each offshore tour. Projections for employment related to deepwater production operations are based on the same assumptions used for shallow-water production operations.

The MMS is developing a study to survey employment needs of the offshore industry and will update its employment assumptions with the availability of this new information.

K. Accidental Events

Collisions

The National Offshore Safety Advisory Committee (NOSAC) was commissioned by the U.S. Coast Guard to examine collision avoidance measures between a generic deepwater structure and marine vessels in the Gulf of Mexico. The final report of the NOSAC study was published on April 8, 1999, (NOSAC, 1999). The report focuses on the factors, equipment issues, and practices that could result in collisions. Hazard analysis tools were used to formulate the initial findings and recommendations in the report. A Ahigh level@ (coarse) quantitative risk assessment was performed to evaluate the likelihood and consequences of collisions and to evaluate recommendations, e.g., use of intervention vessels and early notification/warning schemes. The NOSAC recommendations are categorized into three areas. These include (1) voluntary initiatives for offshore operators, (2) recommendations for joint government/industry cooperation or study, and (3) recommendations for new or continued USCG action.

The report states that oil and gas facilities may be used as aids to navigation because of their proximity to fairways, fixed nature, well-lighted decks, and their presence on navigational charts. Mariners intentionally set and maintain course toward these facilities, essentially maintaining a collision course. Unfortunately, most deepwater facilities do not install collision avoidance radar systems to alert offshore facility personnel of a potentially dangerous situation.

The report estimates that 7,300 large vessels (e.g., tankships, freight ships, passenger ships, and military vessels) Apass@ within 35 mi of a typical deepwater facility each year. This estimate results in approximately 20 transits per day for the current 13 deepwater surface production structures.

The report estimates the total collision frequency to be approximately one collision with a deepwater facility in 250 years (3.6×10^{-3} per year). If the number of deepwater facilities is increased to 25, the estimated frequency increases to one collision in 10 years.

A cost-benefit analysis within the report did not support the use of a dedicated standby vessel for the generic facility. However, the analysis did support the use of a radar system on deepwater facilities if the system=s annualized costs were less than or equal to $124,500 per year.

In October 1997, the Health and Safety Executive in the United Kingdom produced an offshore technology report entitled, AClose Proximity Study@ (HSE, 1997). The objective of the study was to assess the risks of collision during close proximity operations involving shuttle tankers at offshore locations. It also identified standards of control and mitigation to reduce the risks of collisions to the A. . . lowest reasonable practicable levels.@ The report provided some typical ranges of statistical probabilities of collision between dynamically positioned offtake tankers and offshore export facilities. As a note to the conclusions, the report states, AIt is not possible to make a straight comparison of the figures above without taking account of the various assumptions and parameters that have been used to support each original calculation. Each facility is different. For example, there are differences in the number of cargo offtakes per year.@

Oil Spills

Although spills by nature are unforeseeable events, in the mature development areas of the Gulf of Mexico, MMS can rely on past experiences to predict many factors regarding oil-spill risks. Information gathered on past spills allows MMS to make predictions about expected spill frequency and magnitude, slick behavior and impacts, and spill-response capabilities. Spill predictions for deepwater areas are done with much less certainty. As industry rapidly expands operations into deeper waters with technological advances, all parties involved are attempting to assess what could happen if a spill were to occur. In the deepwater OCS, there will be different sources, potentially larger magnitudes and, because of the possible locations and types of oil that could be spilled, different fate and effects.

New Sources for Spills

Conventional fixed platforms, compliant towers, TLP=s, and spars used in deepwater are not expected to have greatly distinguishable potentials for spill occurrence or spill magnitudes from platforms used for shelf operations. The following summary provides information on new types of activities in deep water that have the potential either to spill very large volumes of oil or to increase the likelihood of spill occurrence.

Spills from Oil Storage on Deepwater Drilling Facilities

Deepwater drill ships with large-volume oil storage and/or carrying capacity pose a risk of potentially larger surface spills than is typical with shallow-water drilling rigs. By the year 2001, there may be 10-18 ultra-deepwater-capable drilling rigs operating in the Gulf (Chapter II.C.). These rigs/ships will remain at sea for long periods of time, and thus will carry large cargos of different types of oil. For example, the not yet completed *Global Hull 456* drilling ship, capable of drilling in 12,000 ft of water, will include below-deck tankage for 28,000 ft^3 of drilling mud; 7,000 bbl of brine; 2,500 bbl of base oil; 45,000 bbl of fuel oil; and 130,000 bbl of crude oil (WorkBoat, 1998). Several of the new drillships will have large storage capacities ranging up to 500,000 bbl to store crude oil. Loss of containment, through collision or other failure, of one or more of these storage tanks could result in a very large (over a 100,000-bbl) oil spill.

The likelihood of a very large oil spill occurring from a deepwater drilling vessel is different when the ship is in transit versus when the ship is stationary (moored). While in transit, the ship operates as a vessel. Examination of data on spills from vessels shows that, despite the large oil-carrying capacity of many vessels, the likelihood of a very large spill is very small. Dr. Etkin of the Cutter Information Corporation analyzed the data on 1,720 oil spills larger than 238 bbl (10,000 gallons) occurring worldwide from vessels (Etkin, 1997). Of these, less than 3 percent were larger than 238,000 bbl (10 million gallons). Predominate causes of the 1,720 vessel spills included grounding (24.8%), collision with another vessel (21%), structural or mechanical failure (11.3%), ramming of a stationary object (such as a platform) (7.6%), fire/explosion (7.6%), and sinking (6.9%). Correlation of cause by vessel size was not analyzed.

Less information is available about the risk of a large oil spill occurring in deepwater from a drilling vessel that is stationary than is available about the risk of a spill that occurs while the vessel is in transit. The MMS=s database on spills that have occurred from drilling operations conducted on the OCS between 1976 and 1985 was analyzed. There were about 80 diesel spills greater than 1 bbl reported. The database provides limited information, however, that would serve to project the likelihood of a spill from drilling in deepwater. The MMS database does not distinguish if the spill was from a drill ship or a fixed facility. The effect of any difficulties specific to deepwater operations that might cause spills is not reflected in the data. Finally, the data do not support an assessment of the potential for very large spills occurring because, historically, drilling rigs did not store large quantities of oil. What the data do show are that most spills were very small (median size 5 bbl) and about 20 of the 80 diesel spills were due to equipment malfunction involving the fuel tanks or due to ramming involving supply vessels (8 of the 80 diesel spills). A vessel collision was the cause of the only diesel spill greater than 1,000 bbl to occur during drilling.

Spills during Oil Transfer Operations Associated with Drilling Operations

The risk of spills during routine oil transfer operations may be slightly higher in deep water than in the shallow waters of the Gulf. Because of the high development costs in deep water, industry may conduct extended well-testing operations from the drilling rig prior to its leaving the site, and these wells must also be unloaded and cleaned up before the rig moves offsite. Oil produced during well testing and well cleanup is likely to be loaded directly onto a barge or temporarily stored on the drilling vessel before offloading to a shuttle tanker or barge (see discussion above), unless the operator gets special permission to burn the liquids. The risk of a spill occurring during this kind of oil transfer operation in deep water is compounded by the use of barges to facilitate the transfer. Statistically, barges have resulted in a greater number of spills as compared with other types of vessels (United States Coast Guard data). Although no formal database exists, industry has records of six fairly recent incidents involving problems with barges either breaking loose or colliding during deepwater operations (Satterlee, personal communication, 1997). No oil was spilled in any of these incidents, but they do indicate the risk of events that could result in an oil spill.

Spills can also occur from a drilling rig or the moored service vessel because of failures of the mooring systems or as a result of a collision. Mooring system designs are more complex to accommodate the sea conditions encountered in deepwater. The frequency of collisions between service vessels and mobile units is greater than between service vessels and fixed facilities data provided to the MMS by Satterlee (personal communication, 1997).

Oil transfer activities between a rig and a barge are governed by USCG regulations. The master of the tug in charge of the barge is ultimately responsible for safe and prudent transfer operations. Oil offloading activities should occur only when established criteria allow for these operations. Despite this, transfers have occurred in rough seas when there is no storage for the oil being produced during well testing.

Seafloor Spills from Blowouts or Pipeline Ruptures

Deepwater fields may be developed by large subsea developments tied by flowlines over great distances to centralized processing surface facilities, called host facilities, that will function as hubs for deepwater production. Although the loss of well control (blowout) is not a new source of spills, the likelihood and magnitude of spills from them or from a large pipeline rupture in deep water may be very different from the likelihood and magnitude of such spills in shallow water. Of particular concern is the ability to stop a deepwater subsea spill once it begins, thus limiting its size. For a subsea blowout, the lack of a surface structure and the possible high-flow rate that may be encountered may make intervention to regain control of a subsea well difficult. To date, industry has estimated worst-case spill volumes ranging from 5,000 to 116,000 bbl/day for 120 days for a continuous flow (i.e., bridging, reservoir depletion, or intervention does not occur). For the 5,000-bbl/day spill, MMS estimated that, not accounting for a cleanup, close to 600,000 bbl of oil would be remaining on the sea surface after 120 days of weathering.

Extensive systems of large-diameter pipelines are expected to service most of the deepwater operations. Because of the large volumes of oil that must be transported (recently a 400,000 bbl/day line was installed) and the specific characteristics of some of the oils, these deepwater pipeline systems are not expected to tie into the existing networks on the shelf; they are expected to extend from deep water to shore. The risk of spill occurrence from shallow-water pipelines is well known. Given that the greatest cause of pipeline spills is anchor damage in shallow waters, it is surmised that the risk of a spill from the portion of the pipeline in deep water would be much less than the risk of a spill from the portion of the pipeline in shallow water. Spill occurrence risk from deepwater pipelines is complicated by uneven terrain and the potential for mass transport of sediments. Pipeline failures may be mitigated by hydrate plugging after shutting off flow and by the hydrostatic equilibrium existing on the seabed.

Information about the behavior and transport of oil from the seafloor to the surface in deep or ultra-deep water is limited. High hydrostatic pressure and low ambient temperatures are expected to affect oil behavior, phase changes, and the physics of the rising plume. A recently completed modeling effort showed that neutrally buoyant hydrates might form from some of the gaseous components in a blowout fluid (S.L. Ross Environmental Research Ltd., 1997). This would allow the oil to rise to the surface as dispersed oil droplets under gravity forces only, although viscous water-in-oil emulsions could also form. If the oil were to reach the sea surface, the surface signature of the spill may be far away from the subsea origin. It may consist of oil droplets that form a very thin surface slick spread out over a larger area, accelerating the speed that the slick breaks up and dissipates. Field trials and modeling efforts recently completed by IKU (Rye and Brandvik, 1997) showed that the stratification of the ambient water masses may prevent the subsurface oil plume from reaching the sea surface. Not all of the oil originally released subsea would be expected to reach the surface in the form of a surface slick.

Leaks in Subsea System Flowlines/Risers

Typically, the produced well stream will be carried from subsea wells along the seafloor via flowlines, then through the water column to the surface facility via risers. There may be as many as 36 risers to one surface facility (Lovie, 1997). Leaks in the fittings or structural breach of any flowline or riser can result in release of oil. Because natural gas solubilities increase by orders of magnitude in deep water and because of the oil densities, surface detection may be nearly impossible. Leaks may be detected by pressure drops in the lines and confirmed by ROV inspection of the lines and other components. Equipment that can detect leaks in multiphase flowlines is critical for deepwater operations because, given the water depth, it is unlikely that a surface slick would quickly form and be spotted. Safety valves at the host facility and in the production tubing beneath the subsea tree can shut-in and limit the size of a spill whenever a leak is detected. With these safety mechanisms, a seabed or mid-water spill from a flowline or riser rupture would likely not be as large as a spill resulting from a subsea blowout. To date, few, if any, deepwater flowlines have multiphase detection meters installed. Once a leak is detected and the line is shut-in, leakage may stop because of hydrate plugging, dependent upon the composition of the well stream and whether there is an operating heating system for the flowline. Even without detection systems in place, spill size may be limited by the hydrostatic pressure of the water column at a small leak site.

Spills from Storage on FPSO=s

Common misconceptions are that tanker-based FPSO=s will be much more prone to oil spills than other deepwater facilities and that FPSO-related spills will be very large. The FPSO spill history does not support this perception. The following conclusions are drawn from examining spill occurrences from international applications of this technology.

To date, FPSO=s show only a slightly elevated likelihood of the occurrence of a large oil spill. The following information is taken from Key and Wallace=s (1998) overview of FPSO spill history. Since 1986, there has only been one spill greater than 1,000 bbl (a 4,725-bbl spill that occurred in 1997 due to operator error during startup of the FPSO); the cause of this spill was not related to the facility being an FPSO. To compare the likelihood of such spills occurring from FPSO=s to the likelihood of such spills occurring from fixed platforms, the same methodology for calculating the spill occurrence rate (i.e., spills > 1,000 bbl per BBO handled) was used for both platform types. The one historic FPSO spill results in a spill rate of 0.56 spills per BBO handled for FPSO=s. This is slightly higher than the spill rate of 0.45 spills per BBO for fixed platforms; a rate based on 12 spills > 1,000 bbl since 1967.

Comparison of the volumes of oil spilled from FPSO=s and volumes of oil spilled from conventional offshore oil production facilities disagrees with the belief that more oil would be spilled from FPSO=s. In addition to the 4,725-bbl spill, there have been some small spills from FPSO=s. A total of 171 spills < 1,000 bbl (all actually < 200 bbl) have occurred from FPSO=s since 1986, with a total spillage of only 425 bbl. In contrast, there have been 322 spills < 1,000 bbl from OCS facilities (both platform and pipeline) in the Gulf of Mexico. Since the number of facilities is very different, a better comparison would be the volume of oil spilled per volume handled. The overall record for FPSO=s to date is 2.9 bbl of crude spilled for every million barrels of produced crude. The overall record for OCS platforms and pipelines (1971-1995) is 4.5 bbl spilled per million barrels produced.

Despite this good record, there remains concern that the large volumes of oil that will be stored on the FPSO creates the potential for a catastrophic spill. Storage capacities in the existing worldwide FPSO fleet range from 55,000 to 2,300,000 bbl. The FPSO=s projected for use in the Gulf of Mexico are expected to have storage capacities of 1 million bbls of produced oil. Various risk assessments have identified the risk and potential causes of a large oil spill from FPSO operations. Appropriate prevention and response protocols need to be developed and evaluated. The type of event that could result in a worse case spill of nearly the entire volume of oil stored being lost (a catastrophic spill) is expected to be limited to structural failure of the vessel due to fire, explosion, hurricane, or collision.

Spills from Shuttle Tankers Servicing FPSO=s

Shuttle tankers servicing FPSO=s are a new source of potential OCS spills in the Gulf of Mexico. The capacity of shuttle tankers used to transport oil from an FPSO to shore would likely range from 50,000 to 500,000 bbl. The size of the shuttle tanker is dependent on several factors, including the storage capacity of the FPSO, the intended offloading terminal, and the availability of vessels. At present, shuttle tankers are routinely used in the Gulf to offload imported oil from supertankers, and the risk of spill occurrence associated with these operations is well known (ITOPF, 1998; Etkin, 1997; NRC, 1998). Although the public perception is that tanker spills are always large, the vast majority of tanker-related spills (86%) are less than 50 bbl. Most small spills occur from operational errors during loading and offloading (58%). Safety features allow transfer operations to be quickly shut down, thus preventing large spills from occurring.

Large spills are almost always caused by accidents, collisions, groundings, hull failures, fires, and explosions (83%). The National Academy of Science, National Research Council=s Marine Board Committee on Tank Vessel Lightering, has just released a study on oil-spill risks from lightering (vessel-to-vessel oil transfer) operations. Overall, the Marine Board=s report characterized lightering spills as A. . . very low rates of spillage of oil both in absolute terms and compared with all other tanker-related accidental spills.@ In the study, the Board stated that approximately 95 percent (by volume) of the offshore lightering off the U.S. coast takes place in the Gulf of Mexico. The Board collected additional data for 1993-1997 from the USCG, industry, and State agencies. These data indicated that only seven spills were reported in the Gulf. The volume spilled constituted less than 0.003 percent of the total volume lightered. Only one spill was substantial; more than 850 bbl of fuel oil were spilled as a result of a collision in 1995 near Galveston, Texas. The Board also examined USCG spill data from 1984 to 1996. These data indicated that recurring causes of spills that appear to be directly related to lightering operations involve valve failure, tank overflows, and hose ruptures. The average spill volume documented in this 1984-1996 data was 26 bbl.

Industry has established guidelines for lightering operations. The Oil Companies International Marine Forum (OCIMF), an international group of vessel owners and charterers, has developed comprehensive minimum standards for offshore lightering. In U.S. waters, a supplement to the OCIMF guidelines was developed by the Industry Taskforce on Offshore Lightering (ITOL).

The MMS developed rates of spill occurrence (spills ≥ 1,000 bbl) for various transport modes based on the volume of oil handled (Anderson and LaBelle, 1994). The statistics show that it is the sheer volume of oil transported by tankers that has resulted in the recent frequency of tanker spills. The U.S. tanker spill rates for spills ≥ 1,000 bbl are 0.51 spills per BBO at sea and 0.70 spills per BBO in coastal waters near port. Caution should be taken in comparing these spill rates for U.S. tankers to the spill rate for OCS pipelines because the spill rate for OCS pipelines was calculated using only historical spills occurring in Federal waters. Despite this fact, the spill rate for spills ≥1,000 bbl from OCS pipelines is much larger--1.32 spills per BBO transported. Other factors to be considered when comparing tanker-related to pipeline-related spills are the size of the spills and the most likely locations of the spills. The median size of OCS pipeline spills occurring between

1980 and 1993 is 5,100 bbl (average size is 8,500 bbl) compared with the median size for tanker spills of 9,000 bbl (average size of tanker spills is 27,500 bbl) (Anderson, 1997). In general, OCS pipeline spills will occur farther from shore than where tanker spills are most likely to occur.

Factors Affecting the Environmental Impact of Spills from Deepwater Operations

Causes

Despite an increased number of new sources for potential spills, as well as the possibility of much larger spills, one should not conclude that there is an increased risk of environmental impact from spills in deep water. There may not be as many spills. The major causes of spills in shallow water are not factors in deep water. For example, one of the major causes of spill occurrence on the OCS has been interactions with other vessels. Twenty percent of the total numbers of spills and 74 percent of the volume of oil spilled from 1971 to 1984 was caused by vessel mishaps. Since deepwater operations will be consolidated into fewer numbers of surface structures located away from the highest vessel traffic areas, the risk of collision is expected to be much less than the risk that exists for shallow-water operations. Also, hurricanes and storms have played a large part in causing spills from older Ashelf@ platforms in the Gulf. New deepwater facilities (both floating and fixed) will utilize state-of-the-art design to withstand the storm conditions expected in the Gulf of Mexico. In addition, the perception that the likelihood of spills from tankers is much greater than from platforms and pipelines is not supported by an examination of statistics on historical occurrences versus volume handled.

Shoreline Contact of Deepwater Spills

The likelihood that a deepwater spill will reach sensitive coastal features is relevant in determining the potential for environmental impact from these spills. It is generally believed that an oil spill can be most damaging when it accumulates in coastal environments. The likelihood that a spill occurring in deep water might be transported to shore within 30 days was determined by OSRA model results that incorporate only physical oceanography and wind transport (Price et al., 1997). The OSRA model runs do not include any containment or cleanup responses to a spill that would be initiated by an operator for an actual event. During September through April, the western Gulf of Mexico has a well-developed westward coastal current from Louisiana to Texas waters. Under the physical oceanographic and meteorological conditions during this period, the risk of a deepwater spill contacting the nearest shore line may be extremely low; the higher risks of contact may displaced to areas farther from the spill source.

Except for the area around the Mississippi Delta, spills that might occur in the CPA in water depths of 200-900 m (656-2,953 ft) have as high as a 48-percent probability of reaching land within 30 days, a 21-percent probability for operations in water depths 900-3,000 m (2,953-9,843 ft), and a 7-percent probability for operations in water depths greater than 3,000 m (9,843 ft) of water. Probabilities for shallower water depths are as high as 99 percent.

Model runs show that the likelihood that a spill from deepwater operations in the WPA might reach land is surprisingly greater than in the CPA. There is up to a 70-percent chance that a spill occurring in water depths greater than 200 m (656 ft) would reach land within 30 days, and up to a 47-percent chance for water depths greater than 900 m (2,953 ft).

There is a slight risk that the oil may impact Mexico, Cuba, or southern Florida=s coastal resources. Several circumstances would need to coincide: a very large spill, ineffective clean-up operations, and slick persistence for at least 30 days. The OSRA trajectories show that, if an oil spill were to occur in water depths greater than 3,000 m (9,843 ft) in the CPA, there is an 11-percent probability that it could reach the Florida Keys within 30 days. There is also a very small probability that the eastern portion of Florida would be contacted; the area near Miami has a 2-percent probability of being contacted from a spill occurring in the CPA in deep water. If a spill were to occur in the WPA in water deeper than 3,000 m (9,843 ft), there is a very small chance (1%) that it could reach the Mexican area just south of Matamoras. The model did not analyze the risk of contact south of this area.

Persistence of the Slick

The OSRA model results do not include the likelihood that the slick may break up and disperse before 30 days. The resultant surface slick may dissipate naturally over time or be contained and cleaned up before reaching coastal waters. Most of the smaller spills are expected to dissipate prior to reaching shallow water. Only the largest of slicks are expected to remain on the surface of the water long enough (30 days or longer) for a very large volume of oil to possibly reach coastal resources. Of concern is the fact that very large volume spills projected for subsea blowouts might be continuous spills lasting up to 120 days. These spills will not weather as quickly as spills that are of short duration because there is a continuous source of unweathered oil. There may be substantial quantities of oil transported by winds and currents for even longer than the 30-day period analyzed by the OSRA model runs.

The form that the slick takes from a subsea spill in deep water may be very different from oil spilled at the surface and may affect the persistence of the surface slick. Oil released subsea (e.g., subsea blowout or pipeline leak) in these deepwater environments could remain submerged for some period of time and travel away from the spill site and then surface as a very thin slick covering a large diffuse area. It is expected that weathering of such a slick will occur very rapidly, resulting in the slick disappearing from the surface of the water after a short time, thus decreasing the likelihood that the slick will reach sensitive coastal features.

To complicate further any assessment of the persistence of a deepwater slick, information is limited about the characteristics of oil that will be produced in deep water. Initial geochemical information on oil characteristics in deep water shows that some of the oil may be fairly heavy, may be waxy, and/or may contain fairly high asphaltenes, high metals, and high sulfur relative to typical oils produced in shallower waters in the Gulf of Mexico. All of these characteristics will affect the way spilled oil will weather over time. Oils having an API gravity less than 10 are generally expected to sink. Oils having an API gravity ranging from 10 to 17.5 are expected to float initially but could sink after weathering and/or incorporating particulate matter. Lighter oils with low asphaltene content are known to dissipate rapidly. At present, both the oil and gas industry and MMS are gathering data on the chemical and physical characteristics of deepwater oils.

Response to Deepwater Spill Incidents

The ability to respond to a spill that might occur in deepwater will vary, dependent upon a number of factors. Among these factors are the chemical and physical characteristics of the oil, the volume of oil spilled, the rate of spillage, the weather conditions at the time of a spill, the source of the spill (e.g., subsea blowout, pipeline release, surface release from an FPSO or a drill ship), and the amount of time necessary for response equipment or chemical countermeasures to reach the spill site. Since no single, spill-response method is 100 percent effective, larger spills in deep water under certain conditions may require the simultaneous use of multiple cleanup methods (e.g., mechanical cleanup, *in situ* burning, and dispersant application). Spill responses may be complicated by the potential for very large magnitude spills (because of the high production rates associated with deepwater wells), the length of time it could take to abate the source of the pollution (e.g., subsea blowout or pipeline leak), and the possibly longer response times from shore-based facilities to deepwater locations. However, the distance from shore will generally allow more time for containment and cleanup efforts and natural dissipation of the oil to take place at sea.

The capability to respond to a spill depends, in part, on the physical and chemical properties of an oil. Since the physical and chemical characteristics of future deepwater oils are unknown, it is difficult to determine how slicks of these oils will respond to any of the existing oil-spill-response countermeasures. Although there is a possibility that oil spilled from either a drillship or an FPSO in deep water could sink or that oil released subsea (e.g., subsea blowout or pipeline leak) in deep water could remain submerged for some period of time and travel away from the spill site, there are few practical spill-response options for dealing with submerged oil. It should be expected that it may not be possible to predict the movement of the oil or to detect submerged oil in the deepwater environment. Containment and recovery operations are most effective when the oil is in shallow, clear, sheltered waters, so the oil slick is relatively stationary and restricted in extent (Brown et al., 1998).

The model results of a recently completed study (S.L. Ross Environmental Research Ltd., 1997), which was discussed previously, indicate that slicks from bubble plume blowouts in deep water will be too thin and too wide, even near the source, to consider containment and removal operations. In those cases where the gas plume from a blowout does not develop, the slicks formed are expected to be narrower at the source, but more patchy than the bubble plume slicks. These slicks (where a gas plume does not develop) will also be thin and, as a result, are also not expected to be amenable to containment and removal operations. Chemical dispersants appear to be the only likely viable spill-response countermeasure that would be effective under these conditions. Burning may not be a feasible response option for subsea spills, which are likely to incorporate large percentages of water through emulsification. It is possible that natural dispersion of these oil slicks would alleviate the necessity for any response action to be mounted for blowouts in some deepwater locations (S.L. Ross Environmental Research Ltd., 1997). The MMS is funding a study to provide an in-depth analysis of oil-spill behavior from subsea blowouts and subsea pipeline releases in deep water. The ability to determine appropriate spill-response countermeasures to these deepwater events will be enhanced by the results of this study.

Spill response to an oil release that could occur from deepwater drill rigs/ships and FPSO=s in the Gulf of Mexico is also a concern because of the potentially very large volumes of oil stored on these facilities. Since information is limited about the chemical and physical properties of future deepwater crudes, it is difficult to determine which of the available spill-response strategies would be the best option for these areas. Response to spills in these areas will of necessity vary, dependent upon the weather and sea conditions present during a spill event. Again, it would be expected that, for the larger spills in deep water, the simultaneous use of multiple cleanup methods (e.g., mechanical cleanup, *in situ* burning, and dispersant application) would be initiated.

Since the application of dispersants may be the only feasible oil-spill-response option to some deepwater spills, the availability and suitability of dispersant application in the deepwater environment is a concern. Spill-response plans submitted for owners/operators of the deepwater leases generally cite contracts with the following oil-spill removal organizations (OSRO=s): (1) Clean Gulf Associates (CGA); (2) Marine Spill Response Corporation (MSRC); and/or (3) National Response Corporation (NRC). At present, both CGA and MSRC have contracts with Airborne Support Inc. (ASI) located in Bourg, Louisiana, which has a stockpile of 45,300 gal of the dispersant Corexit 9527 available for application by two DC-3 and one DC-4 aircraft. The NRC has a verbal agreement with ASI for assistance (Barker, personal communication, 1999). At a 20:1 application ratio, the DC-3 holds enough dispersant to spray a slick of approximately 476 bbl of oil and the DC-4 can spray a 952-bbl slick. At this same 20:1 ratio, the stockpile of dispersant available through

ASI is sufficient to spray a 22,000-bbl oil spill; however, numerous Asorties@ would be required to apply this volume of dispersant.

Until response planning standards are determined for the potential sources of very large deepwater spills, it will not be possible to determine the amount and/or types of dispersants that should be stockpiled in the Gulf. The total volume of dispersant currently stockpiled along the Gulf of Mexico coast may not be adequate to respond to a very large spill in deepwater. The April 1998 Final Report of the Preparedness Partnership Project sponsored by the Texas General Land Office concluded that there was not enough equipment or dispersant stockpiled to respond to that large an incident (Texas General Land Office, 1998). The MMS has funded a study to inventory Gulf Coast dispersants and to determine the adequacy of the current stockpiles.

Suggested Mitigation Measures for Further Evaluation

Mitigation Measure: Require operators to have contractual agreements to access all stockpiled dispersants and delivery systems in the Gulf area.

Anticipated Benefit: Expedite response to deepwater spill incidents. Provide adequate dispersant response capability in the event of a very large deepwater spill.

Mitigation Measure: Require operators to have contractual agreements and a tracking system for suitable rigs for emergency assistance in drilling a relief well.

Anticipated Benefit: Expedite response to deepwater spill incidents.

Mitigation Measure: Require operators to maintain an inventory of compatible BOP, riser, casing, and other critical components in the event of equipment loss as a result of loss of well control.

Anticipated Benefit: Expedite response to deepwater spill incidents. Expedite drilling of a relief well.

Mitigation Measure: Commander Stanton, Chief, Response Branch of the U.S. Coast Guard, District 8 Office, Marine Safety Division, has proposed to the MMS that MMS require that all operators archive representative samples of their reservoir and flowline oils for subsea completions.

Anticipated Benefit: If an oil slick of unknown origin were to be located in deep water, the samples taken from the slick could be Afingerprinted@ (chemically characterized) and compared to the archived samples to provide a mechanism for determining the source of the oil. By knowing the source of the oil, the facility causing the spill can be shut-in, limiting the size of the spill. By knowing the responsible party, a more timely and efficient spill response can be launched. The MMS needs to do additional evaluation to determine the feasibility of this methodology as it relates to changing oil field characteristics.

Mitigation Measure: Require multiphase detection meters on subsea system flowlines and risers.

Anticipated Benefit: Earlier detection of a leak, enabling the operator to take immediate action to limit the amount of oil released.

Suggested Research and Information Synthesis

Currently, no databases are maintained on spills from vessels, that is, from a vessel ramming into an OCS facility, or on collisions between vessels and OCS drilling rigs in transit. Although the Coast Guard maintains records of all spills occurring in navigable waters, the databases do not capture information needed to determine which incidents are associated with OCS operations. Such information would facilitate assessment and comparison of the potential risk of spills from these two types of incidents. Such an assessment would support the development of safety initiatives or mitigation measures that may prevent serious accidents or major oil spills.

Currently, no databases are maintained on spills during transfer of OCS oil to barges, the safety record of these barges, or the frequency of use of the barges to transfer oil from drilling/well-testing activities. Such information would facilitate assessment and comparison of the potential impacts of barging versus flaring in support drilling/well operations. Such information would facilitate assessment and comparison of the potential impacts of barging versus pipeline transport of OCS produced oil. Such an assessment would support the development of safety initiatives or mitigation measures that may prevent serious accidents or major oil spills.

Information on the mechanics and behavior of subsea spills is quite limited. Further research on the dynamics of a subsea oil release in deep water is needed before the fate of accidental subsea spills in deep water can be fully evaluated. The MMS, in collaboration with industry, is sponsoring the development of a three-dimensional model of oil-spill behavior from subsea well blowouts in deep water. The Offshore Operators Committee=s (OOC=s) Deep Spills Working Group and MMS are co-funding efforts by Clarkson University to modify the existing 3D trajectory model for deepwater scenarios. MIT/University of Hawaii will do the laboratory work to support the model=s development. DeepStar is sponsoring a deepwater field release of crude oil in Norway in the year 2000 with possible participation by the MMS. The release is designed to validate and calibrate numerical trajectory models. The completion of the model would assist in the development of spill prevention and response requirements. Additional field studies in the Gulf of Mexico involving the transport of oil from natural oil seeps in the Gulf of Mexico would help in the development of the model and would enhance the model=s applicability to modeling Gulf of Mexico subsea spills.

To enhance MMS=s and industry=s ability to predict the potential environmental consequences of oil spills in the deepwater areas of the Gulf and to respond to deepwater spills, the development of the following information and oil spill model enhancements are recommended: (1) development of a library of the chemical and physical characteristics of deepwater oils; (2) oil spill models that simulate subsea transport of spilled oil; (3) the capability for models to simulate continuous spill releases; (4) improved weathering model capability to simulate the chemical and physical changes that would occur from very large, continuous subsea spills; and (5) enhancement of industry modeling capabilities through the use of the latest physical oceanographic data developed by MMS to characterize the trajectory of the spilled oil for greater than 30 days.

In addition, development of a better understanding of the dispersability of deepwater crudes would support the determination of whether or not the dispersant (Corexit 9527) at present stockpiled in the Gulf of Mexico is the best choice for dispersing these oils.

Information is limited about the likelihood of spills from deepwater subsea flowlines/risers and the behavior of these oil spills at depths. Research to improve spill detection equipment would enable collection of information on these topics.

A risk assessment for FPSO=s should be completed to identify potential hazards to the FPSO, the potential for structural failure of an FPSO that would result in loss of its storage of oil, the likelihood of major spills occurring, and the aspects of risk that could be mitigated. Such information would help in the development of appropriate spill prevention and response protocols. Risk assessment and environmental analysis on offloading procedures and shuttle-tanker operations are needed to develop appropriate spill prevention and response protocols related to these operations.

Chemical Spills

Chemical products are used for a number of different purposes during offshore oil and gas operations (Chapter II.D.). Of concern is the risk of spills occurring, especially spills of large volume, and the potential environmental and human health impacts that could occur due to such spills. The risk of spills includes (1) the potential for harm to marine life, (2) the threat to local worker health and safety, and (3) the likelihood to cause air pollution. We are most concerned with the potential of a very large spill occurring because of (1) the loss of structural integrity of the offshore facility where all or some of the storage containers rupture, (2) the severance of a large chemical pipeline system, or (3) a leak at a subsea complex that continues without detection, potentially impacting nearby sensitive benthos. Because chemicals are either piped or barged to deepwater facilities, chemical spills could also occur near shore, resulting in risk to the safety or health of coastal inhabitants as well as environmental damage.

For many years the focus of regulatory agencies, such as the USCG and the International Maritime Organization (IMO), has been to develop guidelines to prevent and respond to spills of oil. Recent incidents of chemical spills as well as the passage of the Oil Pollution Act of 1990, which also sets protocols for the development of response requirements for spills of chemicals, has mobilized a number of agencies. A number of agencies, including USCG, USEPA, and the IMO, have or are establishing guidelines to strengthen requirements that provide human and environmental protection from chemical product spills. The USCG recently proposed rulemaking (*Federal Register,* 1999) on tank vessel response plan requirements for hazardous substances. Their proposed rulemaking has been highly controversial and finalization of the rule is expected to take some time.

In order to assist in the development of effective mitigation and response measures related to chemical spills, the MMS is collecting additional information on the amounts and kinds of chemicals used by the oil industry, on the impact of spilled chemicals to the marine environment, and on effective response protocols for many type of chemical spills. Chemical products used by the offshore industry may contain hazardous or toxic substances and could generate hazardous wastes. Many of these chemical products are mixtures of complex compounds, the composition and concentrations of which are adjusted for different fields and wells. Two of the most commonly used compounds, used in large quantities, are ethylene glycol and methanol. Some of the active ingredients are not known because they are considered proprietary commercial information. Identification of the amounts and types of all components is critical to understanding the behavior of the fluid if it is spilled and to establish effective cleanup methods. Larger quantities of some chemical products are expected to be used and stored in support of deepwater operations than is the case for operations on the shelf. This may indicate a potential for larger volume chemical spills in deepwater. The exact composition and the physical properties of deepwater chemical compounds, where and when the mixtures are made, the rate of consumption, the method of disposal of any used mixture, and where the treating chemicals will ultimately end up are all important issues important to assessing spill risk and response.

Even if detailed information is available on the chemical composition of products used by the OCS industry, information on how spills of these chemicals would impact the marine ecosystem is limited. According to a group of panelists at the 1998 Clean Gulf Conference, there is no comprehensive index of hazardous chemicals that provides a guide to their potential impact when spilled in salt water. This concern was reiterated by a special working group assigned to refine a strategy regarding hazardous substances for the OSPAR Convention for the Protection of the Marine Environment (HSSR, 1998). This group of experts found that firsthand information on how hazardous substances affect the sea was remarkably rare. The group also felt that using acute toxicity (often the only information provided on chemical products) was not enough to determine whether a substance is hazardous in the sea. The effects of long-term exposure, persistence, and bioaccumulative potential were essential factors.

There is very little documentation on OCS-related chemical spill occurrences. In the last several years, a number of spills of chemical compounds have been documented by other agencies or industry. The MMS currently has no requirement for reporting chemical product spills.

The MMS is funding two research projects that will provide much needed information. The first study is a literature review of industry practices and application of a chemical spill risk model. A risk assessment is included for several worst-case spill scenarios. The literature review will develop a baseline inventory of the types of chemical products being used by OCS operators, especially those products used in the deepwater areas of the Gulf of Mexico; give an overview of the usage, transport mechanisms, and storage protocols for these chemicals; provide an estimate of the typical and maximum volumes of these chemicals in terms of type of operation, volumes transported, and volumes stored offshore and at shore bases; assess the potential for a spill, the risk of spill occurrence, and the severity of impacts relative to spill size; and address human exposure, along with environmental damage from worse-case spill scenarios. The second study examines the effects of methanol, ethylene glycol, and dodecyl benzene sulfonate on three species of fish.

Suggested Mitigation Measures for Further Evaluation

Mitigation Measure: Require effective leak detection systems on all subsea chemical flowlines.
Anticipated Benefit: Early leak detection, enabling earliest possible shut-off of the flowline and spill response.

Mitigation Measure: Ensure compliance with requirements to store separately chemical products that are highly reactive with each other.
Anticipated Benefit: Reduce the possible effects of accidental chemical spills.

Mitigation Measure: Require operators to specify on the MSDS sheets information on the reactivity potential of different OCS-related chemical products that will be stored together.
Anticipated Benefit: Increase the likelihood of using the most appropriate spill response for chemical spill.

Suggested Research and Information Synthesis

Development of the following information would help refine current mitigation measures, identify additional mitigation measures, and develop appropriate response to chemical spills:

- types and volumes of historic OCS-related chemical spills;
- likelihood of future OCS-related chemical spills;
- short-term and long-term environmental impact of OCS-related chemical spills on the marine ecosystem;
- risk to human health and safety from OCS-related chemical spills;
- transport processes and long-term fate of OCS-related chemical spills;
- regulatory authorities over chemical usage, storage, and transport of OCS-related chemicals; and
- effectiveness of current leak detection systems for chemical flowlines in umbilicals.

L. Current Regulatory Framework

The issuance of a lease grants the lessee the right to conduct preliminary activities on the OCS. Upon meeting appropriate Federal requirements, OCS lessees are legally entitled to explore, develop, and produce oil and gas contained within their lease area. To retain this right, the lessee must proceed with Adue diligence,@ which means the lessee must begin exploration and subsequent activities on its lease within an amount of time set by law, called the lease term. Prior to commencing exploration or development activities, the operator must submit detailed plans for MMS review. No activities may occur until approval has been granted by the MMS. Proposed activities are evaluated through established technical, safety, and environmental review processes. Upon approval of activities, lessees must comply with all lease stipulations, operational regulations, permit requirements, mitigation measures, and other applicable Federal laws and regulations. Operators are ultimately responsible for the safe conduct of operations and pollution prevention.

The MMS has established regulations and operating procedures to ensure that proposed operations are orderly, safe, and pollution-free, specifically including reducing the risk of oil-spill occurrence and mitigating impacts should an oil spill occur. The MMS considers the best mitigation of environmental impacts to be risk management and avoidance of accidental events. The goal of the established MMS review and approval processes and the MMS inspection program is to minimize adverse impacts from routine operations and reduce the potential for accidental impacts. Proposed operations must meet or exceed the safety standards set by MMS. Site-specific and project-specific mitigation measures can be identified and become requirements at any stage of review or operations. Regulations for oil, gas, and sulphur lease operations on the OCS are specified in 30 CFR 250. Regulations for geological and geophysical exploration operations on the OCS are specified in 30 CFR 251.

Lease Stipulations

The only stipulation currently applicable to deepwater leases is the Military Areas Stipulation. The stipulation reduces potential impacts by curtailing certain OCS operations and support activities in areas where military operations are being conducted. Operators are required to notify and coordinate with appropriate military authorities prior to conducting oil and gas activities in a designated military warning area.

Postlease Regulatory Framework and Review Processes

The MMS=s established regulatory framework is applicable to, and is considered to be part of, all deepwater operations considered in this EA. The MMS=s established review, evaluation, and decisionmaking processes are applicable to all deepwater operations.

The MMS is responsible for regulating and monitoring the oil and gas operations and activities on the Federal OCS. The MMS has established operating regulations and procedures to ensure that proposed activities are orderly, safe, and pollution-free. These regulations include technical and environmental reviews and evaluations by the MMS to ensure all operations are conducted in a safe and environmentally sound manner. The focus of the regulations is to reduce the risks associated with actions conducted in the offshore environment. The lessee or operator has the primary responsibility for ensuring all operations meet or exceed the MMS=s regulatory requirements.

The MMS= Operating Regulations, 30 CFR 250, are designed to, A. . . regulate all operations conducted under a lease, right of use and easement, or right-of-way to promote orderly exploration, development, and production of mineral resources and to prevent unreasonable harm or damage to, or waste of, any natural resource (including any mineral deposits in areas leased or not leased), any life (including fish and other aquatic life), property, or the marine, coastal, or human environment@ (30 CFR 250.105). The Operating Regulations provide requirements and guidance on each phase of offshore operations. The Operating Regulations incorporate by reference numerous industry practices, methods, codes, and measurements that are accepted as standards in conducting offshore operations. This allows the integration of the most current practices into the day-to-day work offshore.

Regulations for prelease geological and geophysical exploration operations on the OCS are specified in 30 CFR 251. Oil-spill response requirements for OCS facilities are specified in 30 CFR 254. Leasing activities information can be found in 30 CFR 256, 259, and 260. The MMS=s Notices to Lessees and Operators (NTL's) are formal documents that provide clarification, description, or interpretation of OCS regulations or standards. The NTL's provide guidelines on the implementation of special lease stipulations or regional requirements and provide industry with a better understanding of the scope and meaning of regulations.

All proposed operations must meet or exceed the safety standards set by MMS. The MMS requires use of the Best Available and Safest Technology (BAST) for OCS operations, which includes state-of-the-art drilling technology, production safety systems, completion of oil and gas wells, oil-spill response plans, pollution-control equipment, and specifications for platform/structure designs.

Prior to any exploration, development, or production activities being conducted on a lease, companies must submit plans to the MMS for evaluation and decision. Specific requirements must be addressed in these plans relative to operating conditions and environmental considerations. Required supporting environmental information may include an archaeological survey and report, a biological report, and a geohazards survey and report. If a plan is approved, operators must still submit applications for specific operations for review and approval prior to commencing operations.

The MMS does a technical and safety review of all proposed structure designs and installation procedures. To ensure that new structures are designed, fabricated, and installed using standardized procedures to prevent structural failures, MMS uses third-party (a Certified Verification Agent) expertise and technical input in the verification process. All surface production facilities, including separators, treaters, compressors, headers, and flowlines must be designed, installed, and maintained in a manner that provides for efficiency, safety of operations, and protection of the environment. Safety systems utilized for drilling, workover, and production operations on the OCS must be designed, installed, used, maintained, and tested in a manner to ensure the safety and protection of the human, marine, and coastal environments. All tubing installations open to hydrocarbon-bearing zones below the surface must be equipped with safety devices that will automatically shut off the flow from the well in the event of an emergency (unless the well is incapable of flowing).

New and unusual technologies for deepwater activities are evolving rapidly. Most of the MMS=s operating regulations were written prior to the rapid increase in deepwater activities, and advancements in technology typically outpace the regulation revision process. As a result, MMS has seen and is expecting to see more operator requests for alternative technologies and departures from the regulations. The uniqueness of deepwater operations and its environment compared to traditional shelf activities necessitates flexibility in the regulations to permit these development operations to proceed in deepwater areas of the Gulf. To ensure that MMS continues to meet its mandates for orderly development, safety, and environmental protection, additional review processes have been established for proposed deepwater operations and for proposed subsea developments.

NTL 98-8N requires operators to submit, for early technical review by MMS, a Deepwater Operations Plan (DWOP) for operations in deep water and for all projects using subsea production technology. The DWOP is intended to address the different functional requirements of production equipment in deep water, particularly the technological requirements associated with subsea production systems, and the complexity of deepwater production facilities. The DWOP provides MMS with information specific to deepwater equipment issues to demonstrate that a deepwater project is being developed in an acceptable manner as mandated in the OCS Lands Act, as amended, and the MMS operating regulations at 30 CFR 250. The MMS reviews deepwater development activities from a total system perspective, emphasizing operational safety, environmental protection, and conservation of natural resources. The DWOP process is a phased approach that parallels the operator=s state of knowledge about how the field will be developed.

For MMS to grant alternative compliance approvals, the operator must demonstrate an equivalent or improved degree of protection. A departure can be granted when necessary if the operator can demonstrate that an acceptable level of protection exists. The MMS=s case-by case technical and engineering evaluations of departure requests can involve a qualitative risk assessment and a review of the operations and equipment. Comparative analysis with other approved systems, equipment, and procedures is another tool that MMS can use to assess the adequacy of protection provided by the alternative. Actual in-service experience is necessary with alternative compliance measures before MMS will consider them as proven operational technology. An example of this philosophy is the evolution from the traditional vertical bore production tree to the horizontal tree currently being used in deepwater applications.

The MMS evaluates the design, fabrication, installation, and maintenance of pipelines. Proposed pipeline routes are evaluated for potential geologic hazards and other natural or manmade seafloor or subsurface features or conditions that could have an adverse impact on the pipeline. Routes are also evaluated for potential impacts on archaeological resources and biological communities. Operators are required to periodically inspect pipeline routes, and monthly overflights are conducted to inspect pipeline routes for leakage.

The MMS=s responsibilities include spill prevention, oil-spill response plans (OSRP=s), oil-spill containment and cleanup equipment, financial responsibility certification, and civil penalties. The MMS=s regulations require that all owners and operators of oil handling, storage, or transportation facilities located seaward of the coastline submit an OSRP for approval before an owner/operator can use a facility. Owners or operators of offshore pipelines are required to submit a plan for any pipeline that carries oil, condensate, or gas with condensate; pipelines carrying essentially dry gas do not require a plan. The Environmental Protection and Response Plan within the OSRP outlines the availability of spill containment and cleanup equipment and trained personnel. It must ensure that full-response capability can be deployed during an oil-spill emergency. The plan includes specification for appropriate equipment and materials, their availability, and the time needed for deployment. All MMS-approved OSRP's are required to be reviewed and updated every two years.

The MMS=s regulations provide for the collection of information about potential sources of pollution in order to determine whether projected emissions of air pollutants from a facility may result in onshore ambient air concentrations above USEPA significance levels and to identify appropriate emissions controls to prevent accidents and air quality deterioration. Regulated pollutants include carbon monoxide, suspended particulates, sulphur dioxide, nitrogen oxides, total hydrocarbons, hydrogen sulfide, and volatile organic compounds (as a precursor to ozone).

All operators on the OCS involved in production of sour hydrocarbons that could result in atmospheric hydrogen sulfide (H_2S) concentrations above 20 ppm are required to file an H_2S contingency plan that includes procedures to ensure the safety of the workers on the production facility. All operators are required to adhere to National Association of Corrosion Engineers (NACE) Standard Material Requirement MRO75-97 for Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment (NACE International, 1997). The American Petroleum Institute (API) has also developed ARecommended Practices for Oil and Gas Producing and Gas Processing Plant Operations Involving Hydrogen Sulfide@ (API Recommended Practices 55, 2nd Edition, February 15, 1995). The MMS issued an NTL titled AHydrogen Sulfide (H_2S) Requirements@ to provide guidance on sensor location, sensor calibration, respirator breathing time, measures for protection against sulfur dioxide, requirements for classifying an area for the presence of H_2S, requirements for flaring and venting of gas containing H_2S, and other issues pertaining to H_2S-related operations.

The MMS has pollution prevention and control regulations (30 CFR 250.300) to ensure lessees do ". . . not create conditions that will pose an unreasonable risk to public health, life, property, aquatic life, wildlife, recreation, navigation, commercial fishing, or other uses of the ocean . . ." during offshore oil and gas operations. Control and removal of pollution is the responsibility and is at the expense of the lessee. Operators are required to install curbs, gutters, drip pans, and drains on structures and deck areas in a manner necessary to collect all contaminants and debris not authorized for discharge. Disposal of any solid waste into the marine environment is prohibited. Fixed and floating structures, drilling rigs, manned production platforms/structures, and support vessels operating under a Federal oil and gas lease are required to develop Waste Management Plans and to post placards reflecting discharge limitations and restrictions. Operational discharges such as produced water and drilling fluids and cuttings are regulated by USEPA through the NPDES program; MMS may restrict the rate of drilling fluid discharge or prescribe alternative discharge methods.

Under MMS operating regulations and lease agreements, all lessees must remove objects and obstructions upon termination of a lease. Lessees/operators must notify MMS at least 30 days before a structure removal and provide information that includes the following: complete identification of the structure; size of the structure (number and size of legs and pilings); removal technique to be employed (if explosives are to be used and the amount and type of explosive per charge); and the number and size of well conductors to be removed and the removal technique. Lessees must ensure all objects related to their activities are removed following termination of their lease. NTL 92-02 established site clearance verification procedures.

The MMS conducts both announced and unannounced onsite inspections of all production facilities and monthly inspections of all drilling and workover facilities to ensure compliance with lease terms, NTL's, and approved plans, and to ensure that safety and pollution-prevention requirements of regulations are met. The focus of these inspections is on the facility=s safety equipment and on the records the operator maintains that reflect the periodic testing required by the Operating Regulations. Inspectors may require the activation of some safety equipment on a facility to ensure it is working properly.

The MMS encourages all operators to participate in the Safety and Environmental Management Program (SEMP) that is detailed in the American Petroleum Institute=s Recommended Practice, API RP 75. This is a comprehensive environmental and safety program that addresses all facets of oil and gas operations.

The MMS requires lessees or operators to demonstrate that they have the financial resources to cover any obligation that may develop from their operations. Certain bonding requirements have been made on the lessees and operators to ensure any financial obligations could be met, such as properly abandoning a well and clearing a lease.

MATRIX OF FINDINGS

RESOURCE	INTERFACES AND IMPACTS			FINDINGS
	Air	Water	Seafloor	
Chemosynthetic Communities	N/A	Temporary turbidity associated with anchoring, sea – surface and seafloor discharge of drill cuttings/mud, structure installation and removal, and pipeline installation.	Partial or complete burial from temporary turbidity associated with anchoring, sea-surface and seafloor discharge of drill cuttings/mud, structure installation and removal, and pipeline installation. Crushing or damage from anchors, mooring lines, structures, and pipelines.	Chemosynthetic communities are susceptible to direct physical impact from seafloor-disturbing activities and to partial or complete burial by muds and cuttings. Time periods as long as hundreds of years may be required to reestablish a chemosynthetic. Mitigation: Deepwater wells and discharge points must be at least 1,000 ft away from any potential high-density chemosynthetic communities. Other disturbing activities such as anchors must be at least 250 feet away from potential communities. Project/site-specific review and mitigation are appropriate to protect sensitive seafloor resources.
Non-Chemosynthetic Benthic Communities	N/A	Temporary turbidity associated with anchoring, sea-surface and seafloor discharge of drill cuttings/mud, structure installation and removal, and pipeline installation.	Partial or complete burial from temporary turbidity associated with anchoring, sea-surface and seafloor discharge of drill cuttings/mud, structure installation and removal, and pipeline installation. Crushing or damage from anchors, mooring lines, structures, and pipelines.	Deepwater reefs and hard-bottom areas appear to be limited in deep water. Hard-bottom communities may be similar to protected pinnacles and topographic features on the shelf. Most impacts are expected to be similar to those associated with operations on the continental shelf. Mitigation: Avoid direct physical disturbance of rare hard substrate outcrops, which may support such communities. Project/site-specific review and mitigation are appropriate to protect sensitive seafloor resources.

RESOURCE	INTERFACES AND IMPACTS			FINDINGS
	Air	Water	Seafloor	
Marine Mammals	Emissions; noise from helicopter traffic.	Service vessel collisions; ingestion of debris; oil spills; chemical product spills; spill response activities; noise from service vessels, structure installation and operation, and seismic surveying; explosive structure removals; and temporary turbidity associated with seafloor disturbance.	N/A	Deepwater activities are unlikely to have a long-term adverse effect on the size and productivity of any marine mammal species and population stock in the northern Gulf of Mexico. Small numbers of marine mammals could be killed or injured by chance collision with service vessels and by eating indigestible debris. Oil spills can cause chronic (longer-term lethal or sublethal oil-related impacts) or acute (spill-related deaths occurring during an event) effects on marine mammals. Contaminants in discharges could indirectly affect marine mammals through food-chain biomagnification. Deaths due to structure removals are not expected because of existing mitigation measures. The evidence on whether there are adverse impacts from anthropogenic noise is inconclusive. Mitigation: Minimize noise impacts from seismic surveying operations. Programmatic EIS's currently address these issues. Additional information on noise impacts and potential mitigation measures will be addressed in the EA on Geological and Geophysical activities being prepared.

RESOURCE	INTERFACES AND IMPACTS			FINDINGS
	Air	Water	Seafloor	
Sea Turtles	Emissions; noise from helicopter traffic.	Service vessel collisions; ingestion of debris; oil spills; chemical product spills; spill response activities; noise from service vessels, structure installation and operation, and seismic surveying; explosive structure removals; and temporary turbidity associated with seafloor disturbance.	N/A	Deepwater activities are unlikely to have a long-term adverse effect on the size and productivity of any sea turtle species and population stock in the northern Gulf of Mexico. Small numbers of sea turtles could be killed or injured by chance collision with service vessels or by eating indigestible OCS-related debris. There is direct evidence that turtles have been seriously harmed by oil spills. Oil spills can cause chronic (longer-term lethal or sublethal oil-related impacts) or acute (spill-related deaths occurring during a spill) effects on sea turtles. Contaminants in discharges could indirectly affect sea turtles through food-chain biomagnification. Deaths due to structure removals are not expected because of existing mitigation measures. The evidence on whether there are adverse impacts from anthropogenic noise is inconclusive. Mitigation: Minimize noise impacts from seismic surveying operations. Programmatic EIS's currently address issues. Additional information on noise impacts and potential mitigation measures will be addressed in the EA on Geological and Geophysical activities being prepared.
Fishing and Fisheries	N/A	Temporary turbidity associated with anchoring, sea-surface and seafloor discharge of drill cuttings/mud, structure installation and removal, offshore discharge of produced waters, pipeline installation, and surface and seafloor oil and chemical spills	Space-use conflicts due to the presence of offshore structures. Gear conflicts with subsea facilities and other underwater obstructions.	The effects from deepwater activities are expected to be inconsequential. The resulting influences on fisheries resources should be indistinguishable from natural population variations. A limited amount of area will be unavailable to fishing because of the physical presence of offshore structure and associated seafloor systems. Programmatic EIS's adequately address these issues.

RESOURCE	INTERFACES AND IMPACTS			FINDINGS
	Air	Water	Seafloor	
Air Quality	Emissions associated with routine and support operations, structure installation and decommissioning, pipeline installation, flaring and burning, and oil and chemical spills.	Emissions from unburned oil and chemical product spills.	N/A	MMS air quality evaluations must continue to occur at the flare/burn request stage. Current procedures are working to identify potentially significant flare/burn requests. Mitigation: limit flaring; disallow burning of liquids. The FWS is concerned that the Class I increments for SO_2 may be consumed. Mitigation: Use of low-sulfur fuel in diesel engines on structures emitting greater than 250 tons of SO_2 facilities within 100 km of the Breton National Wilderness Area is recommended. Glycol still vents are primary point sources of BTEX emissions in the U.S., and the majority of OCS glycol still vents are uncontrolled. Potentially substantial quantities of BTEX are being emitted. The MMS does not currently have explicit jurisdiction to regulate BTEX emissions. Voluntary mitigation: Condensers on glycol still vents to control BTEX emissions. Reanalysis of 8-hr averaging period data indicates OCS sources substantially contribute to onshore ozone. These contributions could be deemed significant in some cases once the September 2000 redesignation occurs. Mitigation: Reduce ozone precursors (NO_X and VOC) via engine-timing retardation for diesel engines, use of turbines and "clean-burning" engine, and use of condensers on large-volume glycol still vents. A surface spill or subsea blowout in deep water could possibly generate substantial quantities of VOC's and corresponding ozone for an extended period of time. The impact level of deepwater OCS-related H_2S is not expected to be significant. Mitigation: Offshore "sweetening" of produced sour gas. Both programmatic EIS's and project/site-specific reviews with appropriate mitigation measures are needed to address these issues.

RESOURCE	INTERFACES AND IMPACTS			FINDINGS
	Air	Water	Seafloor	
Archaeological Resources	N/A	Seafloor oil and chemical spills.	Crushing or damage from anchors, mooring lines, pipelines, structures, and other seafloor-disturbing activities.	Bottom-disturbing activities may damage or destroy archaeological resources, primarily historic period shipwrecks. If operators conduct the required high-resolution seismic surveys prior to initiating activities, there is low probability of impact. Impacts from spills on historic coastal sites are expected to be temporary and reversible. Project/site-specific review and mitigation are appropriate to protect these resources.
Water Quality	N/A	Marine waters: operational discharges, chemical and oil spills, and spills and discharges from support activities. Coastal waters: discharges, spills, and resuspension of sediments associated with support activities near shore and onshore.	Resuspension of sediments from seafloor-disturbing activities. Oil and chemical spills and operational discharges at the seafloor..	Short-term localized degradation of marine water quality may occur, especially at host facilities. Incremental increases in degradation of coastal water quality may also occur. Deepwater activities are expected to incrementally increase support activities and the expansion or construction of support bases. Impacts from this type of growth are due to all OCS Program activities and are not specific to deepwater activities. Moderate, short-term, water quality degradation may increase at a few support bases that are expected to grow as a result of deepwater activities. Existing onshore and waste disposal practices may change. Programmatic EIS's adequately address these issues.
Coastal Habitats	Emissions associated with OCS-related helicopters and service vessels, dredging, construction activities, and service base operations.	Temporary resuspension of sediments with anchoring, dredging, and installation of pipelines; spills and leaks of oil and chemical products; and discharges from vessels.	Anchoring, dredging, pipeline installation, and other seafloor-disturbing activities.	Most deepwater-related impacts to coastal habitats are expected to be largely indistinguishable from those generated by OCS Program activities overall. The probability of deepwater spills occurring and reaching coastal habitats is very low. Impacts from oil on coastal habitats are proportional to the amount of oil reaching the shore. Therefore, if a very large spill were to result from deepwater operations or support activities, larger amounts of oil could reach the coast and the potential impacts could be greater than impacts associated with historically smaller spills from OCS activities on the shelf. Programmatic EIS's and project/site-specific reviews/mitigation address these issues.

RESOURCE	INTERFACES AND IMPACTS			FINDINGS
	Air	Water	Seafloor	
Socioeconomic Resources	N/A	N/A	N/A	Employment for deepwater activities is expected to be filled primarily by persons already in OCS oil- and gas-related employment, and unemployed and underemployed persons living mostly within the coastal counties/parishes of Texas and Louisiana. Some positive economic effects should occur in these areas. These areas will also experience potential impacts from expansions. Only minor workforce fluctuations are expected. Social and cultural problems typically associated with migration are not expected to occur. Programmatic EIS's adequately address these issues.

COMPONENT	INTERFACES AND IMPACTS			FINDINGS
	Air	Water	Seafloor	
Mooring system	Emissions from vessels during installation, maintenance and repair, and decommissioning operations	Discharges and noise from vessels during installation, maintenance and repair, and decommissioning operations. Space-use and gear conflicts with commercial fisheries.	Some mooring systems have components that lie on the seafloor posing potential physical impacts to seafloor resources.	Impacts are expected to be similar to shelf activities. The areal extent of mooring lines will increase with water depth. Impact-factors associated with installation, maintenance and repair, and decommissioning operations will be short term and localized. Effects on fisheries are expected to be inconsequential. Project/site specific review and mitigation are appropriate to protect sensitive seafloor resources.
Anchoring	Emissions from vessels during installation, maintenance and repair, and decommissioning operations	Discharges and noise from vessels during installation, movement, and decommissioning. Temporary turbidity.	Physical impacts to seafloor resources. Penetration and channeling of sediments (anchor scars). Burial or destruction of nearby seafloor resources.	Impacts are expected to be similar to shelf activities. Footprint size (i.e., area of seafloor impacted) increases with water depth. Impact-factors associated with installation, maintenance and repair, and decommissioning operations will be short term and localized. Effective mitigation measures are in place to protect sensitive seafloor resources.
Dynamically Positioned Stationkeeping	Emissions	Noise	N/A	Emissions must be evaluated on a project-specific basis.
Topside Production Equipment	Emissions	Produced-water discharges. Accidental chemical or oil spill.	N/A	Impacts are expected to be similar to shelf activities for comparable production throughput. Deepwater production rates are expected to be greater than rates on the continental shelf. Emissions must be evaluated on a project-specific basis. Discharges must conform to USEPA NPDES permit requirements. Regulations and operating procedures are in place to reduce the risk of spill occurrence and mitigate impacts should a spill occur.

COMPONENT	INTERFACES AND IMPACTS			FINDINGS
	Air	Water	Seafloor	
Pipelines	Emissions from vessels during installation, maintenance and repair, and decommissioning operations.	Discharges and noise from vessels during installation, repair, movement, and decommissioning. Temporary turbidity.	Physical impacts to seafloor resources. Penetration and channeling of sediments (anchor scars). Burial or destruction of nearby seafloor resources. Accidental oil leak/spill.	Impacts are expected to be similar to shelf activities. Emissions must be evaluated on a project-specific basis. Footprint size (i.e., area of seafloor impacted) increases with water depth. Impact-factors associated with installation, maintenance and repair, and decommissioning operations will be short term and localized. Effective mitigation measures (avoidance) are in place to protect sensitive seafloor resources. Monitoring and maintenance reduce the risk and potential size of leak or spill. Regulations and operating procedures are in place to reduce the risk of spill occurrence and mitigate impacts should a spill occur.
Support Services	Emissions from helicopters and service vessels during installation, routine transit, and decommissioning operations. Noise from service vessels and helicopters during transit.	Discharges and noise from service vessels. Vessel collisions.	Physical impacts to seafloor resources and penetration and channeling of sediments (anchor scars) from vessel and buoy anchors.	Larger support vessels are expected. Emissions must be evaluated on a project-specific basis. Discharges must conform to USEPA NPDES permit requirements. Project/site-specific review and mitigation are appropriate to protect sensitive seafloor resources.
Seismic Survey Operations	Emissions from survey vessels.	Pressure and sound waves in water column	Physical impacts to seafloor resources and penetration and channeling of sediments (anchor scars) from ocean-bottom cables or anchoring of vertical cables	Impacts are expected to be similar to shelf operations. . Emissions must be evaluated on a project-specific basis. An Environmental Assessment on geological and geophysical exploration activities, including seismic surveying, is being prepared.

COMPONENT	INTERFACES AND IMPACTS			FINDINGS
	Air	Water	Seafloor	
Drilling Activities	Emissions from drilling rig, equipment, support aircraft and vessels, and dynamic positioning operations.	Discharge of water-based muds/cuttings, and formation water. Discharge of cuttings wetted with synthetic-based drilling (SBF) fluids. Temporary turbidity from seafloor discharge during pre-riser and riserless drilling.	Burial of nearby seafloor resources from seafloor discharge of pre-riser and riserless drilling operations. Lower available oxygen levels because of degradation of SBF.	Impacts are expected to be similar to shelf operations with some exceptions: - Impacts from SBF (see below) - Increased risk of incidents because of shallow water flows and hydrate formation; these factors pose engineering and operational constraints and require response planning - Dynamic positioning (see above). - Riserless drilling discharges; effective mitigation measures (avoidance) are in place to protect sensitive seafloor resources
Extended Well Test and Well Cleanup Operations	Emissions from operations, venting, and flaring. Emissions from storage and transport of hydrocarbons. Toxic emissions	Produced-water discharges. Accidental chemical or oil spill.	Physical impacts on seafloor resources from anchoring of rigs and support vessels.	Air quality impacts to Class I area (consumption of Breton air increments); MMS air quality evaluations must continue to occur at the flare/burn request stage. <u>Mitigation</u>: limit flaring; disallow burning of liquids. Effective mitigation measures are in place to protect sensitive seafloor resources. Discharges must conform to USEPA NPDES permit requirements. Programmatic EIS's and project/site-specific reviews/mitigation address these issues. Potential hydrocarbon resource conservation issues.
Decommissioning Operations	Emissions from support vessels.	If explosives are used: pressure waves and temporary resuspension of sediments	Disruption of benthos at operational sites (e.g., wells, anchors, and pipelines)	Pressure waves from explosive removals could injure or kill sea turtles, marine mammals, fish, and other biota. Emissions must be evaluated on a project-specific basis In-place abandonment of some components may be sought by operators. Partial removals involve regulatory, fisheries, and defense issues.

COMPONENT	INTERFACES AND IMPACTS			FINDINGS
	Air	Water	Seafloor	
Transport of produced oil by surface vessel	Emissions from storage tanks, offloading operations, and vessel during transit	Discharges from tanker or barge/tug. Accidental oil spill.	N/A	A very limited amount of liquid hydrocarbon is already being barged from OCS operations on the shelf. Lightering of imported oil from supertankers occurs routinely in the Gulf. Discharges must conform to USEPA NPDES permit requirements. Lightering and surface transport of OCS-produced oil would be new to the Gulf. A large spill near shore could have major impacts to the environment. An Environmental Impact Statement to evaluate the potential environmental effects of tankering associated with the possible use of FPSO systems in the deep waters of the Gulf of Mexico is being prepared.
Host Facilities	Emissions associated with routine and support operations, structure installation and decommissioning, pipeline installation, flaring and burning, and oil and chemical spills.	Additional discharges to the sea, temporary resuspension of sediments with new pipelines and umbilicals, and spills/leaks	Some additional sea-bottom disturbance, if facilities are added or expanded; and new pipeline and umbilical routes	Additional throughput and processing of hydrocarbons may result in an increase and concentration of emissions and discharges at the host facility. Emissions must be evaluated on a project-specific basis. Discharges must conform to USEPA NPDES permit requirements. Project/site-specific review and mitigation are appropriate to address potential impacts from proposed host/hub facilities.
Ordnance Disposal Areas	N/A	N/A	Unexploded ordnance may be on or embedded in the sea bottom.	Disturbance may cause ordnance to exploded. Review of all bottom-disturbing activities must include an evaluation for the presence of the unexploded ordnance. The presence of ordnance may be determined by high-resolution and side-scan sonar data.
Oil Spills	Emissions from evaporation of volatile fractions	Toxic effects from soluble fractions.	Subsea releases may have toxic effect on sensitive bottom communities.	Potentially larger spills, different crude oil properties, and different fate and effects. Regulations and operating procedures are in place to reduce the risk of spill occurrence and mitigate impacts should a spill occur. Programmatic EIS's and project/site-specific reviews/mitigation address these issues.

COMPONENT	INTERFACES AND IMPACTS			FINDINGS
	Air	Water	Seafloor	
Chemical Spills	Emissions from evaporation	Potentially toxic, soluble chemicals mix into the water column.	Dense, insoluble chemicals sink to the seafloor and may toxic effects on sensitive seafloor communities.	Increased use of chemicals (both types and volumes) is expected for development of deepwater prospects. Regulations and operating procedures are in place to reduce the risk of spill occurrence and mitigate impacts should a spill occur. Limited information is available about the types, amounts, and potential impacts of chemicals being used in deepwater operations. The MMS has funded a study to acquire and assess this information. The study will support the development of additional measures to decrease spill risk and the identification of additional chemical spill response procedures
Synthetic-Based Drilling Fluids (SBF)	N/A	Discharge of drill cuttings coated with SBF.	Partial or complete burial of sensitive seafloor communities. Localized hypoxic or anoxic conditions in surficial sediments as SBF decompose.	Potential effects of SBF in the marine environment are not well characterized. An interim mitigation measure (avoidance) is in place to reduce potential effects. The USEPA has published a proposed rule on effluent limitations for SBF and other non-aqueous drilling fluids. An industry/government monitoring program is underway to evaluate potential impacts from SBF.
Floating Production, Storage, and Offloading Systems	Emissions from production, storage, offloading, and transport operations; and spills	Discharges to the sea of produced waters, temporary resuspension of sediments from anchoring, and spills	Impacts to biota from bottom-disturbing activities, if the FPSO is anchored.	An Environmental Impact Statement to evaluate the potential environmental effects of FPSO systems in the deep waters of the Gulf of Mexico is being prepared.

CHAPTER III

DESCRIPTION OF THE DEEPWATER ENVIRONMENT

III. DESCRIPTION OF THE DEEPWATER ENVIRONMENT

Chapter III contains the description of the existing physical and operational environment that may impact deepwater operations and activities or that influences how and where potential impacts from those operations and activities may occur. Description of the environmental and socioeconomic resources analyzed are included within the analyses themselves.

A. Physiography of the Gulf of Mexico

The Gulf of Mexico is a semi-enclosed, subtropical sea with an area of approximately 1.6 million km^2. The main physiographic regions of the Gulf basin are the continental shelf (including the U.S., Mexican, and Campeche shelves), continental slope and associated canyons, continental rise, abyssal plains, and the Florida and Yucatan Straits (Figure III-1). Operations in the deepwater OCS are currently confined to the continental slope.

The continental shelf width along the U.S. coastline ranges from 350 km offshore west Florida to 16 km off the Mississippi River, with intermediate width of about 150 km at Galveston, Texas. The shelf is characterized by a gentle slope of less than one degree.

The continental slope is that part of the seafloor that extends basinward from the shelf edge at approximately 200 m water depth to an abrupt change in the bathymetric gradient at approximately 2,000 m. In the northwestern Gulf of Mexico, the seaward margin of the continental slope is characterized by the Sigsbee Escarpment in approximately 3,000 m water depth. The continental slope of the central and western Gulf covers an area of more than 120,000 km^2 of hummocky topography broken by canyons, troughs, and escarpments. In the eastern Gulf, the seaward margin of the continental slope is marked by the Florida Escarpment in approximately 2,000-3,000 m water depth. The eastern Gulf slope area, for the most part, is characterized by the partially exposed Cretaceous Reef feature between 250 and 2,000 m water depth. The slope attains its maximum width of 240 km off the west Louisiana shelf. Bathymetric profiles of the slope region suggest a “step-like” overall shape with a moderate (slope) gradient in the upper and lower parts, and a “plateau-like” gentle gradient in the middle part of the slope. The overall gradient of the slope is 3-6 degrees. Slopes may exceed 20 degrees in some places, particularly along escarpments.

The continental rise is the apron of sediments accumulated at the base of the slope and extending out onto the abyssal plain. The gentle incline of the rise is less than one degree. The flat region of the floor of the Gulf is the abyssal plain. The depth of the central abyss is more than 3,600 m.

B. General Geology of the Continental Slope of the Northern Gulf of Mexico

The continental slope in the northern Gulf of Mexico may be subdivided into four subregions based on geological structure styles (Figure III-1): (1) Western Slope, off Texas, characterized by sedimentary sections that are extensively folded and subjected to thrust faulting in Perdido Foldbelt area; (2) Upper Central Slope, off east Texas and west Louisiana, characterized by broad, closely spaced and steeply flanked salt domes and ridge-like diapiric uplifts; (3) Mississippi Slope, off east Louisiana, similar to Western Slope in its regional structural style of folding and associated thrust faulting in Mississippi Fan Foldbelt area; and (4) Lower Slope

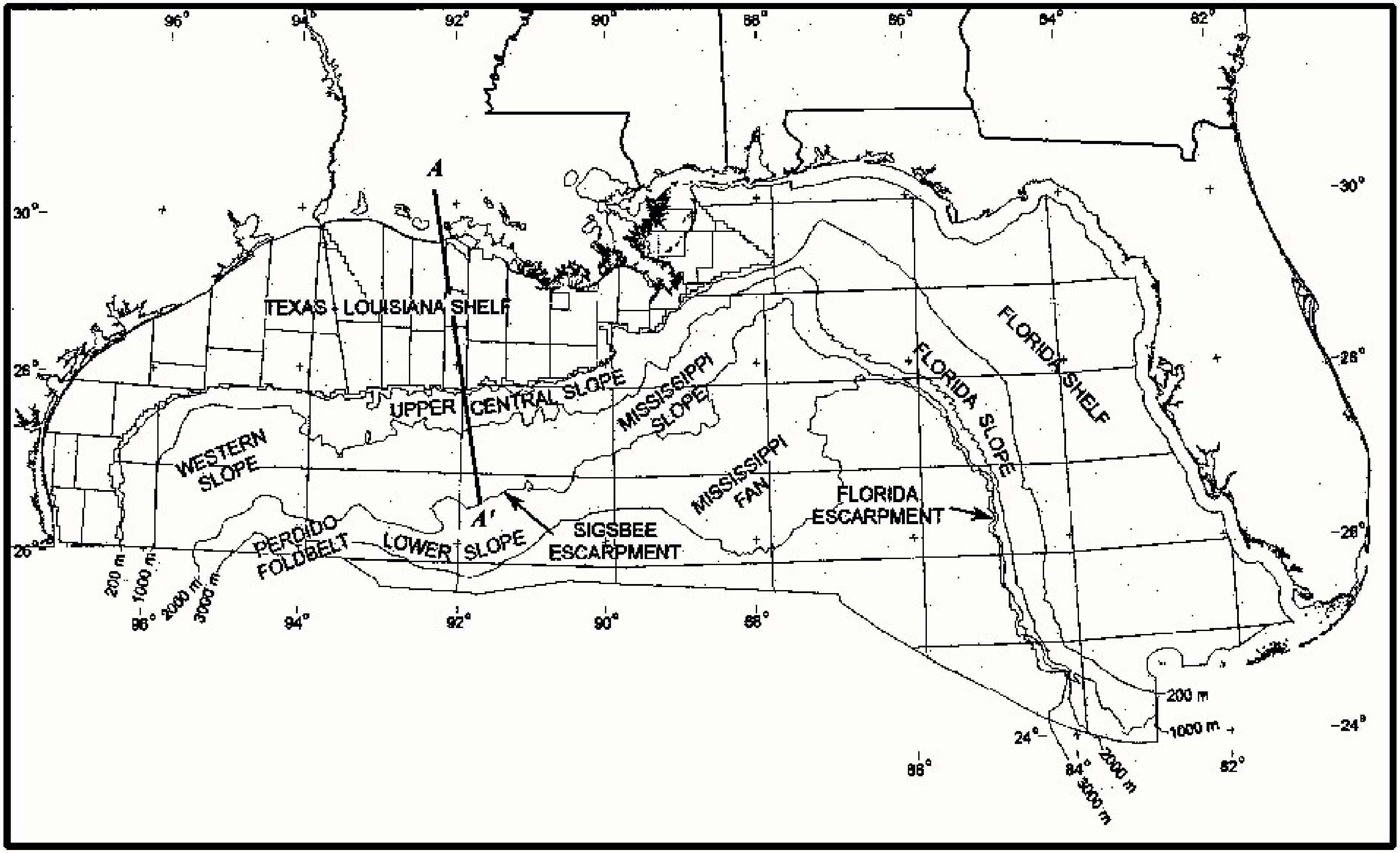

Figure III-1. Major Physiographic Features of the Gulf of Mexico Outer Continental Shelf.

subregion, containing salt structures that are ridges, pillow-like swells, and tongues relatively near the mudline; sedimentary sections above salt features are thin and generally lack major growth faulting.

The sedimentary deposits consisting of mostly shale, silt, and sands are underlain in most areas by the Louann Salt, considered the source of the salt intrusions. The section thickness above the salt varies from a thin veneer of a few thousand feet covering salt ridges and tongues in the lower slope subregion to more than 30,000-ft sediment accumulations in the basins and troughs in the upper slope areas (Figure III-2). The closed topographic depressions surrounded by local diapiric highs are known as intra-slope basins. The inter-domal basins, troughs, and submarine canyons are filled with clastic (sand, silt, and clay) deposits. The growth faulting, a major structural phenomenon, is common only in sedimentary sections of upper slope basins. The ages of sediments beneath the continental slope range from Middle Jurassic through Holocene, of which the Plio-Pleistocene section is by far the thickest and most prospective. Most intra-slope basins in the lower slope subregion are filled with mainly Pleistocene age sediments.

C. Hydrocarbon Potential

The Gulf of Mexico OCS is considered a hydrocarbon-prone basin that has production from Pleistocene, Pliocene, Miocene, Oligocene, Lower Cretaceous, and Upper Jurassic age sediments found in more than 2,000 discovered hydrocarbon accumulations called pools. The vast majority of these pools are located on the shelf (< 200 m water depth), which is considered a mature producing area. A group of known and/or postulated pools that share common geologic, geographic, and temporal properties, such as history of hydrocarbon generation, migration, reservoir development, and entrapment, are commonly referred to as a play. The largely unexplored deepwater area lends itself to the extension of known shelf plays and to the exploration of unknown wildcat plays. Examples of future deepwater exploration targets in the next 10 years will be the Mississippi Fan Foldbelt, Sigsbee Escarpment, and the Perdido Foldbelt. These plays are in ultradeep water and will require specialized drilling equipment and technological breakthroughs to make them economically viable.

The MMS periodically estimates the hydrocarbon resources of the OCS for regulatory and leasing strategy. Resources, by definition, include all naturally occurring liquids and gaseous hydrocarbons that can conceivably be discovered and recovered. The term encompasses both discovered and undiscovered hydrocarbons. When resource potential is discussed, the term undiscovered conventionally recoverable resources (UCRR's) is often applied. The UCRR's are hydrocarbons in undiscovered accumulations analogous to those in existing fields producible with current recovery technology and efficiency, but without consideration of economic viability. These accumulations are of sufficient size and quality to be amenable to conventional primary and secondary recovery techniques. These resources are primarily outside known field limits and are "risked" to determine the estimate. In 1995, the MMS estimated the risked mean of the UCRR of the Gulf's deep water to be approximately 13 billion barrels of oil equivalent (BBOE).

Hydrocarbon reserves in deepwater fields can be designated as proved or unproved. The MMS defines proved reserves as those quantities of hydrocarbons that can be estimated with reasonable certainty to be commercially recoverable from known reservoirs and under current economic conditions, operating methods, and government regulations. Proved reserves must have either facilities operational at the time of the estimate to process and transport those reserves to market, or a commitment or reasonable expectation to install such facilities in the future. Unproved reserves are those quantities of hydrocarbons that can be estimated with some

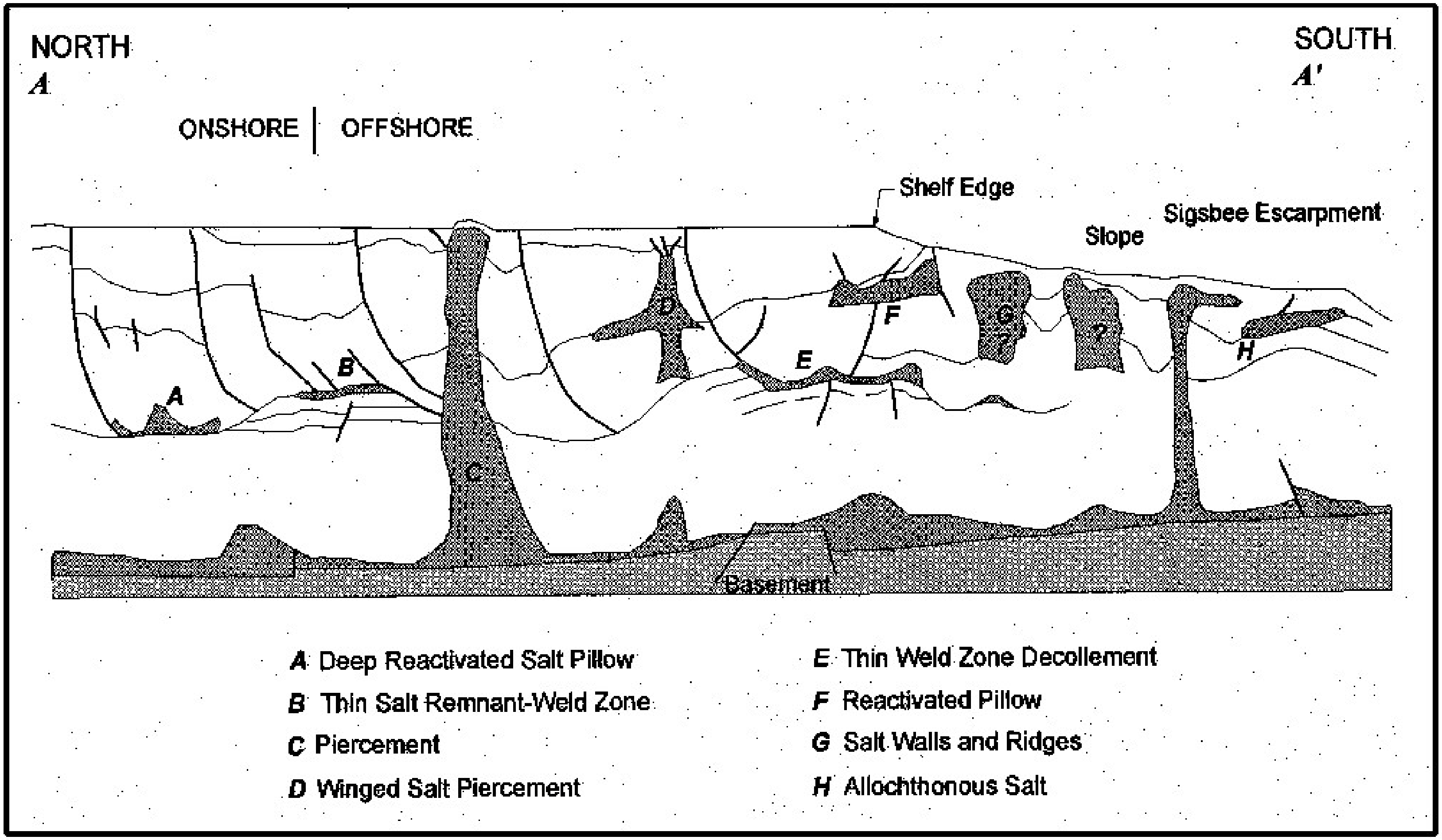

Figure III-2. Cross-Section A-A', Gulf of Mexico Cenozoic Province Identifying Various Salt Features (modified from Brooks, 1993).

certainty to be potentially recoverable from known reservoirs, assuming future economic conditions and technological developments. As of the end of 1996, the remaining proved reserves in the deepwater Gulf were 2.196 BBOE with unproved reserves estimated at 1.374 BBOE by MMS.

D. Geologic Hazards

In the search for and subsequent development and production of hydrocarbons, operators encounter certain problems associated with geologic hazards. Geologic hazards are defined as naturally occurring conditions that might impede or present a risk to exploration, development, or production operations. Many hazards are found throughout the Gulf of Mexico; others are confined to specific areas. High-resolution geophysical surveys provide information and data needed to analyze potential geologic hazards that pose engineering and operational constraints to exploration and development activities. These hazards can usually be effectively mitigated by existing technology, design, and procedures. In most cases, avoidance is the chosen option, but mitigation is an effective and economic alternative in certain cases.

Most geologic hazards that could affect drilling operations can be circumvented with a properly designed and diligently executed drilling program based on information from geophysical surveys and the drilling information from nearby wellbores. A common drilling hazard in the Gulf is geopressure. A pressure/depth gradient of 0.43 psi/ft is considered normal during drilling. However, when a seal occurs in a confined section and inhibits dewatering of the sediments, abnormally high pressure, called geopressure, can develop. Pressure gradients can approach 1.0 psi/ft.

Some deepwater wells have encountered shallow, slightly overpressured water-bearing sand layers, called water sands. These sands appear to be widely scattered across the deepwater areas of the Gulf of Mexico. The water sands are generally in the upper portions of the geologic section, but may lie several thousand feet below the mudline. On deepwater drilling projects, operators have extended the portion of the well normally drilled "riserless" to a depth of approximately 2,000 ft below the mudline. Problems have occurred after sweeps to clean cuttings from the borehole have reduced hydrostatic forces and allowed the water from the water sands to flow into the well. The water flow may destabilize the well, washing out the sediments around the drill site. The consequences of a shallow-water flow may range from drilling delays to loss of the well site.

The International Association of Drilling Contractors (IADC) has devoted a 42-page section to shallow-water flow control in its well planning chapter of the Deepwater Well Control Guidelines (IADC/OOC, 1998). This section of the guidelines addresses geophysical prediction, drilling techniques, pore pressure and fracture gradient predictions, cementing techniques, and mechanical shutoff devices to help contend with shallow-water flows.

The MMS believes that detection and avoidance of the potential overpressured shallow-water zones remains the best mitigation to minimize risks for a drill site. The MMS web site www.gomr.mms.gov/homepg/offshore/safety/wtrflow.html depicts shallow-water flow incidents.

Suggested Research and Information Synthesis: The ability to predict and avoid areas of potential shallow-water flow may require development of regional information and specialized maps to display known and suspected overpressured water sand zones. The maps should be based on geologic and geophysical data from all sources. Sharing of information would save millions of dollars in data collection and would help in avoiding potential future drilling problems.

Gaseous sediments, hydrocarbon seeps, and vents may indicate areas of potential geologic hazards. Gaseous sediments may result from decomposition of organic matter or may be gas from a deeper reservoir that has migrated into surficial sediments along faults. Gaseous sediments may have lower shear strength and less load-bearing capacity than nongaseous sediments, so the stability of bottom-founded structures may be of concern. Seeps and vents may indicate near-surface faulting. Hard substrates, called hardpans, are often associated with hydrocarbon seeps. They are solid carbonate strata formed at the mudline by anaerobic organisms. Hardpans have greater density than the unconsolidated sediments, which can affect the drilling program and the anchoring or mooring of drill rigs or production platforms/structures. Chemosynthetic communities are associated with seeps. Chemosynthetic communities are protected resources, and OCS operations are required to avoid impacting them.

The topography of the seafloor in the deepwater areas of the Gulf has both local and regional dip that makes the occurrence of landslides a threat. Unconsolidated surficial sediments are water saturated and susceptible to mass movement, which can be triggered by earthquakes, storm surges, faulting, sediment loading, dissociation of hydrates, or dewatering processes. This mass movement of sediment can be a local event or cover a large area. The slope of the seafloor controls the direction and speed of the slides. There is an increased risk of sediment failure near steep slopes and scarps, especially along the Sigsbee Escarpment. Although the actual loss of operational equipment (drill string, conductor casing, drilling rig, production platform/structure, riser, subsea production tree, or pipeline) to a landslide is a rare occurrence, the hazard is real. The risk associated with mass movement can be reduced through careful design, siting, and structural engineering.

The topography of the continental slope is very uneven. Mud volcanoes, mud mounds and ridges, salt diapir formations, channels and canyons, escarpments, and consolidated lumps of biogenic calcium carbonate are found throughout the area. Uneven seafloor topography presents challenges to mooring, structure siting, and pipeline routing and emplacement.

Shallowly buried channels or new channel fill may also pose a hazard to deepwater operations. Possible contrasts in load-bearing capacity of the seafloor may exist over short vertical and horizontal distances.

A phenomenon called gas hydrates is also found in the deepwater areas of the Gulf of Mexico. Gas hydrates are natural, solid methane-water ice matrices that form under conditions of high pressure and low temperatures in water depths greater than 300 m. Chemosynthetic community “ice worms” have been found associated with hydrates exposed at the seafloor. Hazards arise from the fact that hydrates are only quasi-stable. The dissociation of hydrates can be gradual or instantaneous. Drilling into the gas hydrates can result in problems in well control and the release of methane into the wellbore and/or water column. Hydrates can also cause sediment instability. Physical disturbances can cause the hydrates to dissociate, which may result in seafloor collapse or subsidence.

In deep water, as in other areas of the Gulf, there is a risk of encountering sour gas or liquids that contain sulfur, hydrogen sulfide (H_2S), and/or carbon dioxide (CO_2). These substances create problems in drilling, production, and processing the hydrocarbons due to their toxicity and corrosive nature. Specialized equipment must be used in the detection, treatment, and/or separation of the hydrogen sulfide, carbon dioxide, and sulfur from the production stream. Based on the amount of H_2S, CO_2, and sulfur, and the field’s volume, another cost variable must be considered in determining the economic feasibility of extracting the hydrocarbons.

E. Physical Oceanography

The Gulf is unique among the world's mediterranean seas, having two entrances: the Yucatan Strait and the Straits of Florida (Figure III-1). Both straits restrain communication from the deep Atlantic waters because of the limited sill depths--1,600 m and 1,000 m, respectively. The water volume of the Gulf, assuming a mean water depth of 2 km, is 2 million km^3. The water volume over the continental shelf, assuming a mean water depth of 50 m, is just over 1 percent of the total volume. A portion of the Gulf Stream system, the parent Loop Current, whose presence and influence are described below, is present in the Gulf. The amount of freshwater input to the Gulf basin from precipitation and a large number of rivers--dominated by the Mississippi and Atchafalaya Rivers--is enough to influence the hydrography of most of its northern shelves.

Sea-surface temperature is nearly isothermal (about 30^o C) in August, but sharp north-south horizontal gradients are present in January, ranging from 25^o C in the Loop core down to 14-15^o C along the shallow northern coastal estuaries. August temperatures at 150 m depth show a warm Loop Current and an anticyclonic feature in the Western Gulf (both about 18-19^o C) grading horizontally into surrounding waters (the Gulf Common Water, see below) at 15-16^o C. The winter temperature pattern is similar, but about 1^o colder. At 1,000 m water depth, the temperature remains close to 4.9^o C year-round.

Surface salinities along the northern Gulf display seasonal variations because of the cycles of freshwater input from local precipitation and rivers. During months of low freshwater input (fall-winter months), deep Gulf water penetrates into the shelf, and salinities near the coastline range between 29 and 32 practical salinity units (psu). High, freshwater-input conditions (spring-summer months) are characterized by strong horizontal gradients and inner-shelf salinity values of less than 20 psu.

Table III-1 shows the characteristic seven major watermasses identified in the Gulf, down to about 1,000 m. This profile arrangement illustrates the influence of the Atlantic Ocean in the Gulf hydrography and reflects the changes in source water characteristics brought about by the local climatology and hydrology. The main result is the creation of the Gulf Common Water, confined to the surface layer through most of the Gulf basin. Intimately related with the vertical distribution of temperature is the seasonal thermocline, defined as the depth at which the temperature gradient is at maximum. During January, the thermocline depth is about 30-61 m in the Eastern Gulf and 91-107 m in the Central and Western Gulf. In May, the thermocline depth is about 46 m throughout the entire Gulf (Robinson, 1973).

Sharp discontinuities of temperature and/or salinity at the sea surface, such as the Loop Current front or fronts associated with eddies or river plumes, are dynamic features that may act to concentrate buoyant material (i.e., oil, detritus, or plankton). Motion of such materials here is principally along the front because the water moves sideways (along the front) faster than it pushes in and out (perpendicular to the front). In addition to open ocean fronts, a coastal front, which separates turbid, lower salinity water from the open-shelf regime, is probably a permanent feature of the northern Gulf shelf, with a width that varies between a few km and 100 km. The Loop Current, a highly variable current feature, enters the Gulf through the Yucatan Strait and exits through the Straits of Florida (as the Gulf Stream) after tracing a clockwise (anticyclonic) arc that may intrude as far north as the Mississippi-Alabama shelf. The Loop consists of ascending and descending 25- to 50-km wide bands of rapidly moving water enclosing a relatively quiescent inner region, and the entire feature may be clearly seen in hydrographic sections down to 800-1,000 m. Below that depth, there is evidence of a countercurrent. The volumetric flux of the Loop has been estimated at 30 million m^3/sec. Velocities up to 300 cm/sec have been measured, but a range of 100-200 cm/sec is probably representative.

The “location” of the Loop Current is definable only in statistical terms, due to its great variability. Figure III-3 shows the relative existence probabilities for Loop Current water, based on an analysis of 10 years of satellite images (SAIC, 1989). Values range from a 100-percent core location at 25^{o} N, down to small probabilities (10%) near midshelf.

Table III-1

Watermass Characteristics in the Gulf of Mexico

Watermass	Characteristic	Parameter Value Associated with the Characteristic	Depth Range (m)	Remarks
Gulf (Common) Water	Salinity maximum	34.6-36.5 psu	0-250	Gulfwide
Subtropical Underwater (SUW)	Salinity maximum	<36.8 psu	100-300	Permanent in Eastern Gulf; occasionally found in the Western Gulf in Loop Current eddies
18° Sargasso Seawater (18°SSW)	Oxygen maximum	Small and variable	200-400	Permanent in Eastern Gulf; hinted at in a “shoulder” in the oxygen-vs-depth curve
Tropical Atlantic Central Water (TACW)	Oxygen minimum	2.5-2.9 ml/l	250-400	Gulfwide
Antarctic Intermediate Water (AIW)	Nitrate maximum	29-35 ug-at/l	500-700	Gulfwide
AIW	Phosphate maximum	1.7-2.5 ug-at/l	600-800	Gulfwide
AIW	Salinity minimum	34.88-34.89 psu	700-800	Gulfwide

Periodically (but not “regularly”), the Loop Current extends far to the north and pinches off most of its mass in the form of an anticyclonic “warm core eddy” or “Loop Current eddy” (referred to below simply as an “eddy”). Recent analysis of frontal-position data indicates that the eddy-shedding period varies between 6 and 18 months with an average of about one year. Eddies have diameters on the order of 300-400 km and may clearly be seen in hydrographic data to a depth of about 1,000 m. Surface velocities within the eddies have been reported from 50 to 200 cm/sec, decreasing logarithmically to negligible velocities by a depth of 800-1,000 m. Eddies move into the Western Gulf along various paths to a region between 25^{o} and 28^{o} N. and 93^{o} and 96^{o} W., at speeds ranging from 2 to 5 km/day, decreasing in size as they mix with resident waters. The life of an individual eddy to its eventual disappearance into the regional circulation pattern in the Western Gulf is about one year.

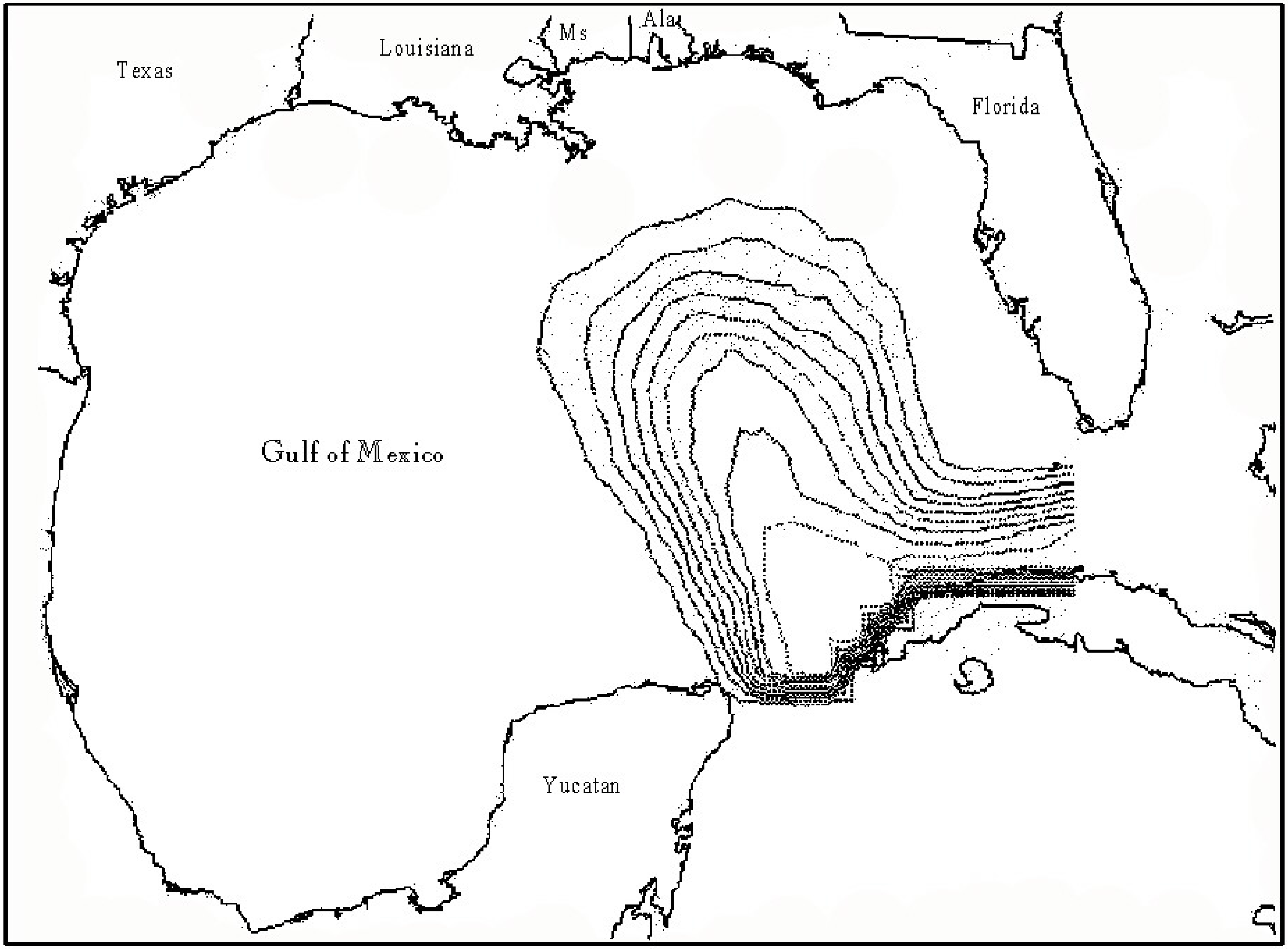

Figure III-3. Loop Current.

Eddy-shedding from the Loop Current is the principal mechanism coupling the circulation patterns of the eastern and western parts of the basin. The heat and salt budgets of the Gulf are dependent on this importation, balanced by seasonal cooling and river input, and probably also by internal, deeper currents that are poorly understood. These currents may be evident in intriguing hints of abyssal bottom scour and the reversed currents beneath the Loop itself. The eddies are frequently observed to affect local current patterns along the Louisiana-Texas slope, hydrographic properties, and possibly the biota of fixed platforms or hard bottoms. There is some evidence that these large reservoirs of warm water play a role in strengthening tropical cyclones when their paths coincide.

When eddies enter the area of deepwater oil and gas activity, they can have a very disruptive impact. Depending on the size and strength of the eddy, certain operations may have to be suspended because the associated currents do not allow specific types of marine engineering work. All offshore structures, however, are designed to withstand both maximum eddy currents and hurricane currents simultaneously, in the rare event that both might occur simultaneously.

Smaller anticyclonic eddies have been observed to be present in the northern Gulf, sometimes clearly generated by the Loop Current, although it is not known if they are merely a scaled-down version of larger Loop Current eddies. They have diameters on the order of 100 km, but the data available indicate a shallow hydrographic signature (on the order of 200 m) and very low velocities (on the order of 10 cm/sec). Their observed movements indicate a tendency to translate westward along the Louisiana-Texas slope, but they appear not to exist longer than about one month. Cold-core, anticlockwise-turning (cyclonic) eddies also occur on the slope throughout the northern Gulf, usually deeply imbedded in the water column. They typically are invisible to satellite sensors but are apparent from the cyclonic circulation pattern above them (at surface speeds of about 50 cm/sec) and from occasional hydrographic measures fortuitously taken across them. Cyclonic eddies seem to be able to exist for over a month. Limited information is available about their formation mechanisms or about possible interactions between them and both types of warm eddies.

Completely unstudied, but of great interest to the oil and gas industry, is the phenomenon of short-lived, intense current "jets" at mid-depths along the Louisiana-Texas slope. Typically, these predominantly eastward jets exist for hours to a few days and do not appear to be direct products of known Loop Current eddies. Because their speeds are on the order of 50 cm/sec (about 1 kn), they can have serious negative impacts on offshore operations (but not structural integrity *per se*) through delays in scheduling and through damage to some ancillary equipment. Academically interesting bottom-boundary-layer effects, caused by the interaction of east-west bottom currents with sloping topography, result in slight uphill-downhill shifts of benthic watermasses, but with associated current speeds that are far too low to affect operations or structural integrity.

Aside from the wind-driven surface layer, current regimes on the outer shelf and slope are the result of balance between the influence of open Gulf circulation features, such as the Loop Current and various types of eddies, and the shelf circulation proper, which is dominated by long-term wind forcing. A notable east-northeasterly current often present along the Louisiana-Texas slope has been explained partly by the effects of the remnants of anticyclonic eddies and the seasonally modulated cyclonic (anticlockwise) gyre circulation on the Louisiana-Texas shelf. The inshore limb of the gyre is the west-southwestward (downcoast) coastal current that prevails except in July-August. Because the coast is concave, convergence of coastal currents occurs at a location where the winds are normal to the shore, often in the vicinity of Padre Island. This return flow crosses the shelf and feeds a prevailing current toward the east-northeast along the shelf edge/slope. The coastal convergence at the western end of the gyre migrates seasonally with the direction of the prevailing wind, ranging from a point south of the Rio Grande in the fall to the Cameron, Louisiana, area by July. The gyre is normally absent in July but reappears in August-September when a downcoast wind component develops (Cochrane and Kelly, 1986).

Extreme surface currents and waves are caused by hurricanes and winter storms (extratropical anticyclones). Typically, during the approach and presence of a hurricane (on the order of 10-100 hours) current velocities at the surface, driven by intense winds, may approach 150 cm/sec. After the passage of the storm, intense "ringing" or rhythmic pulsing remains within the region, due to the inertial response of the shelf and slope watermass to the huge momentum impulse from the storm. The resulting "inertial currents" have speeds of up to 50 cm/sec, cycling clockwise for 3-5 days as they die out. Approximately 10 winter storms occur each year, with similar but reduced impacts.

Primarily on the basis of the results of the Gulf of Mexico Storm Hindcast of Oceanic Extremes (GUMSHOE) Study (Ward et al., 1979), the American Petroleum Institute has published (API, 1993) the best current estimate of the "100-year" wave height relation with depth. The GUMSHOE Study included the complete hindcasting of approximately 24 of the Gulf's worst historical hurricanes, and the API result is considered authoritative. From that work, the maximum wave at 100 m (and deeper) would be approximately 21 m; 100-year waves at lesser depths decrease accordingly. These data have been taken into account in overall API design criteria and in MMS's Notices to Lessees regarding offshore design criteria.

F. Air Quality and Meteorological Conditions

Operations west of 87.5° W. longitude fall under MMS jurisdiction for enforcement of the Clean Air Act; operations to the east are subject to USEPA air quality regulations. The air over the OCS water is not classified, but is presumed to be better than the National Ambient Air Quality Standards (NAAQS) for all criteria pollutants. Gulf coastal counties and parishes currently contain areas both attaining and not attaining the NAAQS for ozone; the NAAQS for the remaining criteria pollutants are met in all of the coastal areas (Figure III-4). The Breton National Wilderness Area (Figure III-5), south of Mississippi and northeast of the Mississippi Delta, is a Prevention of Significant Deterioration (PSD) Class I Area. Class I Areas are afforded the greatest degree of air quality protection. Very little deterioration of air quality is allowed in these areas. One of the purposes of the PSD program is to preserve, protect, and enhance the air quality in these designated areas.

Meteorological conditions may confine, disperse, or distribute air pollutants. Assessments of air quality depend on multiple variables such as the quantity of emissions, dispersion rates, distances between sources and receptors, and local meteorology. The primary meteorological influences upon air quality and the dispersion of emissions are the wind speed and direction, the atmospheric stability class, and the mixing height. Due to the variable nature of these independent yet interrelated factors, pollutant plume transport and ambient air quality are ever-changing dynamic processes.

The general wind flow in the deepwater Gulf of Mexico is driven by the clockwise circulation around the Bermuda High, resulting in a prevailing southeasterly to southerly flow. Superimposed upon this circulation are smaller scale effects such as the sea breeze effects, tropical cyclones, and mid-latitude frontal systems. Because of the various factors, the winds do blow from all directions in the deepwater areas.

A common method of describing atmospheric stability is with the Pascal-Gifford classification. Not all of the Pascal-Gifford stability classes are observed offshore in the Gulf of Mexico. For the most part, the stability of the air mass over the Gulf is slightly unstable to neutral. The extreme ends of the scale are markedly rare. The extremely stable condition, Stability Class F, usually develops at night over land with rapid radiative cooling. The large

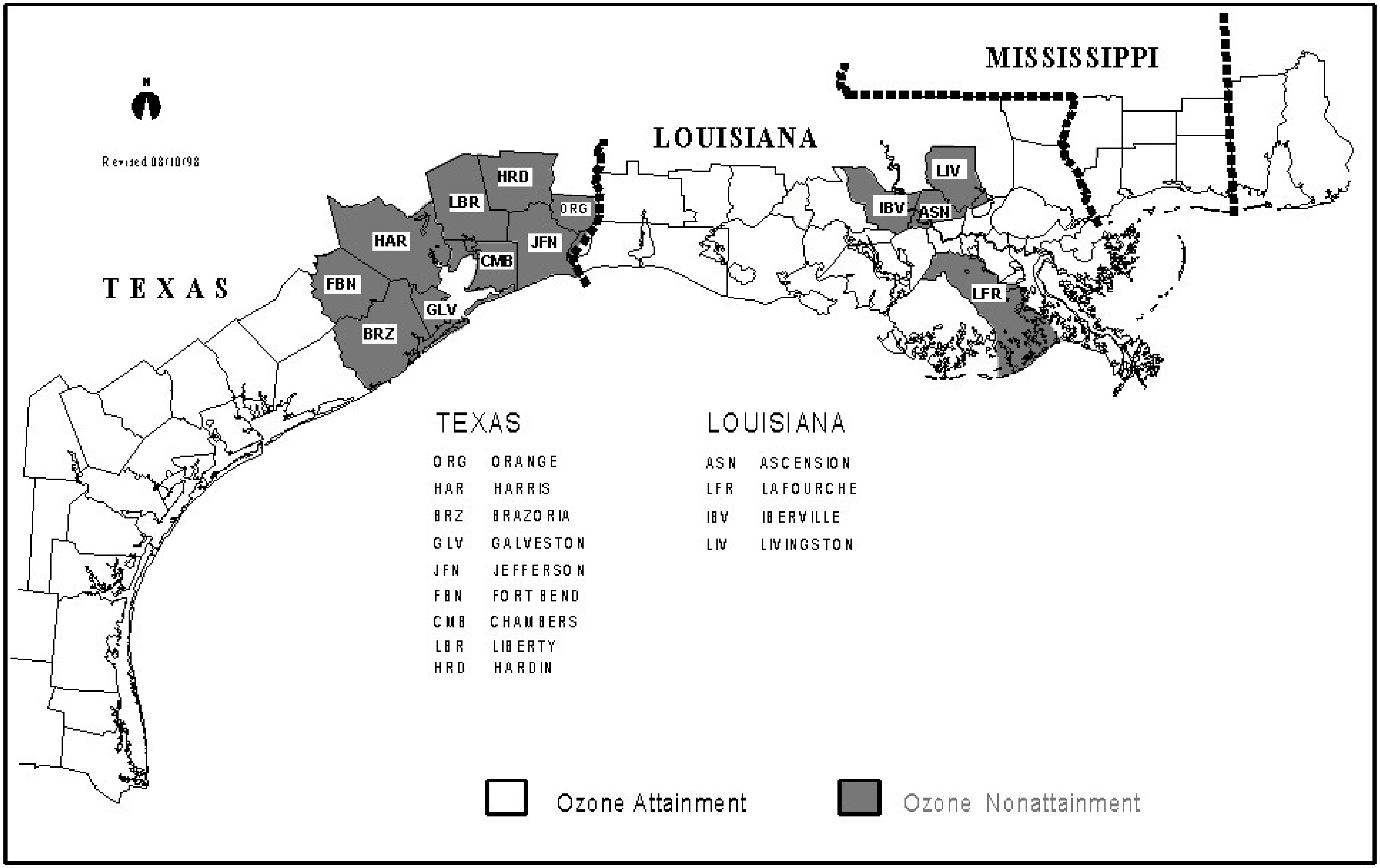

Figure III-4. Status of Ozone Attainment in the Coastal Counties and Parishes of the Central and Western Gulf of Mexico (based on the NAAQS effective 8/10/98).

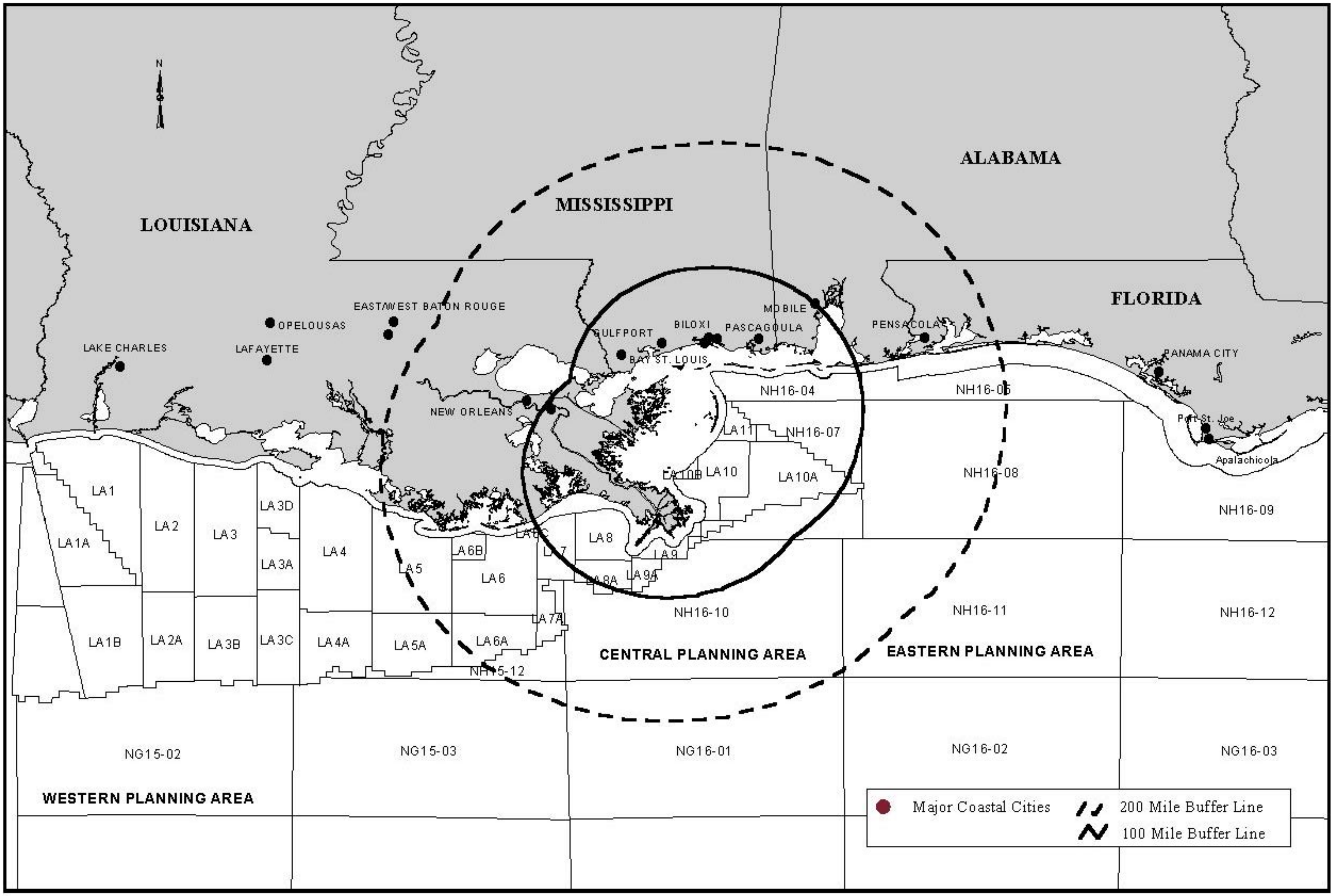

Figure III-5. Breton National Wilderness Area.

body of water of the Gulf is simply incapable of losing enough heat overnight to set up a strong radiative inversion. The extremely unstable condition, Stability Class A, usually requires a very rapid warming of the lower layer of the atmosphere along with cold air aloft. This is normally brought about when cold air is advected aloft and strong insolation rapidly warms the earth's surface, which, in turn, warms the lowest layer of the atmosphere. Once again, the ocean surface is incapable of warming rapidly; therefore, Stability Class A is not expected over the Gulf of Mexico.

The mixing heights offshore are quite shallow, generally 900 m or less. Transient cold fronts have an impact on the mixing heights; some of the lowest heights can be expected to occur with frontal passages and on the cold air side of the fronts. This effect is caused by the frontal inversion.

G. Multiple Uses of the OCS

1. Fisheries

Commercial fishers in the United States landed over 9.6 billion pounds of edible and industrial fishery products in 1996. Approximately 1.5 billion pounds of fishery products were harvested from the Gulf of Mexico by the commercial fishers. Forty-two percent of all fish caught and 29 percent of all fishing trips by recreational fishers were in the Gulf of Mexico in 1996. Although the quantity of commercial landings from deep water is comparatively small, these species are of high value.

Unlike fishing in shallower parts of the Gulf, fisheries in the deep waters of Gulf are not distributed over large areas; not all deepwater areas hold enough of the economically important species to support a fishery. Perhaps for this reason there are a greater variety of fisheries in the deep waters of the Gulf. These fisheries include the following:

- bottom longlining for snapper, grouper, and tilefish by commercial fishers and hook-and-line recreational fisheries for these same species;
- mid-water longlining for tunas, swordfish, and shark by commercial fishers and hook-and-line recreational fisheries for these same species;
- bottom trawling for royal red shrimp and mid-water trawling for butterfish; and
- bottom trapping for golden and red crabs.

Recreational fishing is the only recreational activity that occurs with any regularity in the deep waters of the Gulf of Mexico. Large private boats and some charter boats will travel to the deep waters of the Gulf of Mexico to pursue blue-water game fish such as marlin, wahoo, and tunas. Typically, this is a troll-type fishery in which specially equipped big-game fishing boats use outriggers to drag several baits all day long for many miles. The closer the deep water is to shore or to major population and marina areas, the more likely it is to attract big game or billfishing activity because of accessibility. Deep waters occur as close as 15 mi off the mouth of the Mississippi River, which has resulted in the development of a major offshore recreational fishery in the areas offshore southeast Louisiana and the Mississippi coast. That is not to say that fishing does not occur in the more remote deep waters 100-200 mi from shore, b*ut the inaccessibility discourages all but the most determined and affluent fishermen. Besides the Mississippi Delta area, other well-known underwater topographic features, such as the

Mississippi and DeSoto Canyons, and manmade structures, such as drilling rigs and production systems, attract target species and consequently attract fishermen far offshore in pursuit.

The deep waters of the Gulf of Mexico appear to be a major spawning area for many of the fishery resources mentioned above. The complex currents of deep water critically affect the resultant offspring of all species above, but especially the highly migratory tunas and swordfish since they utilize the water column as a nursery ground. Information is limited about the early life histories of these species or of the many other species found in deepwater areas. Information on fish larvae from deepwater areas of the Gulf of Mexico is limited. In the vicinity of Viosca Knoll and DeSoto Canyon, ichthyoplankton surveys are available from only two seasons and two errant locales.

2. Department of Defense Activities

The Department of Defense (DOD) has designated areas in the Gulf of Mexico for conducting military training, operations, and testing. Many of the blocks within these warning areas are leased, especially in the Central Planning Area. Figure III-6 shows the location of the designated military warning areas in the Gulf of Mexico.

Activities conducted by the DOD within these areas vary in mission and duration. Examples of the types of activities that might be conducted include vessel and aircraft training missions, as well as equipment and weapons testing. The duration of operations within the areas is highly variable.

The MMS, in conjunction with the DOD, developed a military area stipulation that is applied to all leased blocks within any of the designated military warning areas. The purpose of the stipulation is to mitigate potential multiple-use conflicts on the OCS. A brief summary of the stipulation's parts is provided below.

The military area stipulation is composed of three parts:

- The *Hold and Save Harmless* portion of the stipulation serves to protect the U.S. Government from liability in the event of an accident involving the lessee/operator and military activities.
- The *Electromagnetic Emissions* portion of the stipulation requires the lessee/operator and its agents to reduce and curtail the use of radio or other equipment emitting electromagnetic energy within certain designated areas. This serves to reduce the effects of oil and gas activities on the communications of military missions. The stipulation also reduces the possible effects of electromagnetic energy transmissions on Department of Defense flight, testing, or operational activities conducted within individual designated warning areas.
- The *Operational* portion of the stipulation requires the lessee/operator to enter into an agreement with designated command headquarters. The lessee/operator must notify the military of oil- and gas-related activities that take place within the designated military warning areas. This allows the base commanders and their staff to plan military missions and maneuvers to avoid these areas. Prior notification to the military helps reduce the potential effects associated with vessels and/or aircraft traveling unannounced through areas where active military operations are underway.

The Department of the Defense disposed of old ordnance and unexploded (duds) shells and depth charges in areas of the Gulf. Although dumping has not taken place in any of these areas

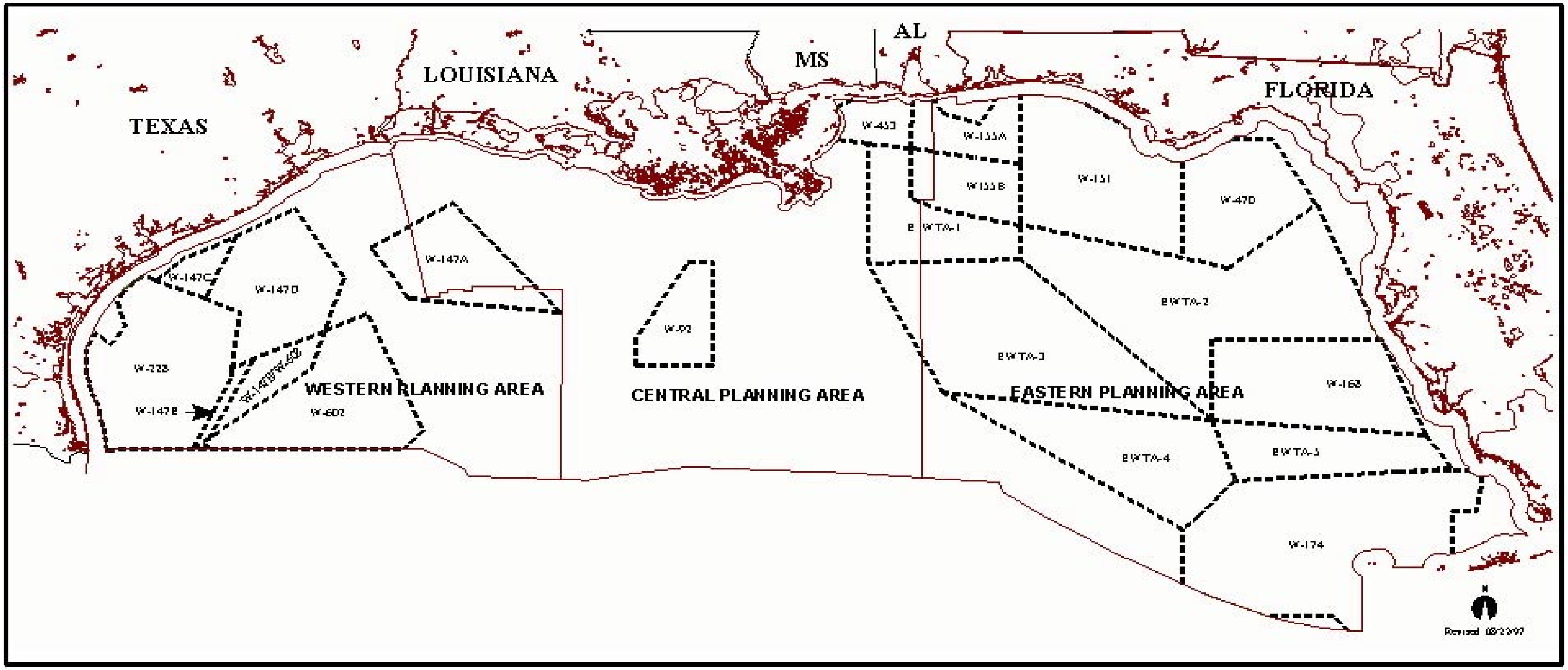

Figure III-6. Military Warning Areas in the Gulf of Mexico.

since 1969-1970, all lessees and operators should take precautions in drilling and locating structures within or near these areas because of the presence of unexploded ordnance.

3. Lightering Areas

Traditionally, lightering operations involve the offloading of imported crude oil from very large crude carriers (VLCC) or ultra large crude carriers (ULCC) to smaller shuttle tankers at sea. These small tankers then transship the crude to shore terminals for offloading. The deep draft of the fully loaded VLCC and ULCC prevents these tankers from docking at shore-based port facilities. These vessels also have the option of delivering their cargos to the Gulf's offshore deepwater port, LOOP.

Lightering operations at sea are generally conducted with both vessels under low power. This forward motion maintains steerage, and power is available for additional maneuvering operations. Lightering operations begin with the two vessels being secured together; flexible transfer lines are connected to the tankers' manifold systems. Pumping is initiated and the crude is transferred. The ships are decoupled and the shuttle tanker heads for port. Multiple shuttle tanker "runs" are required to completely offload the cargo from the larger vessel.

On August 29, 1995, the USCG designated four lightering zones in the Gulf of Mexico (Figure III-7), each located more than 60 mi from the baseline from which the territorial sea of the U.S. is measured. Single-hull tank vessels contracted for after June 30, 1990, and older single-hull tank vessels phased out by the Oil Pollution Act of 1990 can use these designated lightering zones until January 1, 2015. After that date, single-hull vessels will not be permitted to offload oil in the U.S. Exclusive Economic Zone (EEZ).

The USCG also established three adjacent areas in the Gulf of Mexico where all lightering is prohibited (Figure III-7). These areas were identified as areas of concern about the potential impacts from lightering-related oil spills on sensitive communities associated with topographic features.

The USCG prepared an EA, dated October 25, 1994, to evaluate the potential environmental effects from the designation of the lightering zones. Their evaluation resulted in a Finding of No Significant Impact.

As more drilling and production activities occur in or near the designated lightering zones, both MMS and USCG are concerned about minimizing the potential for collisions between moving lightering vessels and stationery OCS structures. All offshore facilities are required to have and maintain aids to navigation. These aids may include signs, lights, fog horns, and other equipment to warn vessels. In addition, the location of fixed structures on the OCS is published in the Notice to Mariners and may also be depicted on navigational charts. The USCG is also examining collision avoidance systems that may improve navigational safety.

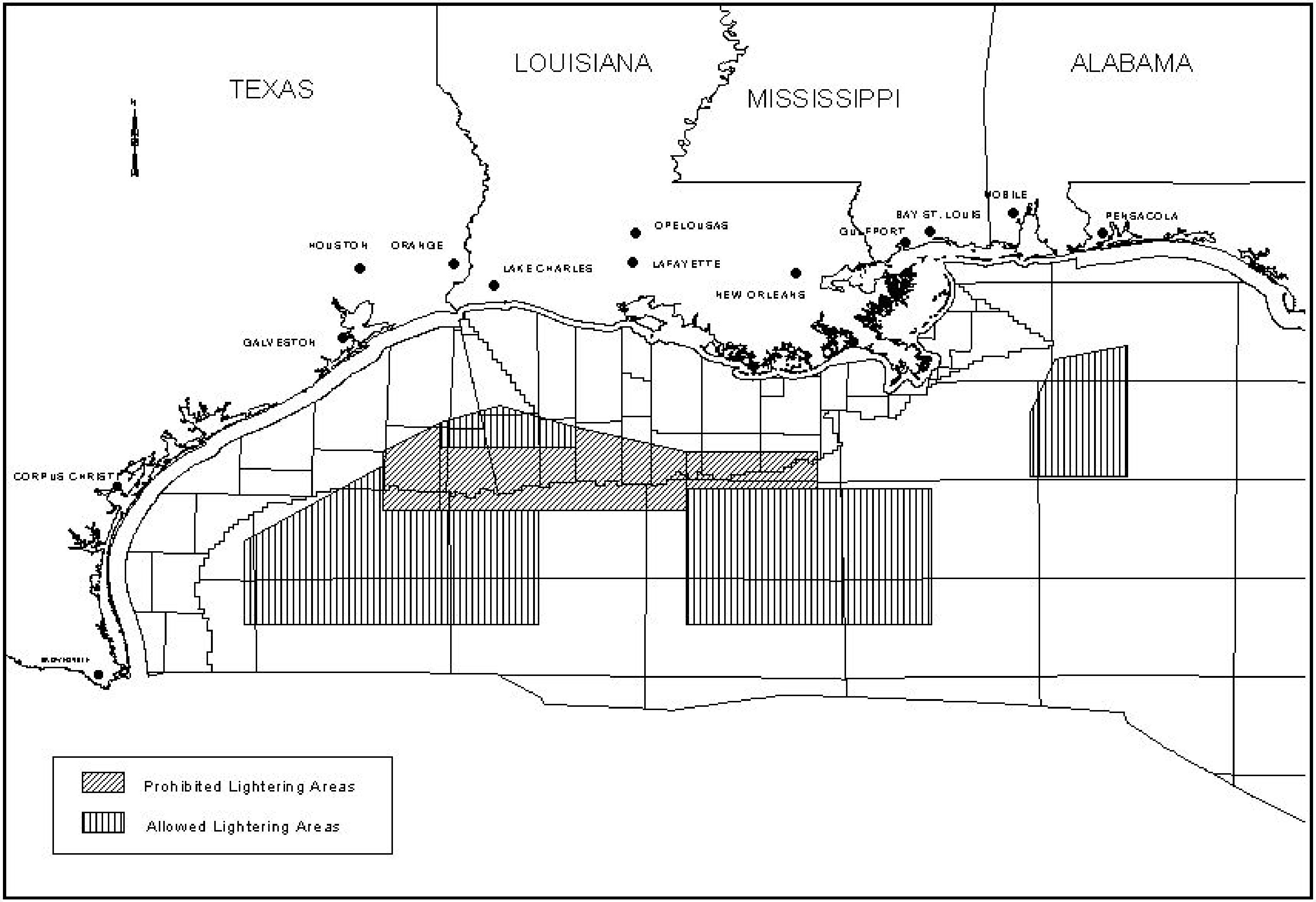

Figure III-7. Lightering and No Lightering Zones in the Gulf of Mexico (U.S. Coast Guard).

CHAPTER IV

ENVIRONMENTAL AND SOCIOECONOMIC RESOURCES AND IMPACT ANALYSES

IV. ENVIRONMENTAL AND SOCIOECONOMIC RESOURCES AND IMPACT ANALYSES

A. Chemosynthetic Communities

1. Description

Chemosynthetic communities are remarkable in that they utilize a carbon source independent of photosynthesis and the sun-dependent photosynthetic food chain that supports all other life on earth. Although the process of chemosynthesis is entirely microbial, chemosynthetic bacteria and their production can support thriving assemblages of higher organisms through symbiosis. The first discovery of deep-sea chemosynthetic communities including higher animals was unexpectedly made at hydrothermal vents in the eastern Pacific Ocean during geological explorations (Corliss et al., 1979). The principal organisms included tube worms, clams, and mussels that derive their entire food supply from symbiotic chemosynthetic bacteria, which obtain their energy needs from chemical compounds in the venting fluids. Similar communities were first discovered in the Eastern Gulf of Mexico in 1983 at the bottom of the Florida Escarpment in areas of Acold@ brine seepage (Paull et al., 1984). The fauna here was found to be generally similar to vent communities including tube worms, mussels, and rarely, vesicomyid clams.

Chemosynthetic communities in the Central Gulf of Mexico were fortuitously discovered by two groups concurrently in November 1984. During investigations by Texas A&M University to determine the effects of oil seepage on benthic ecology (until this investigation, all effects of oil seepage were assumed to be detrimental), bottom trawls unexpectedly recovered extensive collections of chemosynthetic organisms including tube worms and clams (Kennicutt et al., 1985). At the same time, LGL Ecological Research Associates was conducting a research cruise as part of the multiyear MMS Northern Gulf of Mexico Continental Slope Study (LGL and Texas A&M University, 1986). Bottom photography resulted in clear images of vesicomyid clam chemosynthetic communities. A subsequent LGL/MMS cruise also photographically documented tube worm communities *in situ* in the Central Gulf of Mexico (Boland, 1986) prior to the initial submersible investigations and firsthand descriptions of Bush Hill in 1986 (Rosman et al., 1987; MacDonald et al., 1989).

a. Distribution

The northern Gulf of Mexico slope includes a stratigraphic section more than 10 km thick and has been profoundly influenced by salt movement. Oil in most of the Gulf slope fields is generated by Mesozoic source rocks from Upper Jurassic to Upper Cretaceous in age (Sassen et al., 1993). Migration conduits supply fresh hydrocarbon materials through a vertical scale of 6-8 km toward the surface. The surface expressions of hydrocarbon migration are referred to as seeps. Geological evidence demonstrates that hydrocarbon and brine seepage persists in spatially discrete areas for thousands of years. The time scale for oil and gas migration (combination of buoyancy and pressure) from source systems is on the scale of millions of years (Sassen, 1997).

There is a clear relationship between known hydrocarbon discoveries at great depth in the Gulf slope and chemosynthetic communities, hydrocarbon seepage, and authigenic minerals including carbonates at the seafloor (Sassen et al., 1993). While the hydrocarbon reservoirs are broad areas several kilometers beneath the Gulf, chemosynthetic communities are isolated areas involving thin veneers of sediment only a few meters thick. Seepage from hydrocarbon seeps tends to be diffused through the overlying sediment, so the corresponding hydrocarbon seep communities tend to be larger (a few hundred meters wide) than chemosynthetic communities found around the hydrothermal vents of the Eastern Pacific (MacDonald, 1992). There are large differences in the concentrations of hydrocarbons at seep sites.

The widespread nature of Gulf of Mexico chemosynthetic communities was first documented during contracted investigations by the Geological and Environmental Research Group (GERG) of Texas A&M University for the Offshore Operators Committee (Brooks et al., 1986). The occurrence of chemosynthetic organisms dependent on hydrocarbon seepage has been documented in water depths as shallow as 290 m (Roberts et al., 1990) and as deep as 2,200 m (MacDonald, 1992). This depth range specifically places chemosynthetic communities in the deepwater region of the Gulf of Mexico, which is defined as water depths greater than 305 m (1,000 ft). Chemosynthetic communities are not found on the continental shelf. At least 43 communities are now known to exist in 41 OCS blocks (Figure IV-1 and Table IV-1). Although a systematic survey has not been done to identify all chemosynthetic communities in the Gulf, there is evidence indicating that many more such communities exist. The depth limits of discoveries probably reflect the limits of exploration (lack of submersibles capable of depths over 1,000 m). MacDonald et al. (1993 and 1996) have analyzed remote-sensing images from space that reveal the presence of oil slicks across the north-central Gulf of Mexico. Results confirmed extensive natural oil seepage in the Gulf, especially in water depths greater than 1,000 m. A total of 58 additional potential locations were documented where seafloor sources were capable of producing perennial oil slicks (MacDonald et al., 1996). Estimated seepage rates ranged from 4 to 70 bbl/day compared to less than 0.1 bbl/day for ship discharges (both normalized for 1,000 mi^2 (3,430 km^2)). This evidence considerably increases the area where chemosynthetic communities dependent on hydrocarbon seepage may be expected.

Table IV-1

Known Locations of Significant Chemosynthetic Communities in the Gulf of Mexico
(as of December 1996)

Lease Area	Block Numbers
Alaminos Canyon	645
Ewing Bank	1001, 1010
East Breaks	376, 339, 375, 380, 602
Garden Banks	297, 300, 342, 376, 382, 386, 387, 416, 424, 425, 458, 476, 500
Green Canyon	30, 40, 79, 81, 121, 140, 166, 185, 210, 216, 229, 232, 233, 234, 272, 287, 293, 310
Mississippi Canyon	969
Viosca Knoll	826

The densest aggregations of chemosynthetic organisms have been found at water depths of around 500 m and deeper. The best known of these communities was named Bush Hill by the investigators who first described it (MacDonald et al., 1989). It is a surprisingly large and dense community of chemosynthetic tube worms and mussels at a site of natural petroleum and gas seepage over a salt diapir in Green Canyon Block 185. The seep site is a small knoll that rises about 40 m above the surrounding seafloor in about 580-m water depth.

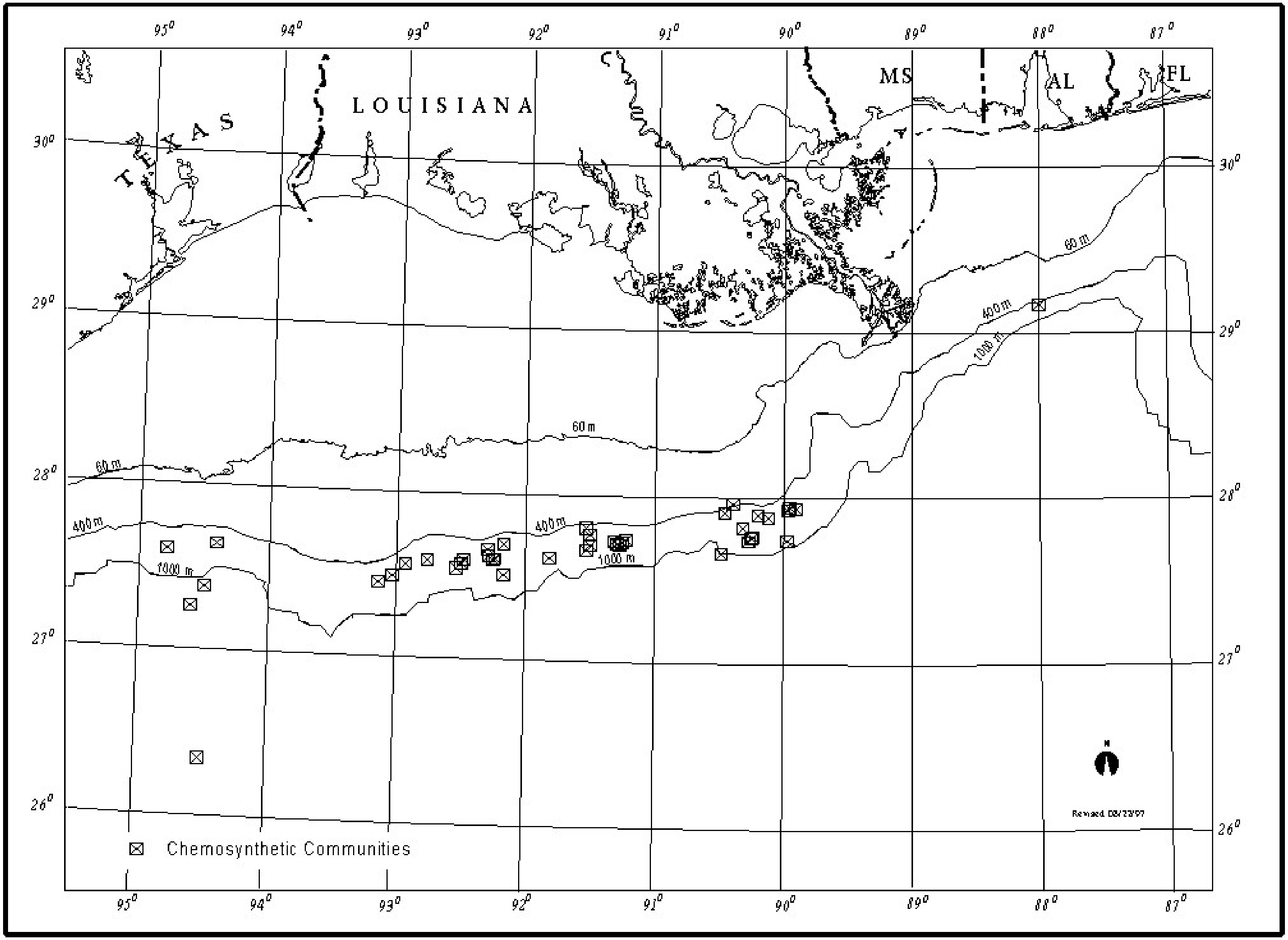

Figure IV -1. Location of Known Chemosynthetic Communities in the Gulf of Mexico.

b. Stability

According to Sassen (1997) the role of hydrates at chemosynthetic communities has been greatly underestimated. The biological alteration of frozen gas hydrates was first discovered during the recent MMS study AStability and Change in Gulf of Mexico Chemosynthetic Communities.@ It is hypothesized (MacDonald, 1998) that the dynamics of hydrate alteration could play a major role as a mechanism for regulation of the release of hydrocarbon gases to fuel biogeochemical processes and could also play a substantial role in community stability. Recorded, bottom-water temperature excursions of several degrees in some areas such as the Bush Hill site (4-5 EC at 500-m depth) are believed to result in dissociation of hydrates, resulting in an increase in gas fluxes (MacDonald et al., 1994). Although not as destructive as the volcanism at vent sites of the mid-ocean ridges, the dynamics of shallow hydrate formation and movement will clearly affect sessile animals that form part of the seepage barrier. There is potential of a catastrophic event where an entire layer of shallow hydrate could break free of the bottom and result in considerable impact to local communities of chemosynthetic fauna. At deeper depths (>1,000 m), the bottom-water temperature is colder (by approximately 3EC) and undergoes less fluctuation. The formation of more stable and probably deeper hydrates influences the flux of light hydrocarbon gases to the surface, thus influencing the surface morphology and characteristics of chemosynthetic communities. Within complex communities such as Bush Hill, oil seems less important than previously thought (MacDonald, 1998).

Through taphonomic studies (death assemblages of shells) and interpretation of seep assemblage composition from cores, Powell (1995) reported that, overall, seep communities were persistent over periods of 500-1,000 years. Some sites retained optimal habitat over geological time scales. Powell reported evidence of mussel and clam communities persisting in the same sites for 500-4,000 years. Powell also found that both the composition of species and trophic tiering of hydrocarbon seep communities tend to be fairly constant across time, with temporal variations only in numerical abundance. He found few cases in which the community type changed (from mussel to clam communities, for example) or had disappeared completely. Faunal succession was not observed. Surprisingly, when recovery occurred after a past destructive event, the same chemosynthetic species reoccupied a site. There was little evidence of catastrophic burial events, but two instances were found in mussel communities in Green Canyon Block 234. The most notable observation reported by Powell (1995) was the nearly perpetual uniqueness of each chemosynthetic community site.

Precipitation of authigenic carbonates and other geologic events will undoubtedly alter surface seepage patterns over periods of 1-2 years, although through direct observation, no changes in chemosynthetic fauna distribution or composition were observed at seven separate study sites (MacDonald et al., 1995). A slightly longer period (12 years) can be referenced in the case of Bush Hill, the first community described *in situ* in 1986. No mass die-offs or large-scale shifts in faunal composition have been observed (with the exception of collections for scientific purposes) over the 12-year history of research at this site.

c. Biology

MacDonald et al. (1990) has described four general community types. These are communities dominated by Vestimentiferan tube worms (*Lamellibrachia c.f. barhami* and *Escarpia* n.sp.), mytilid mussels (Seep Mytilid Ia, Ib, and III, and others), vesicomyid clams (*Vesicomya cordata* and *Calyptogena ponderosa*), and infaunal lucinid or thyasirid clams (*Lucinoma* sp. or *Thyasira* sp.). These faunal groups tend to display distinctive characteristics in terms of how they aggregate, the size of aggregations, the geological and chemical properties of the habitats in which they occur and, to some degree, the heterotrophic fauna that occur with them. Many of the species found at these cold seep communities in the Gulf are new to science and remain undescribed. As an example, at least six different species of seep mussels have been collected but none is yet described.

Individual lamellibranchid tube worms, the longer of two taxa found at seeps (the other is *Escarpia* sp.) can reach lengths of 3 m and live hundreds of years (Fisher et al., 1997). Growth rates determined from recovered marked tube worms have been variable, ranging from no growth of 13 individuals measured one year to a maximum growth of 20 mm per year in a *Lamellibrachia* individual. Average growth rate was 2.5 mm/yr for escarpids and 7.1 mm/yr for lamellibrachids. These are slower growth rates than those of their hydrothermal vent relatives, but *Lamellibrachia* individuals can reach lengths 2-3 times that of the largest known hydrothermal vent species. Individuals of *Lamellibrachia* sp. in excess of 3 m have been collected on several occasions representing probable ages in excess of 400 years (Fisher, 1995). Vestimentiferan tube worm spawning is not seasonal and recruitment is episodic.

Growth rates for methanotrophic mussels at cold seep sites have recently been reported (Fisher, 1995). General growth rates were found to be relatively high. Adult mussel growth rates were similar to mussels from a littoral environment at similar temperatures. Fisher also found that juvenile mussels at hydrocarbon seeps initially grow rapidly, but the growth rate drops markedly in adults; they grow to reproductive size very quickly. Both individuals and communities appear to be very long lived. These methane-dependent mussels (Type Ia) have strict chemical requirements that tie them to areas of the most active seepage in the Gulf of Mexico. As a result of their rapid growth rates, mussel recolonization of a disturbed seep site could occur relatively rapidly. There is some early evidence that mussels also have some requirement of a hard substrate and could increase in numbers if suitable substrate is increased on the seafloor (Fisher, 1995).

Unlike mussel beds, chemosynthetic clam beds may persist as a visual surface phenomenon for an extended period without input of new living individuals because of low dissolution rates and low sedimentation rates. Most clam beds investigated by Powell (1995) were inactive. Living individuals were rarely encountered. Powell reported that over a 50-year timespan, local extinctions and recolonization should be gradual and exceedingly rare.

Extensive mats of free-living bacteria are also evident at hydrocarbon seep sites. These bacteria may compete with the major fauna for sulfide and methane energy sources and may also contribute substantially to overall production (MacDonald, 1998). The white Anonpigmented@ mats were found to be an autotrophic sulfur bacteria *Beggiatoa* species, and the orange mats possessed an unidentified nonautotrophic metabolism (MacDonald, 1998).

Preliminary information has been presented by Carney (1993) concerning the nonchemosynthetic animals (heterotrophs) found in the vicinity of hydrocarbon seeps. Heterotrophic species at seep sites are a mixture of species unique to seeps and those that are a normal component from the surrounding environment. Carney reports a potential imbalance that could occur as a result of chronic disruption. Because of sporadic recruitment patterns, predators could gain an advantage, resulting in exterminations in local populations of mussel beds.

d. Detection of Resource

Chemosynthetic communities cannot be reliably detected directly using geophysical techniques; however, hydrocarbon seeps that allow chemosynthetic communities to exist modify the geological characteristics in ways that can be remotely detected. These known sediment modifications include (1) precipitation of authigenic carbonate in the form of micronodules, nodules, or rock masses; (2) formation of gas hydrates; (3) modification of sediment composition through concentration of hard chemosynthetic organism remains (such as shell fragments and layers); (4) formation of interstitial gas bubbles or hydrocarbons; and (5) formation of depressions or Apockmarks@ by gas expulsion. These features give rise to acoustic effects such as Awipeout zones@ (no echoes), Ahard bottoms@ (strongly reflective echoes), bright spots (reflection enhanced layers), or reverberant layers (Behrens, 1988; Roberts and Neurauter, 1990). Potential locations for most types of communities can be determined by careful interpretation of these various geophysical modifications, but to date, this process remains imperfect.

As part of the recent MMS study AStability and Change in Gulf of Mexico Chemosynthetic Communities@ Sager (1997) characterized the geophysical responses of seep areas that support chemosynthetic communities so that a protocol can be refined to use geophysical remote-sensing techniques to locate chemosynthetic communities reliably. One objective is to use geophysical mapping techniques to reduce the seafloor area that may require searching by much slower and expensive near-bottom techniques. Additional groundtruthing studies would also improve predicative capabilities.

2. Environmental Impact Assessment

a. Physical

A total of 50-60 deepwater projects are likely to be under development by the year 2007, ranging from small subsea developments to large developments involving floating, fixed, or subsea structures. New deepwater pipeline installation is expected to range between 500 and 900 km per year through the year 2007.

The greatest potential for adverse impacts on deepwater chemosynthetic communities would come from those OCS-related, bottom-disturbing activities associated with pipelaying, anchoring, and structure emplacement, as well as from a seafloor blowout. These activities cause localized bottom disturbances and disruption of benthic communities in the immediate area. Routine OCS drilling activities could inflict considerable mechanical damage upon the sea bottom. Structures related to drilling operations physically disturb only a small area of the sea bottom. The presence of a conventional structure can also cause scouring of the surficial sediments (Caillouet et al., 1981).

Anchors from support boats and ships (or, as assumed in these water depths, from any buoys set out to moor these vessels), floating drilling units, and pipelaying vessels also cause severe disturbances to small areas of the seafloor. The areal extent and severity of the impact are related to the size of the mooring anchor and the length of chain resting on the bottom. Excessive scope and the movement of the mooring chain could disturb a much larger bottom area than an anchor alone, depending on the variety of prevailing wind and current directions. A 50-m radius of chain movement on the bottom around a mooring anchor could destroy chemosynthetic communities in an area of nearly 8,000 m^2. Larger anchors and longer anchor chains/mooring lines are expected for operations in deep water as compared to operations on the shelf. Therefore, the areal extent of impacts, both for individual anchors and for the entire footprint, is expected to be greater for operations that employ anchoring in deep water. Many oil and gas support operations involving ships and boats would not result in anchor impacts on deepwater chemosynthetic communities because the vessels would tie up directly to rigs, platforms, or mooring buoys. In addition, there are drillships and pipelaying vessels operating in the Gulf of Mexico that rely on dynamic positioning rather than conventional anchors to maintain their position during operations (anchoring would not be a consideration in these situations). The area affected by anchoring operations will depend on the water depth, length of the chain, size of the anchor, and current. Anchoring will destroy those sessile organisms actually hit by the anchor or anchor chain during anchoring and anchor weighing, or it could cause destruction of underlying carbonate structures on which organisms rely for dispersion of hydrocarbon sources. While such an area of disturbance may be small in absolute terms, it may be large in relation to the area inhabited by dense chemosynthetic communities.

Normal pipelaying activities in deepwater areas could destroy large areas of chemosynthetic organisms (it is assumed that 0.32 ha of bottom is disturbed per kilometer of pipeline installed). Pipelines will likely be used to transport the product ashore from those deepwater areas near the current pipeline network in both the Central and Western Gulf. Pipelines may also be required to transport product from subsea systems to fixed platforms. In areas not near the existing pipeline network, shuttle tankering might substitute for pipelines as a means of transporting the product; therefore, impacts on deepwater communities in these cases would be precluded.

A blowout at the seafloor could create a crater, and resuspend and disburse large quantities of bottom sediments within a 300-m radius from the blowout site, thus destroying many organisms nearby. Structure removals and other bottom-disturbing activities could resuspend bottom sediments, but not at magnitudes as great as blowout events.

The impacts from bottom-disturbing activities are expected to be relatively rare. Should they occur, these impacts could be quite severe to the immediate area affected, with recovery times as long as 200 years for mature tube worm communities, with the possibility of the community never recovering.

b. Discharges

Because of the great water depths, discharges of drilling fluids and cuttings at the surface are spread across broader areas of the seafloor and are, in general, distributed in thinner accumulations than in shallower areas on the continental shelf. Recent information about the effects of surface discharge of drilling fluids (muds) and cuttings at a well in 565 m have been reported by Gallaway and Beaubien (1997). In this situation, a veneer of cuttings was observed scattered over the bottom, in some cases as thick as 20-25 cm. Chemical evidence of synthetic-based drilling fluid components (used during this operation) was found at distances of at least 100 m from the well site. Other information from a geophysical survey documented the extent of drilling discharges at several previously drilled oil and gas sites in about 400-m water depths (Nunez, personal communication, 1994). At these sites, the areal coverage of cuttings was found extending from the previous well locations in splay or finger-like projections to a maximum of about 610 m, with an average of about 450 m. An examination of sidescan sonar records of these splays indicates that they were distributed in accumulations less than 30-cm thick. Effluents from routine OCS operations (not muds or cuttings) in deep water would be subject to rapid dilution and dispersion and are not projected to reach the seafloor at depths greater than 100 m.

Impact from muds and cuttings are also expected from two additional sources: initial well drilling and installation of casing prior to the use of a riser to circulate returns to the surface, and the potential use of various riserless drilling techniques in the deep sea. Pre-riser casing installation typically involves 36-in (91-cm) casing up to a depth of 300 ft (91 m) and 26-in (66-cm) casing to a depth of 1,600 ft (488 m). Jetted or drilled cuttings from the initial wellbore would total as much as 226 m^3 (Halliburton Red Book). In the case of riserless drilling practices, all muds and cuttings from well spudding through total depth would be discharged at the seafloor. Although the full areal extent and depth of burial from these activities are not known, the potential impacts are expected to be localized and short-term. Since these areas would occupy only a minuscule portion of the available seafloor in the deepwater Gulf of Mexico, these impacts are not considered significant, provided that sensitive communities (e.g., chemosynthetic communities) are avoided.

MacDonald et al. (1995) indicate that the vulnerability of chemosynthetic communities to oil and gas impacts may depend on the type of community present. Tube worm and mussel communities may be more vulnerable than clam communities because clam communities are mobile and sparsely distributed. The primary concern related to muds and cuttings discharge is that of burial. Although chemosynthetic organisms thrive with some part of their anatomy located next to or inside of toxic and/or anoxic environments, all chemosynthetic biota (including the symbiotic bacteria) also require oxygen to live. Burial by sediments or rock fragments originating from drilling fluids and cuttings discharges would smother and kill most chemosynthetic organisms (motile clams being one possible exception). Depending on the organism type, just a few centimeters of burial could cause mortality.

The tolerance of various community components to burial is not completely understood and would depend on the depth of burial. Detrimental effects due to burial are expected to decrease exponentially in the same manner that the depth of accumulation of discharges decreases exponentially with distance from the origin. The severity of these impacts is such that there may be incremental losses of productivity, reproduction, community relationships, and overall ecological functions of the community, and incremental damage to ecological relationships with the surrounding benthos.

High-density, Bush Hill-type communities are areas that are considered to be most at risk from oil and gas operations. The disturbance of a Bush Hill-type environment could lead to the destruction of a community from which recovery would occur only over long intervals (200+ years for a mature tube worm colony and 25-50 years for a mature mussel community) or would not occur at all. A long span of time is required for the precipitation of enough carbonate rock to support a large population of tube worms. As dense tube worm communities require hard substrate as well as very active seepage at any point in space, existing communities covered by sediment and physically damaged would likely never recover (Fisher, 1995).

Information is limited about the vulnerability of tube worms to sedimentation/smothering impact. Individual tube worms are often found buried for more than half the length of their tubes by hemipelagic sediment (MacDonald, 1992). Presumably, this burial occurs over long intervals. Evidence of catastrophic burial of high-diversity chemosynthetic communities can be found in the paleorecord as documented by Powell (1995), but the importance of this in causing local extinctions was reported as minor. These burials were probably caused by catastrophic seismic events.

Methanotrophic mussel communities have strict chemical requirements that tie them directly to areas of the most active seepage. Physical disturbance of an active mussel bed is thought not to have a long-lasting effect on the community because of high growth rates of individuals (Fisher, 1995). Catastrophic mud burial would be one possible cause of a mussel community death. It is predicted that a mussel community completely eliminated by physical disturbance could be resettled and mature within 20 years.

Oil and chemical spills are not considered to be a potential source of measurable impacts on chemosynthetic communities because of the water depth. Oil spills from the surface would tend not to sink. Oil discharges at depth or on the bottom would tend to rise some in the water column and similarly not impact the benthos. Evidence from direct observation and remote imagery from space indicates oil slicks on the sea surface originating from natural seeps occur relatively close to known seep locations on the bottom. Shipboard observations during submersible operations located the surface expression of rising oil at a horizontal distance of only 100 m from the origin of the seep on the bottom (MacDonald et al., 1995).

There is some reason to believe the presence of oil may not have an impact in the first place, since these communities live among oil and gas seeps; however, natural seepage is very constant and at very low rates compared with blowout or pipeline rupture. All seep organisms also require unrestricted access to oxygenated water at the same time as exposure to hydrocarbon energy sources.

c. Reservoir Depletion

There has been some speculation about the potential impact to chemosynthetic communities as a result of oil and gas withdrawal, causing a depletion of the energy source (hydrocarbons) sustaining the chemosynthetic organisms. There is evidence that both removal and reinjection of material into reservoirs that supply seeps on land in California affect the seepage rates. Quigley et al. (1996) reported evidence that suggested offshore California oil production resulted in reduced seepage because of reduction in reservoir pressure. The seeps and faults around which chemosynthetic animals live are supplied from the deep reservoirs that transport the gas or oil to the seafloor through combined effects of buoyancy and pressure. When all of the recoverable hydrocarbons from these reservoirs are withdrawn by production operations (the amount that can be economically extracted by current technology is estimated to be 30% or less of the total hydrocarbons), it is possible that oil and gas venting or seepage would also slow or (less likely) stop. Based on current information, it is not possible to determine whether reduced reservoir pressure would actually reduce the seepage (as observed onshore) or whether there may be enough oil already in the Aconduit@ to the surface to continue adequate levels of seepage for long periods, perhaps thousands of years or more. The distribution of chemosynthetic communities is known to occur in association with precise levels and types of chemical gradients at the seafloor; alterations to these gradients may potentially impact the type and distribution of the associated community.

d. Alternatives and Mitigation

Notice to Lessees (NTL) 88-11, reissued as NTL 98-11, has been a measure for the protection of chemosynthetic communities since February 1, 1989. NTL 98-11 makes mandatory the search for and avoidance of dense chemosynthetic communities (such as Bush Hill-type communities) or areas that have a high potential for supporting these community types, as interpreted from geophysical records. The NTL is exercised on all applicable leases and is not an optional protective measure. Under the provisions of this NTL, lessees operating in water depths greater than 400 m are required to conduct geophysical surveys of the area of proposed activities and to evaluate the data for indications of conditions that may support chemosynthetic communities; if such conditions are indicated, the lessee must either move the operation to avoid the potential communities or provide photodocumentation of the presence or absence of dense chemosynthetic communities of the Bush Hill type. If such communities are indeed present, no drilling operations or other bottom-disturbing activities may take place in the area; if the communities are not present, drilling, anchoring, etc. may proceed. To date, in almost all cases, operators have chosen to avoid any areas that show the potential to support chemosynthetic communities. The basic assumptions underlying the provisions of this mitigation measure are (1) that dense chemosynthetic communities are associated with gas-charged sediments or seeps, (2) that the gas-charged sediment zones or seeps have physical characteristics that will allow them to be identified by geophysical surveys, and (3) that dense chemosynthetic communities are not found in areas where gas-charge sediments or seeps are not indicated on the geophysical survey data. These assumptions have not been totally verified. A definitive correlation between the geophysical characteristics record by geophysical surveys and the presence of chemosynthetic communities has not been proven.

Although there are few examples of field verification, the requirements set forth in NTL 98-11 are considered effective in identifying potential areas of chemosynthetic communities. Although there has generally been compliance with NTL 98-11, compliance does not guarantee avoidance of high-density communities without visual confirmation in every case. On rare occasions, high-density chemosynthetic community areas may not be properly identified by using the geophysical systems and indicators specified in the existing NTL. As one recent example, an operator was proposing activity in a lease adjacent to a block known to contain dense tube worm communities. Submitted geophysical records did not include subbottom acoustic records for the adjacent block where one anchor was to be placed. Oil- or gas-saturated sediments and other related characteristic signatures cannot be determined without high-resolution acoustic records. Utilizing only the submitted surface anomaly records for the block would have placed a high-density chemosynthetic community at risk of considerable impact from an anchor deployment. Improved definitions and guidelines are being finalized for a new NTL at the time of this writing. The potential for any impact could also be lessened by the refinement of techniques utilized in the interpretations of geophysical records. As new information becomes available, the NTL will be further modified as necessary.

In the past, site-specific environmental evaluations have required operators to maintain a 152-m (500-ft) separation between anchor placement and geophysical data indicators. This specific separation requirement was not included in NTL 98-11. Requirements for specific separation distance between potential high-density chemosynthetic communities and both anchors (250-500 ft) and drilling discharge points (1,000 ft) have been recommended for the upcoming revision of the chemosynthetic community NTL. The use of differential global positioning system (GPS) has also been required on anchor-handling vessels when placing anchors near an area that has potential for supporting chemosynthetic communities.

High-density, Bush Hill-type communities are, as noted above, largely protected from direct physical impacts by the provisions of NTL 98-11. A limited number of these communities have been found to date, but it is probable that additional communities exist. Observations of the surface expression of seeps from space images indicate numerous other communities may exist (MacDonald et al., 1993 and 1996). The majority of chemosynthetic communities are of low density and are relatively widespread throughout the deepwater areas of the Gulf. Physical disturbance or destruction of a small, low-density area would not result in a major impact to chemosynthetic communities as an ecosystem. Low-density communities may occasionally sustain major or minor impacts from discharges of drill muds and cuttings, bottom-disturbing activities, or resuspended sediments. Areas so impacted could be repopulated from nearby undisturbed areas (although this process may be quite slow, especially for vestimentiferans). Because of the probable avoidance of all chemosynthetic communities (not just high-diversity types) through NTL 98-11 (and its near-future replacement), the frequency of such impact is expected to be low, and the severity of such an impact is judged to result in minor disturbance to the ecological function of the community, with no alteration of ecological relationships with the surrounding benthos. Recolonization after a disturbance would not exactly reproduce the preexisting community prior to the impact, but it could be expected that some similar pattern and species composition would eventually reestablish if similar conditions of sulfide or methane seepage persist after the disturbance.

e. Suggested Mitigation Measures for Further Evaluation

Interim Measures

Mitigation Measure: Using geophysical records, ensure an area of at least 1,000 feet in all directions from proposed discharge sites is clear of potential chemosynthetic communities. Revise NTL 98-11 to establish the conditions and parameters for areas where discharges are to be avoided. This measure would be in effect until fate and effects studies are completed and appropriate No Activity Zones are established.

Anticipated Benefit: Reduce the potential for impact on high-density chemosynthetic communities from pre-riser or riserless drilling discharges (volume up to 226 m^3), some types of riserless drilling where some or all muds and/or cuttings would be discharged at the seafloor, and from any discharge of cuttings wetted with SBF.

Mitigation Measure: Using geophysical records, ensure the full extent of the area of other potential physical impacts, including anchor placement in adjacent lease blocks, is clear of potential chemosynthetic communities for at least 250 feet in all directions. This measure would be in effect until fate and effects studies are completed and appropriate No Activity Zones are established.
Anticipated Benefit: Reduce the potential for impacts from anchoring and mooring systems.

Mitigation Measure: Prohibit the discharge of SBF and SBF-wetted cuttings until uncertainties regarding their impacts on the environment are answered through research programs or until the USEPA provides guidelines for discharge.
Anticipated Benefit: Reduce the potential for impacts from SBF.

Final Measure

Mitigation Measure: Establish No Activity Zones of appropriate radius (to be determined by fate and effect studies) around potential high-density chemosynthetic communities.
Anticipated Benefit: Prevent impacts from discharges associated with pre-riser drilling, riserless drilling techniques, and synthetic drilling fluids.

f. Suggested Research and Information Synthesis

Additional field studies can verify the relationships between the geophysical signatures and the presence of chemosynthetic communities. One of the objectives of the recent MMS study AStability and Change in Gulf of Mexico Chemosynthetic Communities@ (MacDonald, 1998) is to refine geophysical survey techniques as they relate to confirmation of existing chemosynthetic communities. Information from these efforts would ensure and improve the effectiveness of NTL 98-11 and its successors.

In shallow areas (<1,000 m water depth), evidence indicates that dynamics of gas hydrates may result in catastrophic releases of oil and gas, as well as potentially causing extensive impact to chemosynthetic communities. Further study of these phenomena is of great interest, especially at the depths where gas hydrates are at or near the edge of thermal stability. A better understanding of the dynamics of gas hydrates would assist in the engineering design of deepwater facilities and would increase our understanding of the survivability of chemosynthetic communities.

Investigation of potential chemosynthetic community sites in deeper areas (>1,000 m water depth) to verify the presence of communities would improve the effectiveness of our site-specific review and mitigation. Currently, 41 potential sites have been reported, based on evidence of perennial sea-surface oil slicks originating from bottom depths below 1,000 m. Only three communities have been verified.

Field studies to determine the distribution and dispersion of muds and/or cuttings discharged at the seafloor during pre-riser and riserless drilling operations would help refine current mitigation measures and help identify any additional mitigation measures.

Field studies to determine the distribution, dispersion, residence time, and toxicity levels of discharged synthetic-based drilling fluids and cuttings would assist MMS in refining current mitigation measures and identifying any additional mitigation measures. At the time of this writing, a new study to address these questions is being funded for the year 2000.

3. Conclusions

Chemosynthetic communities are susceptible to physical impacts from structure placement (including templates or subsea completions), anchoring, and pipeline installation. NTL 98-11 prevents these physical impacts by requiring avoidance of potential chemosynthetic communities identified on required geophysical survey records or by requiring photodocumentation to establish the absence of chemosynthetic communities prior to approval of the structure emplacement.

Potentially severe or catastrophic impacts could occur to high-diversity communities located near deepwater wells from partial or complete burial by muds and cuttings associated with preriser discharges or some types of riserless drilling. Variations in the dispersal and toxicity of synthetic-based drilling fluids may contribute to the potential areal extent of these impacts.

Studies indicate that periods as long as hundreds of years are required to reestablish a seep community once it has disappeared (depending on the community type), although it may reappear relatively quickly once the process begins, as in the case of a mussel community. Tube-worm communities may be the most sensitive of all communities because of the combined requirements of hard substrate and active hydrocarbon seepage. Mature tube-worm bushes have been found to be several hundred years old, with individual tube worms potentially reaching 400 years of age. There is evidence that substantial impacts on these communities would permanently prevent reestablishment.

B. Nonchemosynthetic Benthic Communities

1. Description

More than chemosynthetic communities are found on the bottom of the deep Gulf of Mexico. Other types of communities include the full spectrum of living organisms also found on the continental shelf or other areas of the marine environment. Major groups include bacteria and other microbenthos, meiofauna (0.063-0.3 mm), macrofauna (greater than 0.3 mm), and megafauna (larger organisms such as crabs, sea pens, crinoids, demersal fish, etc.). All of these groups are represented throughout the entire Gulf--from the continental shelf to the deepest abyss of the Gulf at about 3,850 m (12,630 ft). Enhanced densities of these heterotrophic communities (nonchemosynthetic) occurring in association with chemosynthetic communities have been described (Carney, 1993). Some of these heterotrophic communities found at and near seep sites are a mixture of species unique to seeps and those that are a normal component from the surrounding environment. Because of their very close proximity to chemosynthetic communities, their relevance (and possible impact mitigation) is best considered as part of the previous chemosynthetic community analysis and associated mitigation measures (e.g., NTL 98-11).

There are also rare examples of deepwater communities that would not be considered typical of the deep Gulf of Mexico continental slope. One example is represented by what was reported as a deepwater coral reef by Moore and Bullis (1960). In an area measuring 300 m in length and more than 20 nmi from the nearest known chemosynthetic community (Viosca Knoll Block 907), a trawl collection from a depth of 421-512 m retrieved more than 300 pounds of the scleractinian coral *Lophelia prolifera*. This type of unusual and unexpected community may exist in many other areas of the deep Gulf of Mexico. Because of the difficulty and expense of exploring the deep sea, only a very small percentage of the bottom has been studied below a depth of 300 m.

Past Research

The first substantial collections of deep Gulf benthos were made during the cruises of the U.S. Coast and Geodetic Steamer *Blake* between 1877 and 1880. Rowe and Menzel (1971) reported that their deep Gulf of Mexico infauna data were the first quantitative data published for this region. Pequegnat (1983) summarized this early work including research through the early 1970's and his own data from research at 264 stations across the deep Gulf in the 1960's at depths ranging from 150 to 3,850 m. The Pequegnat final report for MMS, primarily qualitative in nature, first described numerous hypotheses of depth zonation patterns and aspects of faunal differences between the eastern and western Gulf of Mexico.

The first major quantitative deepwater benthos study in the Gulf of Mexico was that of LGL Ecological Research Associates Inc. (Gallaway et al., 1988) as part of the MMS Northern Gulf of Mexico Continental Slope Study. This multiyear project is certainly the most comprehensive of all previous research in the Gulf of Mexico deep sea. Gallaway et al. (1988) reported that after their benthic study results, it was possible to predict with a reasonable degree of certainty the basic composition of the faunal communities on the northern Gulf of Mexico slope between 300 and 2,500 m between 85E and 94E W. longitude, approximately 75 percent of the northern Gulf slope area. There was a reasonable degree of agreement between the faunal distribution results of the LGL study (Gallaway et al., 1988) and Pequegnat (1983). Because of the fact that the deep Gulf has only recently been investigated in any systematic way, a large number of species obtained during the LGL/MMS study were new to science.

Bacteria

Limited research has been done on bacteria in the deep sea and especially in the deep Gulf of Mexico. Controls of bacterial abundance in marine sediments remain poorly understood (Schmidt et al., 1998). Recent results also reported by Schmidt et al. (1998) suggest that bacterial abundance is relatively constant over a wide variety of geographic regions when direct bacterial counts are scaled to fluid volume (pore water) compared to the traditional dimension of dry sediment mass. In any event, the counts of bacteria in marine sediments center around 10^9 bacteria per ml fluid volume, in other words, literally trillions per m^2.

Meiofauna

The density of meiofauna was reported as approximately two orders of magnitude greater than the density of macrofauna throughout the depth range of the Gulf of Mexico continental slope by LGL/MMS (Gallaway et al., 1988). Overall mean abundance was 707 individuals per 10 cm^2 (707,000 per m^2). Densities were generally similar to those previously reported and generally decreased with increasing depth. A total of 43 major groups were identified. Of these, representatives of five taxa of permanent meiofauna (Nematoda, Harpacticoidea, Polychaeta, Ostracoda, and Kinorhyncha), along with naupliar larvae (temporary meiofauna), comprised 98 percent of the collections as reported by Gallaway et al. (1988). The range of density values obtained for meiofauna varied by one order of magnitude. Some comparisons with depth showed a decisive decrease of abundance with depth (at the 5% statistical level), but this trend was not consistent through all seasons and areas of the Gulf.

Macrofauna

Gallaway et al. (1988) reported a total of 1,569 different taxa of macrofauna on the continental slope, 90 percent of those identified to the level of genus or species. Nearly all macrofaunal species were infaunal invertebrates, although some taxa were normally found in surficial sediments, considered nominally epifaunal or surface dwelling. The major group was annelid taxa including 626 polychette taxa. Overall abundance of macrofauna ranged from 518 to 5,369 individuals per m^2. Overall, there was a general pattern of decreased macrofaunal density with depth.

Megafauna

Megafauna collections were made utilizing two techniques in Gallaway et al. (1988), benthic photography and the use of an otter trawl ranging in depth between 300 and 2,882 m. Based on fish and invertebrates collected by trawling, invertebrates were four to five times more abundant than benthic fishes throughout all transects and designated depth zones. Other trends included higher densities of all megafauna in the study=s eastern Gulf transect area (between 85E40' and 85E15' W.) and lowest in the central area (between 89E40' and 89E20' W.), and a tendency of densities to decrease below a depth of 1,550 m. Overall, benthic fish densities ranged from 0 to 704 fish per hectare (10,000 m^2). Overall megafauna invertebrates ranged from 0 to 4,368 individuals per hectare. Results of the LGL studies (Gallaway et al., 1988) supported the zonation scheme proposed by Pequegnat (1983).

All 60 stations in the MMS continental slope study (Gallaway et al., 1988) were also sampled by quantitative photographic methods. Although up to 800 images were obtained at each of the stations, due to the relatively small area Asampled@ by each photograph (approximately 2 m^2), abundance of most megafauna taxa was low. Megafauna that did appear in benthic photographs generally indicated much higher densities than that obtained by trawling, with variations being more than four orders of magnitude in some cases. Overall density from photography was 8,449 animals per ha. The highest density of any organism sampled by photography was that of a small sea cucumber (never obtained by trawling) resulting in a peak density of 154,669 individuals per ha.

While the previous groups of sediment-dwelling organisms could be considered immobile and unable to avoid disturbances caused by OCS activities, megafauna could be categorized into two groups: a nonmotile or very slow-moving group including many invertebrates, and a motile group including fish, crustaceans, and some other types of invertebrates such as semi-pelagic sea cucumbers.

2. Environmental Impact Assessment

a. Physical

Benthic communities other than chemosynthetic organisms could be impacted by OCS-related, bottom-disturbing activities associated with pipelaying, anchoring, and structure emplacement, as well as from a seafloor blowout. These activities cause localized bottom disturbances and disruption of benthic communities in the immediate area. Considerable mechanical damage can be inflicted upon the bottom by routine OCS drilling activities. The structures related to a drilling operation disturb a small area of the seafloor. These impacts are the same as those encountered in shallower continental shelf waters.

Anchors from support boats and ships (or, as assumed in these water depths, from any buoys set out to moor these vessels), floating drilling units, and pipelaying vessels also cause severe disturbances to small areas of the seafloor with the areal extent related to the size of the mooring anchor and length of chain that would rest on the bottom. Excessive scope (length) and movement of the mooring chain could disturb a much larger area of the bottom than would an anchor alone, depending on the prevailing wind and current directions. A 50-m radius of chain movement on the bottom around a mooring anchor could destroy communities in an area of nearly 8,000 m^2. Larger anchors and additional scope of anchor chain are expected for operations in deep water as compared to operations on the shelf. Therefore, the areal extent of impacts, both for individual anchors and for the entire footprint, are expected to be greater for operations that employ anchoring in deep water. The area affected by anchoring operations will depend on the water depth, length of the chain, size of the anchor, and current. (Many OCS-support operations and activities will not result in anchor impacts to deepwater benthic communities because vessels will tie up directly to rigs, platforms, or mooring buoys or will use dynamic positioning.) Anchoring will not necessarily directly destroy small infaunal organisms living within the sediment; the bottom disturbance would most likely change the environment to such an extent that the majority of the directly impacted infauna community would not survive (e.g., burial or relocation to sediment layers without oxygen). In cases of carbonate outcrops or reefs with attached epifauna, the impacted area of disturbance may be small in absolute terms, but it could be large in relation to the area inhabited by hard corals or other organisms that rely on exposed rock substrate.

As described in the previous section for chemosynthetic communities, normal pipelaying activities in deepwater areas could destroy large areas of benthic communities (it is assumed that 0.32 ha of bottom is disturbed per kilometer of pipeline installed). Without consideration of chemosynthetic organisms, there are no differences between this activity in deepwater compared to shallow-water operations.

A blowout at the seafloor could also resuspend large quantities of bottom sediments and even create a large crater, destroying many organisms within an area of a 300-m radius of the well site. Structure removals and other bottom-disturbing activities could also resuspend bottom sediments, but not at magnitudes as great as blowout events.

The impacts from bottom-disturbing activities other than blowouts are part of normal OCS activities. It could be assumed that highly motile megafauna (primarily benthic fish and some crustaceans) would be capable of moving to new locations and avoid the majority of these physical impacts. When they occur, these impacts could be quite severe to the nonmotile benthos in the immediate area affected. Because of the proximity of undisturbed bottom with similar populations of benthic organisms from microbenthos to megafauna, these impacts are considered to be very localized and reversible at the population level. The recovery from the impact of a blowout would be similarly reversible.

b. Discharges

Because of the great water depths, discharges of drilling muds and cuttings at the surface are spread across broader areas of the seafloor and are, in general, distributed in thinner accumulations than in shallower areas on the continental shelf. Recent information about the effects of surface discharge of muds and cuttings at a well in 565 m is reported by Gallaway and Beaubien (1997) and is described in the previous section on chemosynthetic communities. In this instance and in another deepwater survey reported by Nunez (personal communication, 1994), muds and cuttings were documented in accumulations ranging up to 30 cm thick at distances up to 610 m from the well site.

Impact from muds and cuttings are also expected from two additional sources: initial well drilling prior to the use of a riser to circulate returns to the surface and the potential use of various riserless drilling techniques in the deep sea. Jetted or drilled cuttings discharged at the bottom from the initial wellbore would total as much as 226 m^3 (Halliburton Red Book). In the case of some riserless drilling practices, all muds and cuttings from well spudding through total depth would be discharged at the seafloor. Although the full areal extent and depth of burial from these activities are not known, the potential impacts are expected to be localized and short-term. Since these areas would occupy only a minuscule portion of the available seafloor in the deepwater Gulf of Mexico, these impacts are not considered significant, provided that sensitive communities (e.g., chemosynthetic communities) are avoided.

Burial by sediments or rock fragments originating from drilling muds and cuttings discharges could smother and kill most all community components of benthic organisms, with the exception of highly motile fish and possibly some crustaceans such as shrimp capable of moving away from the impacted area. Depending on the organism type, just a few centimeters of burial could cause death. The damage would be both mechanical and toxicological. Some types of macrofauna could burrow through gradual accumulations of overlying sediments depending on the toxicological effects of those added materials. Information on the potential toxic effects on various benthic organisms is limited and essentially nonexistent for deepwater taxa.

It can be expected that detrimental effects due to burial would decrease exponentially with distance from the origin. The physical properties of the naturally occurring surface sediment (grain size, porosity, pore water) could also be changed as a result of discharges, such that recolonizing benthic organisms would comprise different species than had inhabited the area previous to the impact. Although the impacts could be considered severe to the nonmotile benthos in the immediate area affected, they would be considered very temporary. Because of the close proximity of undisturbed bottom with similar populations of benthic organisms from microbenthos to megafauna, these impacts would be very localized and reversible at the population level and are not considered significant.

Carbonate outcrops not associated with chemosynthetic communities, such as the deepwater coral reef reported by Moore and Bullis (1960), are considered to be most at risk from oil and gas operations. Because deepwater corals require hard substrate, existing communities covered by some amount of sediment would likely never recover.

Effluents other than muds or cuttings from routine OCS operations in deep water would be subject to rapid dilution and dispersion and are not projected to reach the seafloor at depths greater than 100 m. Oil and chemical spills are also not considered to be a potential source of measurable impacts to nonchemosynthetic benthic communities due to the water depth. Oil spills from the surface would tend not to sink. Accidental oil discharges at depth or on the bottom would tend to rise in the water column and similarly not impact the benthos.

c. Alternatives and Mitigation

Physical disturbance or destruction of a limited area of benthos or to a limited number of megafauna organisms, such as brittle stars, sea pens, or crabs, would not result in a major impact to the deepwater benthos ecosystem as a whole. Surface discharge of muds and cuttings, as opposed to seafloor discharge, would reduce or eliminate the impact of smothering of benthic communities on the bottom.

Under the current review procedures for chemosynthetic communities, carbonate outcrops are targeted as one possible indication (3D anomaly) that chemosynthetic seep communities are nearby. Unique communities that may be associated with any carbonate outcrops or other topographical features could be identified via this review along with the chemosynthetic communities. Any proposed activity in water depth greater than 400 m would automatically trigger the NTL 98-11 evaluation described above.

d. Suggested Mitigation Measures for Further Evaluation

Interim Measure

Mitigation Measure: Require avoidance of direct physical disturbance to rare hard substrate outcrops. Outcrops that are not associated with chemosynthetic communities may nonetheless support luxuriant communities similar to pinnacles or topographic features. This measure would be in effect until the existence of sensitive benthic communities can be verified or disproved.

Anticipated Benefit: Reduce the potential for impacts on benthic communities from seafloor discharge of muds and cuttings associated with pre-riser or riserless drilling operations and from discharge of cuttings wetted with SBF.

Final Measure

Mitigation Measure: If new biologically sensitive, hard-bottom communities (i.e., other than chemosynthetic communities, e.g., coral communities) are discovered in the deep Gulf of Mexico, establish No Activity Zones of appropriate radius (to be determined by fate and effect studies) around the communities. Issue an appropriate NTL to establish the conditions and parameters for areas where discharges are to be avoided.

Anticipated Benefit: Prevent impacts to sensitive benthic communities from discharges associated with pre-riser drilling, riserless drilling, and synthetic drilling fluids.

e. Suggested Research and Information Synthesis

Basic research on nonchemosynthetic communities within vast areas of the deep Gulf of Mexico is limited. Other than subsurface geologic mapping using geophysical data, only a tiny fraction of the area encompassed by the continental slope and abyssal plain in the Gulf of Mexico has been studied and described. The relationship between heterotrophic (nonchemosynthetic) benthic community groups and seep (chemosynthetic) organisms has not been characterized. Field studies to evaluate the potential for currently undiscovered, rare, and potentially valuable biological resources other than chemosynthetic communities in the deep Gulf of Mexico would support development of mitigation measures specifically for protection of these benthic communities. A new Gulfwide slope study to study 48 stations between 300 and 3,000 m water depths has recently been awarded to Texas A&M University.

3. Conclusions

Most impacts of deepwater operations to nonchemosynthetic benthic communities are similar to impacts associated with OCS Program activities in general as described here and in past EIS=s. Some impact to benthic communities from drilling and production activities would occur as a result of physical impact from structure placement (including templates or subsea completions), anchoring, and installation of pipelines. Megafauna and infauna communities at or below the sediment/water interface would be impacted from the muds and cuttings normally discharged at the seafloor at the start of every new well prior to riser installation. The impact from muds and cuttings discharged at the surface is expected to be low in deep water. Drilling muds would not be expected to reach the bottom beyond a few hundred meters from the surface-discharge location, and cuttings would be dispersed. Even if substantial burial of typical benthic communities were to occur, recolonization from populations from neighboring substrate would be expected over a relatively short time for all size ranges of organisms, in a matter of days for bacteria and probably less than one year for most all macrofauna species.

Deepwater coral reefs and other potential hard-bottom communities not associated with chemosynthetic communities appear to be very rare in deepwater. These unique communities are similar in nature to those on protected pinnacles and topographic features on the continental shelf. Any hard substrate communities located in deep water would be particularly sensitive to impacts from OCS activities. Impacts to these sensitive habitats could permanently prevent recolonization by similar organisms requiring hard substrate.

C. Marine Mammals

1. Description

Twenty-eight species of cetaceans, one sirenian, and one exotic pinniped (California sea lion) have been confirmed to occur in the Gulf of Mexico (Table IV-2). Seven baleen and 21 toothed whale species have been reported for the Gulf.

Information on the spatial abundance and distribution of deepwater cetaceans in the Gulf has been, until recently, sparse and limited to a few survey areas. In July 1989, the National Marine Fisheries Service, Southeast Fisheries Science Center (NMFS/SEFSC), funded by the MMS, began aerial surveys of cetaceans on the upper continental slope in the north-central Gulf (Mullin et al., 1991 and 1994a). During 1991-1994, MMS funded the GulfCet I study (Davis and Fargion, 1996; Davis et al., 1998), which was jointly conducted by the Texas Institute of Oceanography, Texas A&M University, and NMFS/SEFSC using aerial and shipboard surveys to determine the seasonal and geographic distribution of cetaceans along the continental slope in the north-central and western Gulf (Figure IV-2). The GulfCet II Program was sponsored and administered by the USGS to provide environmental information to the MMS. GulfCet II continued the work on patterns of distribution and abundance of Gulf cetaceans, and on identifying possible associations between cetacean high-use habitats and the ocean environment. Cetaceans were concentrated along the continental slope in or near cyclones and the confluence of cyclone-anticyclone pairs, where locally concentrated zooplankton and micronekton stocks appear to develop in response to increased nutrient-rich water and primary production in the mixed layer (Davis et al., 2000). Higher zooplankton and micronekton biomass may correlate with higher concentrations of cetacean prey. Current information indicates that the deepwater area off the mouth of the Mississippi River may support a resident breeding population of endangered sperm whales.

a. Endangered and Threatened Species

Under the Federal listing of endangered and threatened species, there are five baleen (northern right, blue, fin, sei, and humpback) whale species, one toothed (sperm) whale species, and one sirenian (West Indian manatee) that occur in the Gulf of Mexico (50 CFR 17.11). The sperm whale is common in the Gulf, while the baleen whales are considered uncommon (Davis and Fargion, 1996). Of these animals, the sperm whale is the only deepwater species.

Baleen Whales (Northern Right Whale, Blue Whale, Fin Whale, Sei Whale, and Humpback Whale)

The coastal nature and slow swimming speed of the northern right whale makes it vulnerable to human activities (USDOC, NMFS, 1991). The northern right whale is not a normal inhabitant of the Gulf of Mexico; existing records probably represent strays from the wintering grounds of this species off the southeastern United States, from Georgia to northeastern Florida (Jefferson and Schiro, 1997).

Table IV-2

Marine Mammals of the Gulf of Mexico

Order Cetacea		
Suborder Mysticeti (baleen whales)		
Family Balaenidae		
Eubalaena glacialis	northern right whale	*
Family Balaenopteridae		
Balaenoptera musculus	blue whale	*
Balaenoptera physalus	fin whale	*
Balaenoptera borealis	sei whale	*
Balaenoptera edeni	Bryde's whale	
Balaenoptera acutorostrata	minke whale	
Megaptera novaeangliae	humpback whale	*
Suborder Odontoceti (toothed whales)		
Family Physeteridae		
Physeter macrocephalus	sperm whale	*
Family Kogiidae		
Kogia breviceps	pygmy sperm whale	
Kogia simus	dwarf sperm whale	
Family Ziphiidae		
Mesoplodon bidens	Sowerby's beaked whale	
Mesoplodon densirostris	Blainville's beaked whale	
Mesoplodon europaeus	Gervais' beaked whale	
Ziphius cavirostris	Cuvier's beaked whale	
Family Delphinidae		
Orcinus orca	killer whale	
Pseudorca crassidens	false killer whale	
Feresa attenuata	pygmy killer whale	
Globicephala macrorhynchus	short-finned pilot whale	
Grampus griseus	Risso's dolphin	
Peponocephala electra	melon-headed whale	
Tursiops truncatus	Atlantic bottlenose dolphin	
Steno bredanensis	rough-toothed dolphin	
Stenella coeruleoalba	striped dolphin	
Stenella attenuata	pantropical spotted dolphin	
Stenella clymene	Clymene dolphin	
Stenella frontalis	Atlantic spotted dolphin	
Stenella longirostris	spinner dolphin	
Lagenodelphis hosei	Fraser's dolphin	
Order Carnivora		
Suborder Pinnipedia (seals, sea lions)		
Family Otariidae		
Zalophus californianus	California sea lion	I
Family Phocidae		
Monachus tropicalis	Caribbean monk seal	Ex
Order Sirenia		
Family Trichechidae		
Trichechus manatus	West Indian manatee	*

I = introduced, Ex = extinct, * = endangered

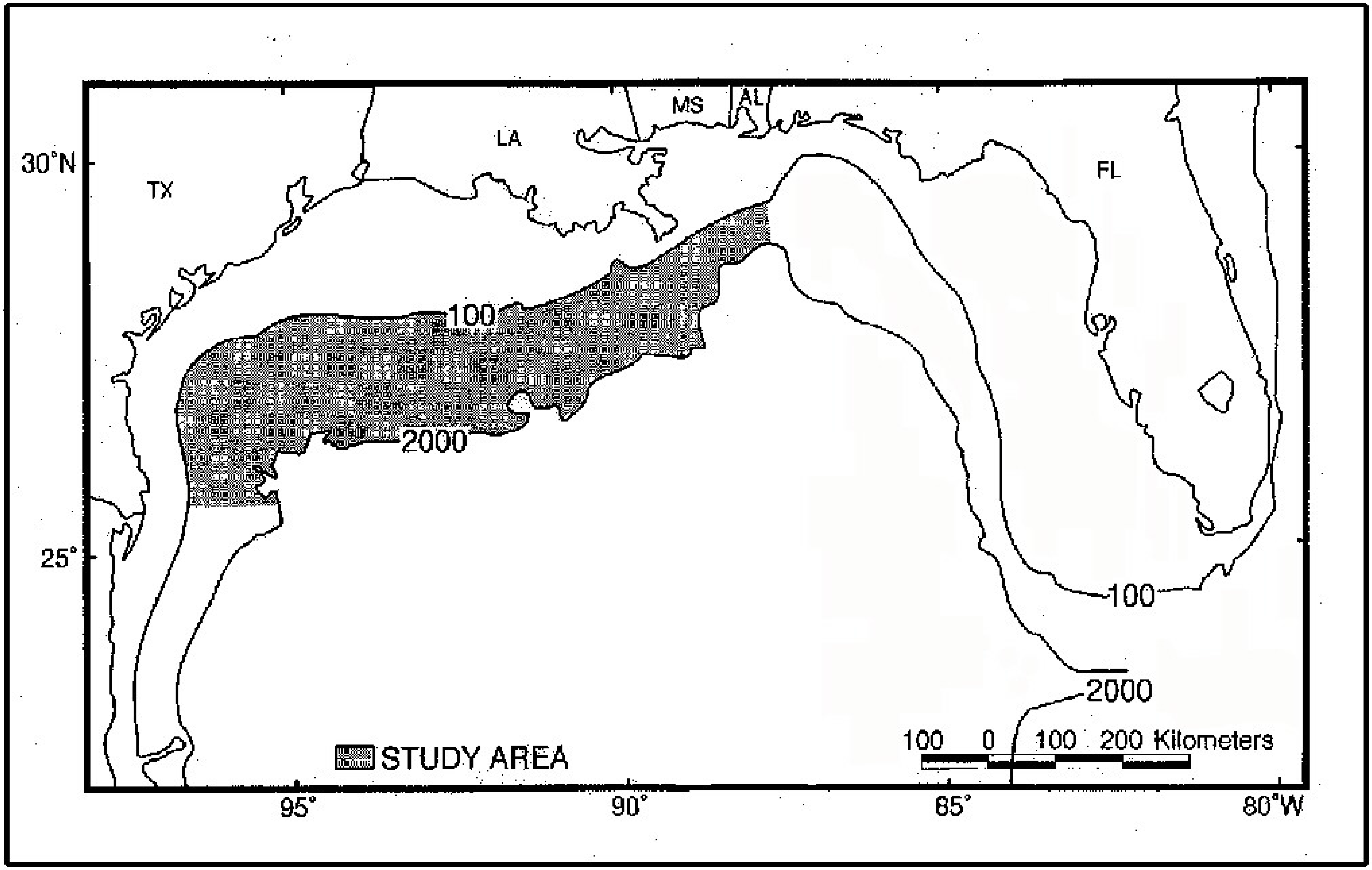

Figure IV-2. GulfCet I Study Area between the 100-m and 2,000-m Isobaths Extending as Far East as the Florida-Alabama Border and as Far Southwest as the Texas-Mexico Border.

There appears to be little justification for considering the blue whale to be a regular inhabitant of the Gulf of Mexico (Jefferson and Schiro, 1997).

It is possible that the Gulf represents a portion of the range of a low-latitude western Atlantic population of fin whales; however, it is more likely that fin whales are extralimital to this area (Jefferson and Schiro, 1997).

Sei whales are most likely of accidental occurrence in the Gulf (Jefferson and Schiro, 1997).

During summer, there are at least five geographically distinct humpback whale feeding aggregations occurring between latitudes 42EN and 78EN; the western North Atlantic stock is considered to include all humpback whales (an estimated 5,450 individuals) from these five feeding areas. Humpback whales from all feeding areas migrate to the Caribbean in winter, where courtship, breeding, and calving occur, although some animals have been reported in the feeding regions during winter. It seems likely that some humpbacks stray into the Gulf of Mexico during the breeding season on their return migration northward. The time of the year (winter and spring) and the small size of the animals involved in many sightings point to the likelihood of these records being of inexperienced yearlings on their first return migration (Weller et al., 1996).

Toothed Whale (Sperm Whale)

The sperm whale is the most abundant large cetacean in the Gulf of Mexico and has been sighted on most surveys conducted in deeper waters (Fritts et al., 1983a; Mullin et al., 1991; Davis and Fargion, 1996). Sperm whales are found primarily in deep waters beyond the edge of the continental shelf, frequently along the lower slope (1,000-2,000 m bottom depth), although there are a few records from over the shelf (Collum and Fritts, 1985; Mullin et al., 1994a; Jefferson and Schiro, 1997). Congregations of sperm whales are commonly seen off the shelf edge in the vicinity of the Mississippi River Delta (Mullin et al., 1991 and 1994a; Davis and Fargion, 1996). The combination of deep water within 20 km of the delta and the enhanced primary productivity associated with the river discharge may increase the abundance of squid and be responsible for the year-round occurrence of sperm whales in this area (Davis et al., 1998 and 2000). It is likely that there is a resident population of sperm whales in the Gulf (Jefferson and Schiro, 1997) consisting of females, calves, and immature whales (Davis and Fargion, 1996). Large mesopelagic squid are the primary diet of sperm whales, though other cephalopods, demersal fishes, and occasionally benthic invertebrates are eaten (Rice, 1989).

Sirenian (Manatee)

The manatee normally ranges no farther north along the west coast of Florida than the Suwannee River. Manatees are uncommon along the Florida panhandle and are infrequently found (strandings and sightings) as far west as the Central and Western Gulf Planning Areas (Powell and Rathbun, 1984; Rathbun et al., 1990; Schiro et al., 1998). The Florida manatee subspecies is found from Louisiana (and possibly eastern Texas) east to Florida and north seasonally to the Carolinas and Chesapeake Bay, generally inhabiting the coastal and inland waters of the southeastern United States (Domning and Hayek, 1986). Shallow grass beds with ready access to deep channels are preferred feeding areas in coastal and riverine habitats (USDOI, FWS, 1995). Manatees often use secluded canals, creeks, embayments, and lagoons, particularly near the mouths of coastal rivers and sloughs, for feeding, resting, mating, and calving (USDOI, FWS, 1995).

b. Nonendangered and Nonthreatened Species

Baleen Whales (Bryde=s Whale and Minke Whale)

There are more records of Bryde's whale than of any other species of baleen whale in the Gulf of Mexico. It is likely that the Gulf represents at least a portion of the range of a dispersed, resident population of Bryde's whale (Jefferson and Schiro, 1997). Bryde=s whale sightings have been made near the 100-m isobath (Davis and Fargion, 1996).

Records of minke whales in the Gulf may represent strays from low-latitude breeding grounds elsewhere in the western North Atlantic (Mitchell, 1991; Jefferson and Schiro, 1997).

Toothed Whales (Kogia)

The majority of odontocetes in the Gulf of Mexico are found in deep water. Risso=s dolphins and short-finned pilot whales occur along the upper slope, while striped dolphins, beaked whales, pantropical spotted dolphins, and Clymene dolphins occur in the deepest water. Pygmy/dwarf sperm whales, rough-toothed dolphins, and spinner dolphins occur at intermediate depths between these two subgroups and overlap them. Bottlenose dolphins and Atlantic spotted dolphins occur in shallower waters along the continental shelf, though bottlenose dolphins can be found commonly along the upper slope in water significantly deeper than that for Atlantic spotted dolphins.

Kogia (dwarf and pygmy sperm whales) has been found throughout the range of water depths and topographies in the Gulf (Mullin et al., 1991); the GulfCet study found these animals at a mean depth ranging from 950 to 1,100 m (Davis and Fargion, 1996). *Kogia* is uniformly distributed over the upper continental slope; data suggests that *Kogia* may associate with frontal regions along the shelf break and upper continental slope, areas with high plankton biomass (Baumgartner, 1995). It has been recently suggested that there might be a potential onshore/offshore difference in ecotype, as seen in bottlenose dolphins, with the pygmy sperm whale (*Kogia breviceps*) being more nearshore than the dwarf sperm whale (*Kogia simus*) (Barros et al., 1998). This is supported by GulfCet data, with dwarf sperm whales having the greater frequency of sightings in this study (Davis et al., 1998). *Kogia* feeds in deep water on cephalopods and, less often, on deep-sea fishes and shrimps.

Beaked Whales

There are four species of beaked whales known to occur in the Gulf, including Cuvier's beaked whale and three members of the genus *Mesoplodon* (Gervais' beaked whale, Blainville's beaked whale, and Sowerby's beaked whale). Morphological similarities among species in the genus *Mesoplodon* make identification of free-ranging animals difficult. Life history data on these species are extremely limited. Observed herd sizes of beaked whales are, in most cases, small (1-2 individuals) (Mullin et al., 1991). Beaked whales in the Gulf have been sighted in waters 680-1,933 m in depth (Davis and Fargion, 1996; Davis et al., 1998). An analysis of stomach contents from captured and stranded individuals suggests that they are deep-diving animals, feeding predominantly on mesopelagic fish and squid or deepwater benthic invertebrates (Heyning, 1989; Mead, 1989). The Cuvier=s beaked whale is probably the most common beaked whale in the Gulf (Jefferson and Schiro, 1997). The Gervais= beaked whale is probably the most common mesoplodont in the northern Gulf, as suggested by stranding records (Jefferson and Schiro, 1997). There are only three confirmed records of Blainville=s beaked whale, plus one questionable record (Jefferson and Schiro, 1997). Sowerby=s beaked whale is represented in the Gulf by only a single record; this record is considered extralimital since this species normally occurs much farther north in the North Atlantic (Jefferson and Schiro, 1997).

Dolphins (Bottlenose Dolphin, Atlantic Spotted Dolphin, Risso=s Dolphin, Melon-headed Whale, Pygmy Killer Whale, Killer Whale, Pantropical Spotted Dolphin, Clymene Dolphin, Striped Dolphin, Spinner Dolphin, Rough-toothed Dolphin, Fraser=s Dolphin, Short-finned Pilot Whale, and False Killer Whale)

All remaining species of nonendangered whales and dolphins found in the Gulf are members of the family Delphinidae.

There appear to be two ecotypes of bottlenose dolphins, a coastal form and an offshore form (Hersh and Duffield, 1990; Mead and Potter, 1990). There is evidence to support the assumption that inshore/offshore populations are genetically discrete (Curry et al., 1995). Bottlenose dolphins may be found in waters ranging from 101 to 1,226 m in depth. Inspection of bottlenose dolphin sighting rate distribution with depth reveals an almost bimodal distribution in the Gulf, which may represent the individual depth preferences for the inshore and offshore stocks (Baumgartner, 1995). Recently, two Aoffshore@ bottlenose dolphins were released with satellite tags after rehabilitation following their strandings and have expanded the range and habitat previously reported for the offshore stock of bottlenose dolphins (Wells et al., 1999). One individual was released off central west Florida and moved around Florida and northward to off Cape Hatteras, North Carolina. The two regions previously were considered to be used by different continental shelf stocks of bottlenose dolphins. The second individual was released off the Atlantic coast of Florida and moved southeast out of U.S. waters into waters more than 5,000 m deep. These findings differ from previously held concepts about the stock structure and water depth ranges of offshore bottlenose dolphin.

The Atlantic spotted dolphin is the only species, other than the bottlenose dolphin, that commonly occurs over the continental shelf (Mullin et al., 1991 and 1994a; Davis and Fargion, 1996). This species appears to prefer shallow water within the 250-m isobath with a gently sloping bottom typical of the continental shelf, although it may also occur along the shelf break and upper continental slope (in water with depths of up to 589 m) (Mullin et al., 1994a; Davis and Fargion, 1996; Davis et al., 1998). Atlantic spotted dolphins are sighted more frequently in areas east of the Mississippi River (Mills and Rademacher, 1996).

The Risso’s dolphin is found in water with depths of 150-1,997 m (Davis et al., 1998). A strong correlation between Risso=s dolphin distribution and the steeper portions of the upper continental slope in the Gulf is most likely the result of cephalopod distribution along the continental slope (Baumgartner, 1997; Davis et al., 1998). There may be increased abundance of Risso=s dolphins on the upper continental slope during the spring months (Davis and Fargion, 1996).

Most melon-headed whale sightings have been in deep waters, well beyond the edge of the continental shelf (Mullin et al., 1994b; Davis and Fargion, 1996). Melon-headed whales are sighted almost exclusively west of the Mississippi River (Mullin and Hansen, in press).

Pygmy killer whales do not appear to be common in the Gulf (Jefferson and Schiro, 1997). Pygmy killer whales in the Gulf are found generally in water with bottom depths of 500-1,000 m (Davis and Fargion, 1996).

Most killer whale sightings in the northern Gulf have been in offshore waters with bottom depths greater than 200 m; killer whales are found almost exclusively in a broad area of the north-central Gulf (Mullin and Hansen, in press). Thirty-two individual killer whales have been photo-identified so far in the Gulf; some individuals have a wide temporal and spatial distribution (some with a linear distance of over 1,100 km) (O=Sullivan and Mullin, 1997). It is not known whether killer whales in the Gulf stay within the confines of the Gulf or range more widely (Würsig et al., in press).

The pantropical spotted dolphin is the most common cetacean in the oceanic northern Gulf (Mullin et al., 1994a; Davis and Fargion, 1996). Pantropical spotted dolphins are found most often in waters with a bottom depth greater than 1,200 m (Mullin et al., 1994a; Davis et al., 1998). Baumgartner (1995) did not find that pantropical spotted dolphins had a preference for any one habitat, and he suggested that this species might be able to utilize prey species in each distinct habitat (e.g., within the Loop Current, inside a cold core eddy, or along the continental slope), an ability that very well may contribute to this species= success and abundance in the northern Gulf.

Clymene dolphins are sighted almost exclusively west of the Mississippi River (Mullin and Hansen, in press). This species in the Gulf occurs in water depths with a bottom depth ranging at least 612-3,064 m (Mullin et al., 1994a; Davis et al., 1998). The Clymene dolphin was shown to have a relationship with the depth of the 15EC isotherm, demonstrating a preference for waters where this isotherm shoals (most probably relating to productivity) (Baumgartner, 1995).

Sightings of striped dolphins in the Gulf occur primarily over the deeper waters (bottom depth of 570-1,997 m) off the continental shelf (Davis et al., 1998). Distribution of the striped dolphin was shown to have a relationship with the depth of the 15EC isotherm, demonstrating a preference for waters where this isotherm shoals (most probably relating to productivity) (Baumgartner, 1995).

Sightings of spinner dolphins in the northern Gulf occur primarily over the deeper waters; sightings have been made in areas with a bottom depth of 526-1,776 m (Mullin et al., 1994a; Davis et al., 1998). Although sample sizes are small, most spinner dolphin sightings are east of the Mississippi River (Mullin and Hansen, in press). Distribution of the spinner dolphin was shown to have a relationship with the depth of the 15EC isotherm, demonstrating a preference for waters where this isotherm shoals (most probably relating to productivity) (Baumgartner, 1995).

Sightings of rough-toothed dolphins in the Gulf occur primarily over deeper waters (bottom depth of 950-1,100 m) off the continental shelf (Mullin et al., 1994a; Davis et al., 1998). Rough-toothed dolphins are sighted almost exclusively west of the Mississippi River (Mullin and Hansen, in press). This species feeds on cephalopods and fish.

Sightings of Fraser=s dolphins in the northwestern part of the Gulf were in waters with a bottom depth centering around 1,000 m deep (Davis and Fargion, 1996).

Short-finned pilot whales occur most commonly along the mid-to-upper slope in the Gulf (bottom depths ranging 246-1,906 m), often in areas with a steep bottom gradient (Mullin et al., 1994a; Davis and Fargion, 1996; Davis et al., 1998). This species has been sighted almost exclusively west of the Mississippi River (Mullin and Hansen, in press).

Most sightings of false killer whales in the Gulf have been made in waters with bottom depths greater than 200 m deep (Davis and Fargion, 1996). Although sample sizes are small, most sightings have been east of the Mississippi River (Mullin and Hansen, in press).

2. Environmental Impact Assessment

The major impact-producing factors associated with deepwater OCS oil and gas activities that may affect marine mammals include degradation of water quality resulting from operational discharges; noise from operating drill ships and platforms, helicopter and vessel traffic, and seismic surveys; explosive structure removals; oil spills; oil-spill response activities; and discarded debris from service vessels and OCS structures.

a. Operational Discharges

Produced-water and drilling fluids and cuttings discharges contain components that may be detrimental to marine mammals. Most operational discharges are diluted and dispersed when released in offshore areas (API, 1989; NRC, 1983; Kennicutt, 1995). Any potential impact from drilling fluids would be indirect, either as a result of impacts on prey items or possibly through ingestion via the food chain (API, 1989). Contaminants in drilling fluids or waste discharge may biomagnify and bioaccumulate in the food web, which could kill or debilitate important prey species of marine mammals or species lower in the marine food web; there is uncertainty concerning the possible effect.

The oil and gas industry, USEPA, MMS, and others are developing research efforts to examine any possible effects that could occur from the discharge of SBF. The MMS is funding a literature review and summary of existing information on environmental effects and frequency of SBF use.

b. Noise and Vessel Collisions

Drillships and production facilities produce an acoustically wide range of sounds at frequencies and intensities that can be detected by cetaceans. Some of these sounds could mask cetaceans' reception of sounds produced for echolocation and communication (Richardson et al., 1995). These sounds can frighten, annoy, or distract marine mammals and lead to physiological and behavioral disturbances. Response threshold is thought to depend on whether habituation (gradual waning of behavioral responsiveness) or sensitization (increased behavioral responsiveness) occurs (Richardson et al., 1995). Sounds can cause reactions that might include disruption of marine mammals= normal activities (behavioral and/or social disruption) and, in some cases, short- or long-term displacement from areas important for feeding and reproduction (Richardson et al., 1995). The energetic consequences of one or more disturbance-induced periods of interrupted feeding or rapid swimming, or both, have not been evaluated quantitatively. Energetic consequences would depend on whether suitable food is readily available. Additionally, animals subject to a high energy drain, especially females in late pregnancy or lactation, probably would be most severely affected. Sounds can also disturb the species, such as fishes, squids, and crustaceans, upon which the marine mammals prey (NRC, 1994). It is also known that the physical structure and lights from platforms or drillships may attract these same animals; hence, effects may be difficult to predict. Human-made noise can cause temporary or permanent hearing impairment in marine mammals if the sound is strong enough. Such impairment would have the potential to diminish the individual's chance for survival. Tolerance of noise is often demonstrated, but this does not prove that the animals are unaffected by sound; for example, they may become stressed, making the animal(s) more vulnerable to parasites, disease, environmental contaminants, and/or predation (e.g., Majors and Myrick, 1990). Noise-induced stress is possible, but studies are limited on marine mammals (e.g., Thomas et al., 1990).

Increased deepwater activities will necessitate an increase in helicopter traffic. The increase in traffic might increase the frequency of disturbance behavior exhibited by the animals. Cetacean species, group composition, and their behavior, as well as conditions of the overflight, seem to influence whether or not cetacean behavior or activities are influenced. Overflights can elicit a startle response from, and interrupt cetaceans nearby (depending on the activity of the animals) (Richardson et al., 1995). Whales often react to aircraft overflights by hasty dives, turns, or other changes in behavior. Beaked whales seem especially sensitive to aircraft overflights (Richardson et al., 1995). Almost all data on disturbance reactions have concerned short-term (minutes to hours) behavioral reactions. In most studies, little or no information has been obtained about the duration of altered behavior after disturbance. The significance of short-term behavioral responses to the long-term well-being of individuals and populations is essentially unknown. Most startle responses are considered to be relatively benign. An exception to this could include repeated disturbances during mating or feeding. The impact of helicopter overflights is discussed in greater detail in the multisale EIS=s for the Central and Western Gulf of Mexico (USDOI, MMS, 1997b and 1998).

Increased deepwater activities will be accompanied by an increase in vessel traffic, as well as the use of larger support vessels. The increase in vessels could result in an increase in disturbance of the animals. Noise from service-vessel traffic (see discussion of noise in Chapter II) and the presence of the vessels can elicit a startle and/or avoidance reaction from cetaceans or mask their sound reception. There is the possibility of short-term disruption of movement patterns and behavior, but such disruptions are unlikely to affect survival or productivity, unless they occur frequently. Long-term displacement of animals from an area is also a consideration. In baleen whales, a few cases of medium- to long-term displacement of animals from local areas have been ascribed, at least tentatively, to repeated disturbance (Richardson et al., 1995). Underwater sound was presumably a major factor in some of these cases. Whales might possibly avoid or abandon important feeding areas, breeding areas, resting areas, or migratory routes. Consequences to a cetacean population would be difficult to determine. It should be noted that there are many more reports of noise tolerance by various dolphin and whale species than there are reports of disturbance.

Increased vessel traffic could increase the probability of collisions between ships and marine mammals, resulting in injury or death to some animals. Though cetaceans should be able to avoid vessels, operators should take actions to avoid moving directly at a whale(s) or dolphin(s). There are many occasions that dolphins are struck by propellers, either because they are not attentive (due to behaviors they are engaged in, or perhaps because of their age/health) or because there is too much vessel traffic around them. In accordance with the Marine Mammal Protection Act, NMFS has guidelines for operators of boats with regard to proper maneuvering around cetaceans. Slow-moving cetaceans (e.g., northern right whale) or those that spend extended periods of time at the surface in order to restore oxygen levels within their tissues after deep dives (sperm whale) might be expected to be the most vulnerable. Operators in areas of heavy sperm whale concentration should take care to steer clear of these animals, since the whales must spend roughly 30 minutes resting at the water surface and are not able to perform deep dives at that time. It is possible, though unlikely, that manatees could occur in areas where they could be affected by vessels traveling to and from deepwater areas. If a manatee should be present in an area where there is vessel traffic, they could be injured or killed by a boat colliding into them (Wright et al., 1995). Inadequate hearing sensitivity at low frequencies may be a contributing factor to the manatees= inability to detect boat noise effectively and avoid collisions with boats (Gerstein et al., 1999). The impact on marine mammals by vessel traffic is discussed in greater detail in the multisale EIS=s for the Central and Western Gulf of Mexico (USDOI, MMS, 1997b and 1998).

Seismic surveys produce an intense acoustic (sound) signal. Both high- and low-frequency energy is present in the pulses at considerable magnitude and will certainly be detectable tens of kilometers from the source. Baleen whales seem quite tolerant of low- and moderate-level sound pulses from distant seismic surveys but exhibit behavioral changes in the presence of nearby seismic activity (Richardson et al., 1995). Subtle effects on surfacing, respiration, and dive cycles have been noted (shorter surfacings, shorter dives, and fewer blows per surfacing) (Richardson et al., 1995; Richardson, 1997). Humpback whales off western Australia were found to change course at 3-6 km from an operating seismic vessel survey, with most animals keeping a standoff range of 3-4 km (McCauley et al., 1998a and b). Whales exposed to sound from distant seismic survey ships may be affected even though they remain in the area and continue their normal activities (Richardson et al., 1995). Response appears to diminish gradually with increasing distance and decreasing sound level (Richardson, 1997). Goold (1996) found that acoustic contacts with common dolphins dropped sharply as soon as seismic activity began, suggesting a localized disturbance of dolphins. It was also estimated that seismic energy from the 2,120-in^3 airgun-array in a shelf sea environment was Asafe@ to common dolphins at a radius from the gun array of 1 km (Goold and Fish, 1998). Given the high, broadband seismic-pulse power levels across the entire recorded bandwidth and the known auditory thresholds for several dolphin species, Goold and Fish (1998) considered such seismic emissions to be clearly audible to dolphins across a bandwidth of tens of kilohertz and at least out to the 8-km range. Sperm whales during the Heard Island Feasibility Test were found to cease calling during some (but not all) times when seismic pulses were received from an airgun array >300 km away (Bowles et al., 1994) (whether sperm whales were responding directly to the seismic pulses is not known). In contrast, there are observations of sperm whales in the Gulf continuing to vocalize while seismic pulses are ongoing (Evans, personal communication, 1999). One report of Gulf sperm whales suggested that the animals may have moved 50+ km away in response to seismic pulses (Mate et al., 1994), but further work suggests that the animals may not have moved in response to the sound, but perhaps relative to oceanographic features and prey distribution. It is unclear whether the site fidelity of sperm whales to the area off the mouth of the Mississippi River is a consequence of low sensitivity to seismic sound or a high motivation to remain in the area. Sperm whales have historically occupied this area; their continued presence might suggest tolerance or insensitivity to the seismic signals. During GulfCet II, results showed that the cetacean sighting rate did not change significantly due to seismic exploration signals (Davis et al., 2000). The analysis of the results was unable to detect small-scale (<100 km) changes in cetacean distribution. No obvious behavior modifications relative to the seismic activity were recorded during the majority of the small odontocete observations made during marine mammal monitoring carried out during a 3D seismic survey offshore California in late 1995 (Arnold, 1996). There was also no observable behavior modification or harassment of large whales attributable to the sound effects of the survey (Arnold, 1996).

For baleen whales, in particular, it is not known (1) whether the same individuals return to areas of previous seismic exposure, (2) whether seismic work has caused local changes in distribution or migration routes, or (3) whether whales that tolerate strong seismic pulses are stressed (Richardson et al., 1995). There are no data on auditory damage in marine mammals relative to received levels of underwater sound pulses (Richardson et al., 1995). Indirect "evidence" suggests that extended or repeated exposure to seismic pulses is unlikely to cause permanent hearing damage in marine mammals given a study of damage risk criteria, the transitory nature of seismic exploration, the presumed ability of marine mammals to tolerate exposure to strong calls from themselves or other nearby mammals, and the avoidance responses that occur in at least some baleen whales when exposed to certain levels of seismic pulses (Richardson et al., 1995). Although any one seismic survey is unlikely to have long-term adverse effects on any cetacean species or population, available information is not sufficient to determine whether or not repeated disturbance from seismic activities would cause significant or adverse long-term effects on the size or productivity of any marine mammal species or population.

c. Structure Removal

Information on the effects of explosions on marine mammals is limited (O'Keeffe and Young, 1984). The shock wave produced by explosions can cause physical damage to nearby animals. As explained in detail by NMFS (1995), it is assumed that marine mammals more than 3,000 ft (910 m) from structures to be removed would avoid injury caused by explosions. There is no evidence linking dolphin injuries or deaths in the Gulf to explosive removal of oil and gas structures (Klima et al., 1988; Gitschlag et al., 1997). Sublethal effects caused by ~~to~~ the shock wave and acoustic energy of the detonation include startle responses, behavior effects, and physiological, as well as pathological, effects on the body. Even if dolphins are not capable of hearing the acoustic signature of the explosion, physiological or behavioral responses to detonations could still result. Explosions and shock waves and the intense transient sound field have the ability to produce blast injury and acoustic trauma in marine mammals (Ketten, 1995). Consequences of hearing damage can range from subtle, through modification of certain behaviors that require a modicum of hearing ability, to acute, where concussive effects could lead to death (Ketten, 1995). To minimize the likelihood that detonations occur when cetaceans may be nearby, MMS has issued a series of guidelines to offshore operators on explosive platform removal. Platform observers from NMFS watch for marine mammals in the vicinity of the platform to be removed.

d. Oil Spills

Each major grouping of marine mammals confronts oil in different ways. Spilled oil could affect marine mammals through various pathways: surface contact, oil inhalation, oil ingestion, and baleen fouling (Geraci, 1990). Indirect consequences of oil pollution on marine mammals are those effects associated with changes in the availability or suitability of various food sources (Hansen, 1992). More details on possible effects of oils spills on marine mammals can be found in the multisale EIS=s for the Central and Western Gulf of Mexico (USDOI, MMS, 1997b and 1998). Evidence gathered from the studies of the *Exxon Valdez* spill indicates that oil spills have the potential to cause greater chronic (sublethal oil-related injuries) and acute (spill-related deaths) effects on marine mammals than originally suggested. Some short-term (0-1 month) effects of oil may be (1) changes in cetacean distribution associated with avoidance of aromatic hydrocarbons and surface oil, changes in prey distribution, and human disturbance; (2) increased mortality rates from ingestion or inhalation of oil; (3) increased petroleum compounds in tissues; and (4) impaired health (e.g., immunosuppression) (Harvey and Dahlheim, 1994). Several mechanisms for long-term injury can be postulated: (1) initial sublethal exposure to oil-causing pathological damage; (2) continued exposure to hydrocarbons persisting in the environment, either directly or through ingestion of contaminated prey; and (3) altered availability of prey as a result of the spill (Ballachey et al., 1994). Long-term effects may include (1) change in distribution and abundance because of reduced prey resources or increased mortality rates; (2) change in age structure because certain year-classes were impacted more by petroleum; (3) decreased reproductive rate; and (4) increased rate of disease or neurological problems from exposure to hydrocarbons (Harvey and Dahlheim, 1994).

e. Oil-Spill Response Activities

The potential effects of cleanup activities on cetaceans are not known, but increased human presence (e.g., vessels) could add to changes in cetacean behavior and/or distribution, thereby causing additional stress to the animals, and perhaps making them more vulnerable to various physiologic and toxic effects. Virtually nothing is known about the effects of oil dispersants on cetaceans, except that removal of the oil from the surface would reduce the risk of contact and render it less likely to adhere to skin, baleen plates, or other body surfaces (Neff, 1990). The acute toxicity of most oil dispersant chemicals is considered to be low when compared with the constituents and fractions of crude oils and refined products, and studies have shown that the rate of biodegradation of dispersed oil is equal to or greater than that of undispersed oil (Wells, 1989). Metabolism of surfactants is thought to be rapid enough that there is little likelihood of food chain transfer from marine invertebrates and fish to consumers, including marine mammals (Neff, 1990). Biodegradation is another process used for removing petroleum hydrocarbons from the marine environment, utilizing chemical fertilizers to augment the growth of naturally occurring hydrocarbon-degrading microorganisms. Toxic effects of these fertilizers on cetaceans are unknown. Vessels and booms placed around an oil slick are unlikely to deter cetaceans from entering a contaminated zone (Gubbay and Earll, 1999). Vessel operators should be alert for cetaceans that are lethargic or suffering from other effects of inhaling volatiles, since propeller action could cause physical injury to the animals (Gubbay and Earll, 1999).

f. Debris

With an increase in deepwater activities, there is the possibility of an increase in marine debris. Both entanglement in and ingestion of debris have caused the death or serious injury of marine mammals (Laist, 1997; MMC, 1999). Both MMS and U.S. Coast Guard regulations prohibit the disposal of any trash or debris into the marine environment. Therefore, debris is not expected to have a significant impact on Gulf marine mammals.

g. Suggested Mitigation Measures for Further Evaluation

Decisions related to mitigation of potential impacts from seismic surveys should be deferred until the MMS-funded contract to Continental Shelf & Associates for the environmental assessment on geological and geophysical exploration activities is completed, and findings from the MMS ramp-up study (currently in procurement process) are available.

(1) Ramp-up. Ramp-up is gradually increasing the sound level to operational levels (over at least 20 minutes to give marine mammals adequate time to leave the area).

Anticipated Benefit: Ramp-up is a standard mitigation measure for seismic survey operations, as well as for other activities involving seismic sources, in many parts of the world. This is in recognition of the potential risk that immediate hearing damage could occur to a nearby marine mammal if a seismic sound source were turned on suddenly. It is assumed that if marine mammals find a sound increasingly aversive, they will move away before hearing damage or physiological effects occur. Ramp-up has primarily been a “common-sense” measure, since there have been no comprehensive studies of the effectiveness of ramp-up as a mitigation measure. Such a study is in the MMS procurement process.

There are no widely-accepted standards on how ramp-up should be conducted in terms of length of time, initial sound levels, progression of sound levels, and so on. In U.S. waters, the ramp-up protocol most commonly followed (in accordance with Incidental Harassment Authorizations issued by the National Marine Fisheries Service) requires that the airgun array be ramped up to full operating levels at a rate not to exceed 6 dB per minute between 160 dB and the operating level at the commencement of operations or anytime that the array is powered down below 160 db re 1 uPa) maximum output. There are few specific data upon which to design the most effective protocol. When ramping-up is done as a mitigation measure, there is a need to specify how long the airguns can be silent before full ramp-up must be reinitiated. In the United Kingdom, where the procedure is termed a 'slow build' or 'soft start', guidelines specify that power should be built up slowly from a low energy start-up (e.g., starting with the smallest airgun in the array and gradually adding in others) over at least 20 minutes to give adequate time for marine mammals to leave the vicinity. The guidelines also state there should be a soft start every time the airguns are used, even if no marine mammals have been seen (particularly, e.g., nighttime).

Concerns: It is possible that ramping up a seismic sound source could increase the risk of harm. Marine mammals could gradually accommodate to increasing sound intensity until harmful levels are reached, or they might be attracted toward the sound source by initially weak sounds and thus be exposed to potentially harmful levels as the sound intensity increases.

(2) Establish appropriate safety-zone perimeters as determined through pre-survey modeling and site-specific verification of transmission loss. Safety zones would be defined by the iso-line of the received sound level believed to have the potential for at least temporary hearing impairment for marine mammals. Safety zones would be dependent on air gun array size and depth, water depth and temperature, and the type of marine mammal that may be present. Safety zones would be based on a transmission loss model and, so far, a conservative received level of 180 dB re 1 uPa has been proposed. If marine mammals are sighted within the safety zone within 30 minutes prior to ramp-up, operations would be delayed to give the animals sufficient time to clear the area. A more rigorous level of safety zone monitoring would be the requirement that safety zones be monitored continuously whenever the airgun is operating, and that the array be shutdown if any marine mammal is sighted within the zone. The concern is that marine mammals that are foraging or intent on other activities might inadvertently swim close enough to the airguns to expose themselves to potential hearing damage. Range finders (using lasers) could possibly be used to determine whether or not animals are located in the safety zone.

The U.K. guidelines recommend that, if marine mammals are detected within 500 m (1,640 ft) of the seismic array, an adequate time (at least 20 minutes following the last sighting) must be allowed for the animals to move well away.

Anticipated Benefit: Protection of marine mammals from possible hearing damage.

Concerns: Concern about the adequacy of models to accurately calculate transmission loss in specific seismic survey areas may lead to requirements for site-specific verification of the transmission loss models. Frequent shut down would increase time and expense for a survey. It could be difficult to determine if marine mammals are within the safety zone. For example, sighting conditions such as weather, sea state, and time of day may make distance approximation difficult and deep-diving animals may stay submerged for up to 90 minutes. At the workshop on marine mammals and low-frequency sound convened by the MMS POCSR High-Energy Seismic Survey (HESS) Team (1997), an expert panel was apprehensive about sound levels above 180 dB re 1 uPa with respect to overt behavioral, physiological, and hearing effects on marine mammals in general, though a range of 170-190 dB re 1 uPa was initially adopted. It is likely that the 180-dB iso-line will be used for seismic surveys offshore southern California, although NMFS may use other levels elsewhere.

*(a) Real-time monitoring of safety zone by vessel-based observers***.** Ship-based observers monitoring the designated safety zones around the airgun array during ramp-up and full operation could provide real-time mitigation (airgun shutdown).

Anticipated Benefit: Minimal impact to cetaceans observed within the limits of the established safety zone. Information needed to estimate the “take” of marine mammals by harassment could be gathered. Data can be collected on the occurrence and distribution of marine mammals in the area of seismic operations.

Concerns: Observation of marine mammals is usually not possible at night (unless some form of night-vision equipment is used; range of detection depends on the type of lens) and may not be possible in poor weather or rough seas. Two types, light-amplifying and infrared (IR) have been used for seismic surveys to date. Both systems have advantages and limitations; NMFS is currently supporting field comparisons of available light-amplifying and IR equipment. Mobil (Australia), as one of its guidelines (Procedures for Management of Whale Encounters during Seismic Surveys), has stated that a watch is to be kept for whales at all times during seismic operations, including use of night-vision glasses after dark.

Submerged deep-divers, because of their long dive times, will often not be visible to observers. The fact that observers have not seen animals at the surface is no guarantee that they are not within the safety zone. Frequent shutdown would increase the time and cost of a seismic survey, as would having adequately trained observers available at all times.

(b) Passive acoustic monitoring of the safety zone. In addition to characterizing the seismic source signal and measuring signal propagation properties and ambient noise, acoustic receivers can be used to detect marine mammal vocalizations. There is evidence that passive acoustic monitoring may more effectively detect sperm whales than shipboard observers. For some species, notably the highly vocal sperm whale, acoustic monitoring can help determine the presence of submerged cetaceans. If detected, the seismic survey could be delayed or stopped. Bottom recorders, vessel-based acoustic measurements, and ocean-bottom, cable-based acoustic receivers could be used.

Anticipated Benefits: Acoustic monitoring can detect vocalizing marine mammals, even if submerged. Acoustic monitoring can aid in providing real-time location (bearing and estimated range) for marine mammals within the survey area.

Concerns: Cost-effective acoustic systems capable of locating vocalizing marine mammals precisely enough to be used to monitor safety zones are not yet commercially available. It would be difficult to quickly determine how far away some vocalizing cetaceans, such as sperm whales, are (sperm whale vocalizations may carry over many kilometers). This is unlikely to be a reliable method of detecting beaked whales, which are deepwater species with sensitivity to low-frequency sounds. Frequent shutdowns would increase the time and cost of a seismic survey, as would deployment and maintenance of special monitoring equipment.

(c) Monitoring of the safety zone via aerial overflights. Aerial surveys have been flown as required mitigation or monitoring measures in conjunction with several recent seismic surveys in U.S. waters (Alaska, Santa Barbara Channel, Puget Sound region). In general, the objectives of aerial surveys conducted in conjunction with seismic operations have been (1) to obtain presurvey information on the numbers and distribution of marine mammals in the seismic survey area; (2) to document changes in the behavior and distribution of marine mammals in the area during seismic operations; and, in some cases, (3) to obtain post-survey information on marine mammals in the survey area to document whether detectable changes in numbers and distribution have occurred in response to the seismic operations.

Anticipated Benefits: Any observed responses to seismic pulses would not be biased since the observers would be insulated from knowing exactly when the airguns were turned on. Observations would also not be made from the observation platform (ship) actually causing the potential disturbance.

Concerns: Aerial surveys are limited in their usefulness as mitigation measures for seismic surveys. They are likely to be most effective when the marine mammal species of interest are migrating along a relatively well-defined corridor or are concentrated temporarily in an area for important biological purposes, such as feeding or reproduction (a good example is the annual migration of bowhead whales along the Canadian and Alaskan coasts in the Beaufort Sea).

The costs of conducting aerial surveys would be substantial. Cost of the survey is directly related to the aircraft type and the distance from the target area in the Gulf from a shore base. Twin otters are most frequently used for offshore marine mammal surveys; the approximate cost is $600-1,000/hr. Refueling requirements (depending on distance from shore) may result in short observation periods (=hours). For example, during GulfCet aerial surveys, the twin otter used had a 6.5-hr flight duration time; therefore, for observations on the slope, only four hours could be spent on the actual observation period. The MMS has funded studies involving aerial observations in Alaska to study bowhead whale responses to seismic surveys. These studies have provided information on behavioral responses to seismic survey vessels. Surveys in some locations were paid for ultimately by the oil companies, since the seismic operators work for them. A similar situation might be applicable for the Gulf, with a preliminary survey(s) being funded by MMS to determine validity of the technique for the Gulf; later surveys would be supported by the seismic industry.

In the absence of experimental control over the seismic source, it may not be certain that observed behavioral changes are causally related to the seismic source (i.e., it would not be possible to ask operators to start or stop shooting in order to test whale responses). Any observed startle response might also be in response to other environmental factors (e.g. aircraft).

(d) Limit operations to daylight hours and good visibility conditions. This precautionary principle for government agencies permitting projects that may increase sound levels in the marine environment is recommended in the NRDC report "Sounding the Depths: Supertankers, Sonar, and the Rise of Undersea Noise." Good sighting conditions aid in successful monitoring of whether or not animals are present within the safety zone, and when shut-down procedures should be enacted to avert exposure of marine mammals to potentially damaging sound.

Anticipated Benefit: The ability to determine whether cetaceans are in the area to be surveyed.

Concerns: Operating less than 24 hours each day would incur substantial expenses. Daylight-only operations prolong the duration of seismic survey activities in a given area, thus increasing the likelihood that marine mammals will be harassed. When airguns cease operating, marine mammals might move back into the survey area, increasing the potential for harm when operations resume.

(3) Reducing and/or baffling unnecessary high-frequency sound produced by airguns or other acoustic energy sources. High-frequency energy in the seismic pulse spectrum (i.e., above 1 kHz) is of little interest to the seismic industry and is filtered from survey recordings as noise. Dolphins communicate with high-frequency sounds and are, therefore, most sensitive to these high-frequency sounds. Exposure to high-frequency sounds from seismic surveys might cause localized disturbance of dolphins.

Anticipated Benefit: Reducing or baffling high-frequency sound would reduce noise pollution for these animals.

Concerns: The technology is experimental at this point, but some techniques are known to reduce sound levels for some frequency bands. The potential effectiveness of this measure has not been studied. A workshop was held in London during Summer 1999 to discuss baffling; proceedings are currently not available from this meeting.

(4) Limit sound source strength.

Anticipated Benefit: Potentially lower impacts to marine mammals.

Concerns: May jeopardize the success of the survey by not providing adequate seismic penetration. This is a serious concern where potential reservoirs are deeply buried or located beneath salt. If the array fails to achieve the required penetration, then another survey would need to be conducted, resulting in increased costs and potential impact to marine mammals. This may not be necessary; evidence of harm to marine mammals by seismic sources has not been established. There is also not enough information to determine the appropriate level.

h. Suggested Research and Information Synthesis

In discussing marine mammals and the potential impacts of oil and gas development in deep water, additional information regarding certain issues would augment the planning process. In June 1999, the MMS held a Marine Protected Species Workshop (update to Tucker & Associates, 1990) to review the state of knowledge for marine species and to identify information needs. Workshop participants emphasized that it was critical to study offshore areas before additional exploration and development occur. The workshop participants indicated important basic ecological questions that need to be answered. A particularly important goal is to relate prey distribution and abundance to estimated carrying capacity of the offshore areas.

This will allow for a comparison of Gulf habitats to other large ocean areas of similar scale. For example, the diversity of cetaceans in the Gulf is comparable to other large ocean areas of similar scale (e.g., the northeastern United States and the eastern tropical Pacific); however, the overall density of animals is much smaller. Future studies on zooplankton and micronekton could support an assessment of the correlation between cetacean distribution and the carrying capacity for prey species. This will help in determining whether the lesser density of cetaceans may be a reflection of prey availability in the Gulf or an effect of human activities. Workshop participants also noted that emphasis needs to be placed on conducting surveys to obtain additional distribution and abundance information for the southern and offshore waters of the Gulf.

Studies sponsored by MMS and the Biological Resources Division of the U.S. Geological Survey (GulfCet I and II) have provided much information on deepwater cetaceans; this information can be considered baseline information for Gulf cetaceans. Additional studies to monitor the deepwater cetacean populations are under discussion. Ongoing Gulfwide surveys have not provided sufficient resolution to detect changes in the relative abundance and distribution of these species, unless those changes are dramatic. Analyses are needed to determine the type and level of survey effort that would be required to detect and monitor changes in distribution patterns and abundance in areas where the changes could be caused by oil/gas exploration and development activities. The MMS is providing some monetary support to NMFS to include marine mammal observers on NMFS ichthyoplankton cruises. These cruises, however, do not fully extend into deepwater areas of concern to MMS.

Information on the biology and behavior of deepwater cetaceans is limited, so any information that can be obtained and analyzed regarding natural history, ranges, and vital rates will help in determining what types of effects might occur from deepwater activities. The MMS is negotiating an interagency agreement with NMFS for a sperm whale stock assessment study.

At present, MMS is funding a literature review that will summarize existing information on the frequency of use and the potential environmental impacts of the use of synthetic-based drilling fluids (SBF) in deep water. This effort is an initial component of a much larger effort to provide information on the fate and effects of SBF. Field studies to determine the distribution, dispersion, residence time, and toxicity levels of discharged synthetic-based drilling fluids and cuttings would help in the identification of potential mitigation measures.

The effect of noise on marine mammals is of increasing controversy and concern (e.g., NRDC, 1999). The MMS funded a study to review the effects of noise on marine mammals (Richardson et al., 1995). Continental Shelf Associates was recently awarded a contract by MMS to prepare an environmental assessment of geological and geophysical operations (including seismic surveys) on the marine environment. Information on sound output from platforms is limited, and includes no data for structures operating in the Gulf. Information collected from platforms in other areas, such as off California or in the Arctic, may not be applicable to the Gulf because of differences in the environment that affect sound transmission properties. Research on the ambient noise levels and noise from specific OCS-related activities in the Gulf of Mexico would increase our general understanding of the effects of noise on marine mammals, help in determining the effectiveness of potential mitigation measures (including Aramp-up,@ identification of safety-zone perimeters through presurvey modeling, site-specific verification of transmission loss, the use of shipboard observers, and aerial surveys), and help in the development of additional mitigation measures. A study of the effectiveness of ramp-up is in the MMS procurement process. Measurements of ambient noise are being considered by the MMS's Gulf of Mexico OCS Region.

The Protected Species Workshop expert panel discussed a number of possible study approaches regarding seismic profiles. A strong recommendation was made for a study (experiment) to be conducted to determine the types and levels of seismic survey and other anthropogenic sounds that sperm whales are routinely exposed to in different areas and different times of the year and whether their distribution, movements, vocalization patterns, or other behavior changes are in response to the sound. It is expensive to look at a population=s response to air guns, so it was suggested to dedicate dollars to detailed response of individuals in certain key species (e.g., sperm whale).

3. Conclusions

As a result of a progression of activities into deeper water, there will be an increase in the number of cetacean species (a different constellation of animals) and individual animals affected. Deepwater cetaceans may be more behaviorally sensitive to OCS activities, since these animals occur in areas where they may have had little or no previous exposure to or experience with exploration and development activities. Deepwater cetaceans have a different ear structure than shallow-water cetaceans; deepwater cetaceans are more sensitive to low-frequency sounds, while shallow-water cetaceans are more sensitive to relatively high-frequency sounds. Cetacean stock discreteness also becomes a more important issue.

Deepwater exploration, development, and production activities are unlikely to have long-term adverse effects on the size and productivity of any marine mammal species population stock in the northern Gulf of Mexico. The notable exception would be an oil spill occurring at a time and place where marine mammals are concentrated or a spill that would adversely affect the habitats or habitat component (e.g., important prey species) that are essential to the well-being of any marine mammal species or population stock in the northern Gulf. There is no information on the distribution of cetaceans prior to oil and gas exploration and development in the northern Gulf of Mexico. The present distribution patterns of both large and small cetaceans may already reflect displacements in response to the expansion of OCS activities into deepwater areas.

Small numbers of marine mammals could be killed or injured by chance collision by OCS-related vessels or by eating indigestible trash, particularly plastic items, accidentally lost from OCS-related facilities and vessels. Few lethal impacts are expected. Deaths caused by structure removals are not expected because of existing mitigation measures. The evidence on whether anthropogenic noise has or has not caused long-term displacements of, or reductions in, marine mammal populations is inconclusive. Contaminants in waste discharges and drilling fluids could indirectly affect marine mammals through food-chain biomagnification. Biological impact of any mortality would depend, in part, on the size and reproductive rates of the affected stocks (e.g., whether the species is listed as endangered), as well as the number, age, and sex of animals affected.

D. Sea Turtles

1. Description

Five species of sea turtle are found in the waters of the Gulf of Mexico: Kemp's ridley, loggerhead, green, leatherback, and hawksbill. All are protected by the Endangered Species Act. Commercial fishing has had a devastating impact on both U.S. and world populations of sea turtles (Witzell, 1994). Commercial exploitation is the major cause of the continued decline of the hawksbill sea turtle (USDOC, NMFS, 1993).

Sea turtles spend nearly all of their lives in the water. The females must emerge periodically from the ocean to nest on beaches. Sea turtles are long-lived and slow-reproducing. It is generally believed that all sea turtle species spend the first few years of their lives in pelagic waters, occurring in driftlines and convergence zones (in sargassum rafts) where they find refuge and food in items that accumulate in surface circulation features (Carr, 1986 and 1987). Genetic analysis of sea turtles has revealed in recent years that discrete, noninterbreeding stocks of sea turtles make up "worldwide extensive ranges" of the various species.

Adult turtles in the Gulf are apparently less abundant in the deeper waters of the Gulf of Mexico than in waters less than 50 m deep (NRC, 1990). Loggerheads are probably the most common sea turtle species in the northern Gulf (Rabalais and Rabalais, 1980; Fritts et al., 1983b; Fuller and Tappan, 1986; Rosman et al., 1987; Lohoefener et al., 1990). Sea turtles appear to be more abundant east of the Mississippi River than they are west of the river (Fritts et al., 1983b; Lohoefener et al., 1990); factors such as water depth, bottom sediments, and prey may account for this. Lohoefener et al. (1990) noted a high probability of one or more sea turtles being fairly close to oil and gas platforms east of the Mississippi River.

Kemp=s Ridley

The Kemp=s ridley (*Lepidochelys kempi*) is the smallest living sea turtle and is the most imperiled of the world's sea turtles. The Gulf of Mexico=s population of nesting females has dwindled from an estimated 47,000 in 1947 (Hildebrand, 1963) to a current nesting population of approximately 1,500 females (Byles et al., 1996). The population crash that occurred between 1947 and the early 1970's may have been the result of both intensive annual harvest of the eggs and mortality of juveniles and adults in trawl fisheries (NRC, 1990). The recovery of the species has been forestalled primarily by incidental mortality in commercial shrimping, preventing adequate recruitment into the breeding population (USDOC, NMFS, 1992).

In the Gulf, Kemp's ridleys inhabit nearshore areas, being most abundant in coastal waters from Texas to west Florida (Ogren et al., 1989; Marquez, 1990, 1994; Rudloe et al., 1991). The adults of Kemp=s ridley turtle usually occur only in the Gulf, but juveniles and immature individuals ranged between tropical and temperate coastal areas of the northwestern Atlantic (Marquez, 1990). Juveniles usually are more common outside the Gulf, along the east coast of the U.S. from Florida to New England, especially off Florida and Georgia; other spots of occurrence of juvenile and immature ridleys, quoted in stranding reports, are the west coast of Florida and the mouth of the Mississippi River (Ogren, 1989; Marquez, 1990). Two Kemp=s ridleys were reported for the continental shelf during GulfCet II surveys (Mullin, personal communication, 1998).

Eggs are laid annually, primarily in Rancho Nuevo, Tamaulipas, Mexico (USDOC, NMFS, 1992). After nesting, the adults disperse in two directions towards feeding grounds, one northwest towards Florida, the other southeast to the Campeche Bank. Nesting in the United States occurs infrequently on Padre and Mustang Islands in south Texas from May to August (Thompson, 1988). Kemp=s ridley turtles have occasionally nested in Florida. From 1948 through 1997, 32 nests have been documented on the U.S. coast (Shaver, personal communication, 1997). Two adult female Kemp=s ridleys found at Padre Island were satellite tagged to document post-nesting movements (Shaver, personal communication, 1997). Both females moved northward, spending most of their time in Louisiana waters; one female moved as far as western Florida, the other stayed in the vicinity of Louisiana.

Hatchlings appear to disperse offshore and are sometimes found in sargassum mats (Collard and Ogren, 1989). In the pelagic stage, the turtle is dependent on currents, fronts, and gyres to determine their distribution. Information on the habitats of hatchling and juvenile Kemp=s ridley turtles is limited. Some young turtles stay within the Gulf, whereas others are carried out of the Gulf by currents into the Gulf Stream and up to the northeastern United States. The latter migrate south and enter the Gulf as they approach maturity. With growth, the turtle can move voluntarily to shallow coastal waters, especially off western Louisiana and Florida, where benthic feeding occurs. The north and northeast portions of the Gulf are considered foraging habitat for juveniles, subadults, and post-nesting females (Ogren, 1989; Rudloe et al., 1991). The Kemp's ridley inhabits sandy and muddy bottoms, feeding on portunids and other crabs (Ogren, 1989; Shaver, 1991), and has an associated distribution with seagrass ecosystems (Carr and Caldwell, 1956; Lutcavage and Musick, 1985). Strandings of Kemp=s ridleys on Texas beaches indicate that they are mostly from Mexico (Shaver, personal communication, 1997).

Loggerhead

The loggerhead sea turtle (*Caretta caretta*) occurs worldwide in habitats ranging from estuaries to the continental shelf (Dodd, 1988). The loggerhead is the most abundant species of sea turtle occurring in U.S. waters, throughout the inner continental shelf from Florida through Cape Cod, Massachusetts. Loggerheads are probably the most common sea turtle species in the northern Gulf (e.g., Fritts et al., 1983b; Fuller and Tappan, 1986; Rosman et al., 1987; Lohoefener et al., 1990).

In the western North Atlantic (which includes the Gulf of Mexico), there are at least four loggerhead nesting subpopulations: the Northern Nesting Subpopulation (North Carolina to northeast Florida, about 29^{o} N. latitude), the South Florida Nesting Subpopulation (29^{o} N. latitude to Naples), the Florida Panhandle Nesting Subpopulation (Eglin Air Force Base and the beaches near Panama City), and the Yucatán Nesting Subpopulation (northern and eastern Yucatán Peninsula, Mexico) (Byles et al., 1996). Limited tagging data suggest those adult females nesting in the Gulf of Mexico, which are not part of the South Florida Subpopulation, remain in the Gulf (Meylan, 1982). Information is limited about the adult male distribution; however, they have been observed year-round in South Florida (Byles et al., 1996). Information is limited about seasonal movements of loggerheads in the Gulf (Byles et al., 1996).

In the Central Gulf, little scientific monitoring of nesting has been conducted (Patrick, personal communication, 1997). Loggerhead nesting has been reported on Gulf Shores and Dauphin Island, Alabama; Petit Bois, Horn, and East Ship Islands, offshore Mississippi; and the Chandeleur Islands, Louisiana (Fuller et al., 1987; Lohoefener et al., 1990; Patrick, personal communication, 1997). The Chandeleur Islands may support a substantial amount of loggerhead nesting. Loggerhead nesting was reported at Biloxi, Mississippi, in 1991 (South and Tucker, 1991). It is unknown whether the nesting sea turtles in Alabama, Mississippi, and Louisiana are genetically distinct subpopulations or if they are genetically similar to the Florida Panhandle Subpopulation (Bowen et al., 1993). Nesting in Texas occurs primarily on North and South Padre Islands, although occurrences are recorded throughout coastal Texas (Hildebrand, 1982).

According to aerial survey results, western North Atlantic loggerheads are distributed about 54 percent in the southeast U.S. Atlantic, 29 percent in the northeast U.S. Atlantic, 12 percent in the Eastern Gulf of Mexico, and 5 percent in the Western Gulf of Mexico (Byles et al., 1996). Aerial surveys indicate that loggerheads are common in less than 50 m depth, but they are also found in deeper water (Shoop et al., 1981; Fritts et al., 1983b). Aerial surveys of marine waters in the northern Gulf and nearby Atlantic found turtles largely distributed in waters less than 100 m in depth (Fritts et al., 1983b). Loggerheads were sighted throughout the northern Gulf continental shelf during GulfCet II aerial surveys (Summer 1996/Winter 1997) (Mullin, personal communication, 1998). Loggerheads have been found to be abundant in Florida waters (Fritts and Reynolds, 1981; Fritts et al., 1983b). In the Central Gulf, loggerheads are very abundant just offshore Breton and Chandeleur Islands (Lohoefener et al., 1990).

Juvenile and subadult loggerheads are omnivorous, foraging on pelagic crabs, molluscs, jellyfish, and vegetation captured at or near the surface (Dodd, 1988; Plotkin, 1989). Adult loggerheads are generalist carnivores that forage on nearshore benthic invertebrates (Dodd, 1988). The banks off the central Louisiana coast and near the Mississippi Delta are important marine turtle feeding areas (Hildebrand, 1982). Genetic evidence has suggested that at least two of the subpopulations intermingle on the foraging grounds of the U.S. Atlantic coast (Byles et al., 1996); the genetic origins of benthic immatures in the Gulf have not been determined.

Green

The green turtle (*Chelonia mydas*) is the largest hard-shelled sea turtle. The green turtle has a global distribution in tropical and subtropical waters. In U.S. Atlantic and Gulf of Mexico waters, green turtles are found around the U.S. Virgin Islands, Puerto Rico, and the continental U.S. from Texas to Massachusetts. Areas in Texas and Florida figured heavily in the commercial fishery for green turtles at the end of the last century (Hildebrand, 1982). Reports of nesting in the northern Gulf are infrequent. Nesting has been recorded at Eglin Air Force Base in Okaloosa County, Florida (Meylan et al., 1995). The number of nests in Florida appears to be increasing, but whether this upward trend reflects an actual increase in the number of nests or is a result of more thorough monitoring of the nesting beaches is uncertain (USDOC, NMFS, 1990); Meylan et al., 1995). Unconfirmed nesting of greens in Alabama has been reported (USDOI, FWS, 1997). Green turtles primarily occur in coastal waters, where they forage on seagrasses, algae, and associated organisms (Carr and Caldwell, 1956; Hendrickson, 1980).

Leatherback

The leatherback (*Dermochelys coriacea*) is the largest of the sea turtles. Leatherbacks have unique deep-diving abilities (Eckert et al., 1986), a specialized jellyfish diet (Brongersma, 1972), and unique physiological properties that distinguish them from other sea turtles (Lutcavage et al., 1990; Paladino et al., 1990). This species is the most pelagic and most wide-ranging of sea turtles, undertaking extensive migrations following depth contours for hundreds, even thousands, of kilometers (Morreale et al., 1993). The leatherback=s distribution is not entirely oceanic; it is commonly found in relatively shallow continental shelf waters along the U.S. Atlantic Coast (Hoffman and Fritts, 1982) and northwestern Gulf of Mexico (Fritts et al., 1983b; Lohoefener et al., 1988 and 1990). Primary habitat of the leatherback in the Gulf is oceanic (> 200 m) (Lohoefener et al., 1990). Though sighted throughout the GulfCet study area (Figure IV-2) in all seasons, it was suggested that the region from Mississippi Canyon east to DeSoto Canyon appears to be an important habitat for leatherbacks (Davis and Fargion, 1996). Specific locations could be very important to leatherbacks, at least for brief periods of time, most probably correlated with oceanographic conditions. Four leatherback sightings were made during the GulfCet II aerial surveys (Summer 1996/Winter 1997) in the Destin Dome area (Mullin, personal communication, 1998). Leatherbacks' nesting is concentrated on coarse-grain beaches in the tropical latitudes (Pritchard, 1971); leatherbacks nest annually in U.S. territories within the Caribbean, principally at St. Croix (U.S. Virgin Islands) and Isla Culebra (Puerto Rico) (USDOC, NMFS and USDOI, FWS, 1992).

Hawksbill

The hawksbill (*Eretmochelys imbricata*) is a small- to medium-sized sea turtle. The hawksbill occurs in tropical and subtropical seas of the Atlantic, Pacific, and Indian Oceans. The species is widely distributed in the Caribbean Sea and western Atlantic Ocean, with representatives of at least some life history stages occurring in southern Florida and the northern Gulf of Mexico (especially Texas) (USDOC, NMFS, 1993). In the continental U.S., the species is recorded from all the Gulf States and from along the eastern seaboard as far north as Massachusetts; however, sightings north of Florida are rare (USDOC, NMFS, 1993). The hawksbill is the least commonly reported sea turtle in the Gulf (Hildebrand, 1982). Stranded hawksbills have been reported in Texas (Hildebrand, 1982; Ogren et al., 1989) and in Louisiana (Koike, 1996); these tend to be either hatchlings or yearlings. Northerly currents may carry immature hawksbills away from their natal beaches in Mexico northward into Texas (Amos, 1989; Collard and Ogren, 1989). Hawksbills found stranded in Texas are from Mexico (Shaver, personal communication, 1997). Texas and Florida are the only States where hawksbills are sighted with any regularity (USDOI, FWS, 1995). This turtle is a solitary nester. Within the continental U.S., nesting is restricted to the southeast coast of Florida and the Florida Keys. Hawksbill turtles are generally associated with coral reefs or other hard substrate areas, where they forage primarily on sponges (Carr and Stancyk, 1975; Meylan, 1988). This species feeds in the photic zone and prefers warm water temperatures.

2. Environmental Impact Assessment

The major impact-producing factors related to deepwater operations that could affect sea turtles include water-quality degradation from operational discharges; noise from helicopter and vessel traffic, drillships, production facilities, and seismic surveys; explosive platform removals; brightly lit platforms; OCS-related debris; oil spills; and oil-spill response activities.

a. Discharges

Produced waters, drill muds, and drill cuttings are routinely discharged into offshore marine waters and are regulated by the USEPA's NPDES permits. Most operational discharges, as regulated, are diluted and dispersed when released in offshore areas and are considered to have sublethal effects on sea turtles (API, 1989; Kennicutt, 1995). Any potential that might exist for impact from drilling fluids would be indirect, either by impact on prey items or possibly through ingestion via the food chain (API, 1989). Contaminants in drilling fluids or waste discharge can biomagnify and bioaccumulate in the food web, which could kill or debilitate important prey species of sea turtles or species lower in the marine food web. Sea turtles could potentially bioaccumulate chemicals, such as heavy metals that occur in drilling mud, which could ultimately reduce reproductive fitness in the turtles an impact that the already diminished population(s) cannot tolerate. Samples from stranded turtles in the Gulf of Mexico carry high levels of organochlorides and heavy metals (Sis et al., 1993).

b. Noise

There have been no systematic studies of the reactions of sea turtles to aircraft overflights and even anecdotal reports are scarce; it would seem reasonable to expect that aircraft noise could be heard by a sea turtle at or near the surface and cause it to alter its normal behavior pattern (Advanced Research Projects Agency, 1995). Noise from service-vessel traffic can elicit a startle reaction from sea turtles and produce a temporary sublethal stress (NRC, 1990). Startle reactions could result in increased surfacings, possibly causing an increase in the risk of vessel collision. Vessel-related injuries were noted in 13 percent of stranded turtles examined from strandings in the Gulf of Mexico and on the Atlantic Coast during 1993 (Teas, 1994), but this figure includes those that could have been struck by boats postmortem. Reactions, such as any avoidance behavior, might result in disruption of normal activities, including feeding. Important habitats may be avoided because of noise production in the vicinity. Information is limited on the possible consequences that these disturbances may have on sea turtles over a long period.

Drillships and production facilities produce an acoustically wide range of sounds at frequencies and intensities that may be detected by turtles. Drilling noise from semisubmersibles is not particularly intense and is strongest at low frequencies (Richardson et al., 1995). Seismic surveys produce an intense noise with both high- and low-frequency energy present in the acoustic pulse at considerable magnitude that will certainly be detectable tens of kilometers from the source. Turtle hearing sensitivity is not well studied. A few preliminary investigations using adult green, loggerhead, and Kemp=s ridley turtles suggest that they are most sensitive to low-frequency sounds (Ridgway et al., 1969; Lenhardt et al., 1983; Moein Bartol et al., 1999). Bone-conducted hearing appears to be a reception mechanism for at least some of the sea turtle species, with the skull and shell acting as receiving structures (Lenhardt et al., 1983).

Captive loggerhead and Kemp=s ridley turtles exposed to brief audio-frequency vibrations initially showed startle responses of slight head retraction and limb extension (Lenhardt et al., 1983). Sound-induced swimming has been observed for captive loggerheads (O=Hara and Wilcox, 1990; Moein et al., 1993; Lenhardt, 1994); some loggerheads exposed to low-frequency sounds responded by swimming towards the surface at the onset of the sound, presumably to lessen the effects of the transmissions (Lenhardt, 1994). An anecdotal observation of a free-ranging leatherback=s response to the sound of a boat motor suggests that leatherbacks may be sensitive to low-frequency sounds, but the response could have been to mid- or high-frequency components of the sound (Advanced Research Projects Agency, 1995). The potential direct and indirect impacts of sound on sea turtles includes physical auditory effects (temporary threshold shift), behavioral disruption, long-term effects, masking, and adverse impacts on the food chain. Based on conclusions of Lenhardt et al. (1983) and O=Hara and Wilcox (1990), low-frequency sound transmissions could cause increased surfacing behavior and deterrence from the area near the sound source. The potential for increased surfacing behavior could place turtles at greater risk of vessel collisions and potentially greater vulnerability to natural predators. If sound affects any prey species, negative consequences to sea turtles would depend on the extent to which prey availability is altered. Noise-induced stress has not been studied in sea turtles.

c. Structure Removal

Oil and gas structures serve as artificial reefs that have been shown to provide habitat for sea turtles (Gitschlag and Herczeg, 1994). Loggerheads have been observed to reside at specific offshore structures for long periods of time (Rosman et al., 1987; Gitschlag and Renaud, 1989). The probability of occupation by sea turtles increases with the age of the structures (Rosman et al., 1987). Sea turtles use oil platforms as places to feed and rest. Offshore structures afford refuge from predators and stability in water currents, and loggerheads have been seen sleeping under platforms or next to support structures (Hastings et al., 1976; Rosman et al., 1987; Gitschlag and Renaud, 1989). Only near the Chandeleur and Breton Islands were sea turtles positively associated with platforms (Lohoefener et al., 1989, 1990). The dominant species of turtle observed during monitoring of explosive structure removal activities is the loggerhead, but leatherback, greens, Kemp=s ridley, and hawksbill have also been observed (Gitschlag and Herczeg, 1994; Gitschlag et al., 1997).

Information about the effects of underwater explosions on sea turtles is extremely limited. O'Keeffe and Young (1984) assumed that shock waves would injure the lungs and other organs containing gas, expected that ear drums of turtles would be sensitive, and expected that smaller turtles would suffer greater injuries from the shock wave than larger turtles. The NMFS conducted several studies before and after an explosive platform removal to determine its effects on sea turtles in the immediate vicinity (Duronslet et al., 1986; Klima et al., 1988). Immediately after the explosion, the turtles closest to the vicinity were rendered unconscious (Klima et al., 1988), though they were active and resumed apparently normal behavior 5-15 minutes post-explosion (Duronslet et al., 1986). One of these turtles also sustained damage to the cloacal lining (it was everted) (Klima et al., 1988). Dilation of epidermal capillaries was a condition that continued for three weeks, after which time all turtles appeared normal. Effects on their hearing were not determined. Impacts of explosive removals on sea turtles are not easily assessed, primarily because turtle behavior makes observations difficult. Sea turtles in temperate latitudes generally spend less than 10 percent of their time at the surface, and dive durations can exceed one hour. Injured turtles that are capable of swimming return to the surface, while dying turtles sink to the sea bottom. Unconsciousness may render a turtle more susceptible to predation; effects of submergence on stunned turtles is unknown (Klima et al., 1988). Only three injured turtles have been observed since 1987, when monitoring became mandatory Gitschlag and Herczeg, 1994; NRC, 1996; and Gitschlag, personal communication, 1998). A total of six additional sea turtles have been captured prior to detonation of explosives and have been saved from possible injury or death (Gitschlag and Herczeg, 1994; Gitschlag et al., 1997). The low number of turtles affected by explosive structure removals may be the result of the small number of turtles that find themselves in harm's way at the time explosives are detonated, the effectiveness of the monitoring program in protecting sea turtles, and/or to the inability to assess and detect impacted animals adequately.

In 1987, in response to 51 dead sea turtles that washed ashore on Texas beaches (explosions were identified as the primary cause by Klima et al., 1988), NMFS initiated an observer program at all explosive removal sites of oil and gas structures in State and Federal waters of the Gulf of Mexico. For at least 48 hours prior to detonation, NMFS observers watch for sea turtles from the surface. Helicopter aerial surveys within a mile radius of the removal site are conducted 30 minutes prior to and after detonation (Gitschlag and Herczeg, 1994). If sea turtles are observed, detonations are delayed until the sea turtles have been safely removed or have left the area. Monitoring the water=s surface for sea turtles is not 100 percent effective. Once a turtle is observed, there is currently no practical and efficient means of removing it from the area (Gitschlag and Herczeg, 1994).

d. Platform Lighting

Hatchlings are known to be attracted to light (Raymond, 1984; Witherington and Martin, 1996). Response by older sea turtles to artificial lighting on deepwater platforms/vessels is unknown. Lights can attract a variety of other marine organisms, including potential prey for the turtles. This activity may be sufficient to attract sea turtles indirectly. Potential predators of sea turtles might also be attracted to fish congregations around the platforms.

e. Debris

A wide variety of debris is commonly observed in the Gulf. Marine debris comes from a variety of land-based and ocean sources (Cottingham, 1988). Some of this material is accidentally lost during drilling and production operations. Turtles can become physically entangled in drifting debris and ingest small fragments of synthetic materials (Carr, 1987; USDOC, NOAA, 1988; Heneman and the Center for Environmental Education, 1988; USDOI, MMS, 1989). Entanglement usually involves fishing line or netting (Balazs, 1985). Once entangled, turtles could drown, suffer impaired ability to catch food or avoid predators, incur wounds and infections from the abrasive or cutting action of attached debris, or exhibit altered behavior patterns that place them at a survival disadvantage (Laist, 1987). Both entanglement and ingestion have caused the death or serious injury of individual sea turtles (Balazs, 1985). Balazs (1985) compiled dozens of records of sea turtle entanglement, ingestion, and impaction of the alimentary canal by ingested plastics worldwide; tar was the most common item ingested. The marked tendency of leatherbacks to ingest plastic has been attributed to misidentification of the translucent films as jellyfish. Lutz (1990) concluded that turtles will actively seek out and consume plastic sheeting. Ingested debris can block the digestive tract or remain in the stomach for extended periods, thereby lessening the feeding drive, causing ulcerations and injury to the stomach lining, or perhaps even providing a source of toxic chemicals (Laist, 1987). Weakened animals could then be more susceptible to predators and disease, and less fit to breed and nest successfully.

f. Oil Spills

When an oil spill occurs, the severity of effects and the extent of damage to sea turtles are affected by geographic location; oil type, dosage, and weathering; impact area; oceanographic and meteorological conditions; season; and life history stage of the animal (NRC, 1985). All sea turtle species and lifestages are vulnerable to the harmful effects of oil through direct contact or by fouling of their habitats and food. Experiments on the physiologic and clinicopathologic effects of oil have shown that major body systems in sea turtles are adversely affected by short exposure to weathered oil. Sea turtles accidentally exposed to petroleum products or tarballs may suffer inflammatory dermatitis, ventilatory disturbance, salt gland dysfunction or failure, red blood cell disturbances, immune responses, and digestive disorders or blockages (Vargo et al., 1986; Lutz and Lutcavage, 1989; Lutcavage et al., 1995). Although disturbances may be temporary, long-term effects remain unknown, and chronically ingested oil may accumulate in organs. Exposure to oil can be fatal, particularly to juvenile and hatchling sea turtles. Direct contact with oil can harm developing turtle embryos.

Oil can adhere to the body surface of marine turtles. Turtles can become entrapped by tar and oil slicks and rendered immobile (Witham, 1978; Plotkin and Amos, 1988; Gramentz, 1988). Periocular tissues and other mucous membranes would presumably be most sensitive to oil contact. Changes in the skin of sea turtles are consistent with an acute, primary contact or irritant dermatitis. A break in the skin barrier could act as a portal of entry for pathogenic organisms, leading to infection, neoplastic conditions, and debilitation (Vargo et al., 1986).

Turtles surfacing in an oil spill will inhale petroleum vapors. Any interference with operation of the lungs would probably reduce a sea turtle's capacity for sustained activity (aerobic scope) and its dive time; both effects decrease the turtle's chance of survival.

Lutcavage et al. (1995) found that operation of the salt gland in sea turtles was disrupted with exposure to oil, but the disturbance did not appear until several days after exposure. The salt glands did recover function when tested after two weeks of recovery. Prolonged interference with salt gland functioning could have serious consequences since it would interfere with both water balance and ion regulation.

Studies on the effect of oil on digestive efficiency are underway, but Lutcavage et al. (1995) report finding oil in the feces of turtles that had swallowed oil in experiments. Van Vleet and Pauly (1987) reported that oil ingested by turtles did not pass rapidly through the digestive tract, but was retained within the system for a period of several days, thus increasing the likelihood that toxic components of the oil could be passed on to other internal organs and tissues of the turtle.

Notable changes in blood chemistry following oiling have been reported (Lutcavage et al., 1995). Hematocrit and hemoglobin concentration decreased slightly during oiling; these parameters are critical components of the blood's oxygen transport system. The most striking hematologic finding was an elevation of white blood cell count, which might indicate a "stress" reaction related to oil exposure and/or toxicity.

Eggs, hatchlings, and small juveniles are particularly vulnerable to contact with oil (Fritts and McGehee, 1982; Lutz and Lutcavage, 1989). Potential toxic impacts on embryos will depend on the type of oil and degree of weathering, type of beach substrate, and especially upon the developmental stage of the embryo. Turtle egg development can be altered or arrested by oiling, and hatchlings are especially vulnerable to impacts (Fritts and McGehee, 1982). Fresh oil was found to be highly toxic, especially during the last quarter of the incubation period, whereas aged oil produced no detectable effects. Fritts and McGehee (1982) concluded that oil contamination of nesting beaches would have its greatest impact on nests that were already constructed; nests made on fouled beaches are less likely to be affected, if at all. Hatchling and small juvenile turtles are particularly vulnerable to contacting or ingesting oil because the currents that concentrate oil spills also form the debris mats in which young turtles are sometimes found (Carr, 1980; Collard and Ogren, 1989; Witherington, 1994). The result of sea turtles feeding selectively in surface convergence lines could be prolonged contact with viscous weathered oil (Witham, 1978; Hall et al., 1983). High rates of oiling in very young turtles suggest that bioaccumulation can occur over their potentially long lifespan. A female coming from the offshore waters to nest might be fouled with oil. During the nesting process, she might push oil mixed with sand into the nest and contaminate the eggs (Chan and Liew, 1988). Assuming olfaction is critical to the process, oil-fouling of a nesting area might disturb imprinting of hatchling turtles or confuse the turtles on their return migration after a 6- to 8-year absence (Geraci and St. Aubin, 1985; Chan and Liew, 1988).

Oil might have a more indirect effect on the behavior of marine turtles. Assuming olfaction is critical to the reproductive process, oil-fouling of a nesting area might disturb imprinting of hatchlings (using chemical cues detected through the permeable eggs) or confuse the adult turtles returning to beaches to nest. The effect on reproductive success could therefore be considerable.

Some captive turtles exposed to oil either reduced the amount of time spent at the surface, possibly avoiding the oil, or became agitated and had short submergence levels (Lutcavage et al., 1995). Sea turtles pursue and swallow tarballs, and there is no concrete evidence that free-ranging turtles can detect and avoid oil (Odell and MacMurray, 1986). A loggerhead turtle sighted during an aerial survey in the Gulf of Mexico surfaced repeatedly within a surface oil slick for over an hour (Lohoefener et al., 1989).

Contact with oil may not cause direct or immediate death, but cumulative sublethal effects, such as salt gland disruption or liver impairment, could impair the marine turtle's ability to function effectively in the marine environment (Vargo et al., 1986; Lutz and Lutcavage, 1989). Although many observed physiological insults are resolved in a 21-day recovery period, the impact of tissue oil intake on the long-term health and survival of sea turtles remains unknown (Lutcavage et al., 1995). There is evidence of bioaccumulation in sea turtles exposed for longer periods of time. After the Gulf of Iraq war, a stranded green turtle did not appear to have been oiled, but upon necropsy, was found to have large amounts of oil in its liver and stomach tissues (Greenpeace, 1992).

A study of turtles collected during the *Ixtoc* spill determined that the three animals found dead had petroleum hydrocarbons in all tissues examined and that there was selective elimination of portions of this oil, indicating that exposure to the oil was chronic; the turtles evidently did not encounter the oil shortly before death, but had been exposed to it for some time (Hall et al., 1983). The low metabolic rate of turtles may cause a limited capacity to metabolize hydrocarbons. Prolonged exposure to oil may have caused the poor body condition observed in the turtles, perhaps disrupting feeding activity. In such weakened condition, the turtles may have succumbed to some toxic component in the oil or some undiscovered agent.

g. Oil-Spill Response Activities

Spill response activities could adversely affect sea turtle habitat and cause displacement from these preferred areas. Impacting factors might include artificial lighting from night operations; booms; machine and human activity; equipment on beaches and in intertidal areas; sand removal and cleaning; and changed beach landscape and composition. Some of the resulting impacts from cleanup could include interrupted or deterred nesting behavior; crushed nests; entanglement in booms; and increased mortality of hatchlings due to predation during the increased time required to reach the water (Newell, 1995; Lutcavage et al., 1997). Additionally, turtle hatchlings and adults can become disoriented and normal behavior disrupted by human presence as well as industrial activity. Individual turtles covered with oil have been cleaned, rehabilitated, and released (e.g., FDEP et al., 1997; Mignucci-Giannoni, 1999). The strategy for cleanup operations should vary, depending on the season, recognizing that disturbance to the nest may be more detrimental than the oil (Fritts and McGehee, 1982). As mandated by the Oil Pollution Act of 1990 (OPA), seagrass beds and live-bottom communities are expected to receive individual consideration during oil-spill cleanup. Required oil-spill contingency plans include special notices to minimize adverse effects from vehicular traffic during cleanup activities and to maximize protection efforts to prevent contact of these areas with spilled oil. Studies are completely lacking regarding the effects of dispersants and coagulants on sea turtles (Tucker and Associates, Inc., 1990).

h. Suggested Mitigation Measures for Further Evaluation

Sea turtles would benefit from the same mitigation measures discussed under the marine mammals analysis.

i. Suggested Research and Information Synthesis

In June 1999, the MMS held a Marine Protected Species Workshop (update to Tucker & Associates, 1990) to review the state of knowledge for marine species and to identify information needs. The MMS-funded study (GulfCet I) and the BRD study (GulfCet II) have provided some much needed information on the distribution of sea turtles in deep water. The MMS will be providing some monetary support to the NMFS for marine mammal observers (who also note sea turtle sightings) on their plankton cruises. These cruises, however, do not fully extend into deepwater areas of concern to the MMS. Information about the biology and behavior of sea turtles during their pelagic stage is limited, so any information that can be obtained will help in determining what types of effects might occur from deepwater activities. Differential habitat utilization by species, sex, and life history stage needs to be considered in distribution models for sea turtles. Studies to determine the distribution of post-hatchling and early life history stages in the Gulf would facilitate the identification of activities that may seriously impact them, as well as help in developing mitigation for potential impacts. Information on sea turtle abundance throughout their distribution is needed. A sea turtle meeting focusing on methodology was proposed at the MMS Protected Species Workshop. An initial meeting would be jointly run by NMFS and MMS, and would bring together sea turtle biologists and technology experts. Workshop participants also recommended that sea turtle behavior patterns around platforms be studied.

At present, MMS is funding a literature review that will summarize existing information on the frequency of use and the potential environmental impacts of the use of synthetic-based drilling fluids (SBF) in deep water. This effort is an initial component of a much larger effort to provide information on the fate and effects of SBF. Field studies to determine the distribution, dispersion, residence time, and toxicity levels of discharged synthetic-based drilling fluids and cuttings would help in the identification of potential mitigation measures.

The effect of noise on sea turtles has become an issue of increasing controversy and concern. Information on sound output from platforms is limited, and includes no data for structures operating in the Gulf. Information collected from platforms in other areas, such as off California or in the Arctic, may not be applicable to the Gulf because of differences in the environment that affect sound transmission properties. Sea turtles can occur in areas of high-intensity seismic exploration. Research on the ambient noise levels and noise from specific OCS-related activities in the Gulf of Mexico would increase our general understanding of the effects of noise on sea turtles, help in determining the effectiveness of potential mitigation measures (including Aramp-up,@ identification of safety-zone perimeters through presurvey modeling, site-specific verification of transmission loss, the use of shipboard observers, and aerial surveys), and help in the development of additional mitigation measures.

3. Conclusions

The density of sea turtles and the chance of contact with deepwater activities appear to be less than on the shelf for all but leatherback turtles. Deepwater exploration, development, and production activities are unlikely to have long-term adverse effects on the population size and productivity of any sea turtle species in the northern Gulf of Mexico. The notable exception would be an oil spill occurring at a time and place where sea turtles are concentrated or a spill that would adversely affect the habitats or habitat components (e.g., important prey species) that are essential to the well-being of any sea turtle species in the northern Gulf. There is direct evidence that turtles have been seriously harmed by oil spills.

Sea turtles could be impacted by the degradation of water quality resulting from operational discharges, helicopter and vessel traffic, noise, brightly lit platforms, explosive structure removals, oil spills, oil-spill response activities, and trash and debris from OCS-related facilities or vessels. Most deepwater OCS activities are expected to have sublethal effects (behavioral effects, and nonfatal exposure to or intake of OCS-related contaminants or debris). Contaminants in waste discharges and drilling fluids might indirectly affect sea turtles through food-chain biomagnification; there is uncertainty concerning the possible effects. Chronic sublethal effects (e.g., stress) resulting in persistent physiological or behavioral changes and/or avoidance of impacted areas could cause declines in survival or productivity and result in either acute or gradual population declines. Few lethal impacts are expected. Lethal effects are most likely to be from chance collisions by deepwater-related service vessels and ingestion of plastic materials. Deaths caused by platform removal operations are not expected because of existing mitigation measures. Contact with or consumption of chemical products or diesel might seriously harm individual turtles, thereby possibly seriously impacting the sea turtle population. Biological impact of any mortality would depend, in part, on the size and reproductive rates of the affected stocks (e.g., whether the species is listed as endangered), as well as the number, age, and sex of animals affected.

E. Fishing and Fisheries

Commercial fishers in the United States landed over 9.6 billion pounds of edible and industrial fishery products in 1996. Approximately 1.5 billion pounds of fishery products were harvested from the Gulf of Mexico by the commercial fishers. Although the quantity of commercial landings from deep water is comparatively small, these species are of high value. Forty-two percent of all fish caught and 29 percent of all fishing trips by recreational fishers were taken in the Gulf of Mexico in 1996 (USDOC, NMFS, 1998).

The rich fishery resources found in the Gulf of Mexico are due to the many unique features of the Gulf, including its geology, oceanography, and nutrient sources, to mention a few. Because of the richness of these resources and the contribution that they make to the economy of the Gulf and the Nation, potential impacts of man=s activities in the Gulf on these resources is of National concern.

The following discussion is presented in three parts:

- fishing activities that currently take place in deep water;
- early life stages of fish seen in deepwater plankton; and
- analysis of potential impacts.

1. Description

a. Fishing Activities

Unlike fishing in shallower parts of the Gulf, fisheries in deep waters of the Gulf are not distributed over large areas; not all deepwater areas hold enough of the economically important species to support a fishery. Perhaps for this reason there are a greater variety of fisheries in deep waters of the Gulf (McIlwain, 1999). The variety of fisheries include

- bottom longlining for snapper, grouper, and tilefish by commercial fishers and hook-and-line recreational fisheries for these same species;
- mid-water longlining for tunas, swordfish, and shark by commercial fishers and hook-and-line recreational fisheries for these same species;
- bottom trawling for royal red shrimp and mid-water trawling for butterfish; and
- bottom trapping for golden and red crabs.

Both snapper and grouper habitats require some vertical relief off the bottom. If nearby areas are relatively flat, vertical relief of 1-2 m is sufficient to attract and hold snapper and grouper. Subsea production equipment, seafloor templates, and unburied pipelines are all sufficient relief when surrounded by a flat seascape. Large snappers, such as cubera, dog, and red, will aggregate in loose schools around seamounts, mud mounds, ridges, salt diapirs, and canyon slopes. Snappers, however, are not usually found deeper than about 300 m. Groupers can be divided into shallow water and deepwater assemblages, where the deeper species are found from 200 to 600 m. Tilefish are benthic species generally found in and around submarine canyons in the 200- to 500-m depth range, where they occupy burrows in the sedimentary substrate. All of these species are fished by using a fixed system of anchored longlines. The mainline is attached at both ends to a heavy weight, which is in turn linked to a free-floating surface buoy marked with a high-flyer flag, light, and radar reflector. The mainline, from which baited hooks dangle at regular intervals, can be fished directly on or slightly off bottom and is from 30- to 60-mi long. A single set may take 6-8 hours to complete and is retrieved after an 8- to 12-hr soak time. After retrieval, the mainline is rebaited and fished again. If the line is fishing well, it may be left where it is. If the mainline is not catching much, it will usually be moved to try a new location. In practice, this means that fixed gear or strings of gear will be moving from one location to another on an unpredictable time schedule dictated by fishing pressure and fish response to a baited hook. It is therefore difficult to predict the location of a anchored longline at a given time.

Blackfin and yellowfin tuna and pelagic sharks are targeted by mobile, drifting longlines. Swordfish are also targeted but are usually a bycatch of the tuna fishery. All of these species are highly migratory pelagics covering a great expanse of the Gulf of Mexico. They concentrate on a seasonal basis: in winter, off the mouth of the Mississippi River in 200-800 m of water depth; in late spring, over deep waters of DeSoto Canyon; and in summer, off deep edges of the Yucatan Peninsula. During fishing, one end of the longline is attached to the vessel while the other is secured to a free-floating buoy marked with a high-flyer flag, radio beeper, light, and radar reflector. The mainline between the vessel and the high-flyer will suspend hundreds of baited hooks and has floats on top and weights on the bottom that can be changed to make the line fish at various depths in the water column. The vessel and the 30- to 60-mi longline drift together, which is serious from a maneuverability standpoint. The end of the longline not attached to the fishing vessel usually has a radar reflector/lighted buoy attached to it, and there may be floats or other high-flyers attached at intervals, but all may not be immediately obvious because of being so far from the vessel. Since drift longlining is usually done at night, and often during the darker phases of the moon, this further diminishes the ability for others to be aware of the configuration of drifting longline operations. A drifting longline can be fished anywhere from the surface to over 100 m below the surface.

Both royal red shrimp and butterfish are targeted with trawls. Royal red shrimp do not generally occur in the deepest parts of the Gulf but are found on the slope areas of DeSoto Canyon from 200 to 500 m. Butterfish are found in the middle or lower third of the water column in 300-500 m total depth. Butterfish make seasonal migration farther offshore in the winter and closer in the summer. At this time, butterfish are harvested only from the eastern parts of the Gulf of Mexico. Trawling is a mobile fishery in which a trawl net or double rig is towed behind the fishing vessel at slow speed, either in midwater or, more commonly, along the bottom. The trawler deploys the net(s) in areas where fish or shellfish are noted on the fathometer or where trawling has been successful before. Although it is considered a mobile fishery, when the net is deployed, the vessel is not readily maneuverable relative to any nearby vessels or structures. The net is on the bottom and, in fairly deep water, it can be a quarter-mile behind the vessel.

The golden crab fishery is relatively new to the Gulf of Mexico. Golden crabs are found on the bottom in water about 200-400 m deep. They frequent the continental shelf/slope break and the Florida Escarpment. Trap fisheries for golden crabs are a fixed gear fishery. About 35 baited 3 x 4 ft traps are placed 40 ft apart along a trap line 2-2 2 mi long. The trap line is weighted at the ends, but not buoyed, and must be grappled for retrieval. The traps are left to fish for 7-10 days, then retrieved, rebaited, and put back on the bottom. Normal fishing practice dictates the movements of trap location; if the traps are fishing well, they are left where they are. If the traps are not catching much, they will usually be moved to try a new location. In practice, this means that groups or strings of gear will be moving from one location to another on an unpredictable time schedule dictated by crab population movements. It is therefore difficult to predict the location of any particular string of gear at a given time.

b. Presence of Early Lifestages

Deepwater or slope areas of the OCS are not targeted as essential fish habitat in the most recent version of the Gulf of Mexico Fishery Management Council=s (GOMFMC) recommendations (GOMFMC, 1998). However, the GOMFMC and MMS agree that deep waters of the Gulf of Mexico appear to be an important spawning area for many of the fishery resources mentioned above. Complex deepwater currents critically affect the resultant offspring of all species above, but especially the highly migratory tunas and swordfish since they use the water column as a nursery ground. Limited knowledge is available on the early life histories of these species or of the many other species found in deepwater areas.

Information on fish larvae from deepwater areas of the Gulf of Mexico is limited. In the vicinity of Viosca Knoll and DeSoto Canyon, ichthyoplankton surveys are available from only two seasons and two different locales.

The overall abundance of fish larvae in these deepwater areas is comparable to Gulfwide values. The diversity is less, however, than what is seen from 100 m shoreward (Shaw, personal communication, 1998). The diversity is greatest in the fall and may be due to changes in wind-driven currents during those months. It is important to note that larvae of only about 10 percent of the over 2,000 species of fishes occurring in the Gulf of Mexico and adjacent waters can be identified to the species level (Lyczkowski-Shultz, 1999).

Tuna, dolphin, and billfish larvae occur in both fall and spring ichthyoplankton samples from deepwater areas. Tuna are especially numerous near boundary layers between the Mississippi River plume and canyons of the continental slope where oil and gas development is prevalent. Snapper and grouper larvae appear to be more numerous in fall. The occurrence of larvae of either royal red shrimp or golden crab is unknown.

2. Environmental Impact Assessment

Effects on commercial fisheries from activities associated with the OCS Program in deepwater areas of the Gulf of Mexico could come from emplacement of production structures, underwater OCS obstructions, production structure removals, surface and seafloor oil spills, chemical spills, and offshore discharges of drilling fluids and produced waters. Potential effects from these impact-producing factors are described below.

a. Platform Emplacement

The emplacement of structures causes space-use conflicts. In water depths greater than 450 m, production platforms will be floating structures (such as TLP's and SPAR's), FPS=s, and FPSO=s (Figure IV-2). The USCG has not yet determined what size navigational safety zone will be required during offloading operations from FPSO=s. When reasonable safety zones are factored in, these floating structures will require 7-20 ha of space. Production structures in all water depths have a life expectancy of 20-30 years. Except for royal red shrimping, commercial trawl fishing in the Gulf of Mexico is performed in water depths less than 200 m (Louisiana Dept. of Wildlife and Fisheries, 1992). Longline fishing is performed in waters greater than 100 m and usually beyond 300 m. The MMS data indicate that the total area lost to commercial fishing because of the presence of production platforms has historically been less than 1 percent of the total area available to commercial fishing. Even though structures in deeper water will take up more space, there are few of them compared with the number of bottom-founded platforms in water depths less than 300 m.

b. Underwater Obstructions

Underwater OCS obstructions, such as pipelines and subsea production trees, cause gear conflicts that result in losses of fishing equipment, business downtime, and vessel damage. Historically, it has been trawl fishermen who have experienced gear loss. If that holds true for deepwater areas, fewer than 10 royal red shrimp fishermen would be at risk of conflicts. Although Gulf fishermen are experiencing some economic loss from gear conflicts in shallow water, the economic loss for a fiscal year has historically been less than 0.1 percent of the value of that same fiscal year's commercial fisheries landings. In addition, most financial losses from gear conflicts are covered by the Fishermen's Contingency Fund.

c. Structure Removal

Lessees are required to remove all structures and underwater obstructions from their leases in the Federal OCS within one year of the lease relinquishment or termination of production. Approximately 100 structures are removed each year. Seventy percent of multileg platforms in water depths less than 156 m are removed by severing their pilings with explosives placed 5 m below the seafloor. The concussive force is lethal to fish that have internal air chambers (swim bladders), are demersal, or are in close association with the platform being removed (Scarborough-Bull and Kendall, 1992; Young, 1991). The actual method or combination of technologies that will be used to remove structures from deepwater areas is unknown. At the present time, industry is indicating that they will somehow use the standard explosive method. In any event, the structures will likely be removed in pieces because of their extremely heavy weight. When explosives are used, structure removals from deep water will have a negligible effect on fisheries because of the small number of removals and the consideration that removals kill only those fish proximate to the removal site.

d. Chronic and Acute Oil Spills and Chemical Spills

Chronic low-level pollution, whether hydrocarbons or chemical products, is a persistent and recurring event resulting in frequent but nonfatal physiological irritation to those resources that lie within the range of impact and that are likely to be adversely affected by the pollution. The geographic range of the pollutant effect depends on the mobility of the resource, the characteristics of the pollutant, and the tolerance of the resource to the pollutant in question. In this case, hydrocarbons are the pollutants of concern. Adult fish must experience continual exposure to relatively high levels of hydrocarbons over several months before secondary toxicological compounds that represent biological harm are detected in the liver (Payne et al., 1988). Adult fish are likely to actively avoid an oil spill, thereby limiting the effects and lessening the extent of damage (Baker et al., 1991; Malins et al., 1982).

The direct effects of spilled oil on fish occur through the ingestion of oil or oiled prey, through the uptake of dissolved petroleum products through the gills and epithelium by adults and juveniles, and through death of eggs and decreased survival of larvae (NRC, 1985). Upon exposure to spilled oil, liver enzymes of fish oxidize soluble hydrocarbons into compounds that are easily excreted in the urine (Spies et al., 1982). When contacted by spilled oil, floating eggs and larvae, with their limited mobility and physiology, and most juvenile fish are killed (Linden et al., 1979; Longwell, 1977). Ordinary environmental stresses may increase the sensitivity of fish to oil toxicity. These stresses may include changes in salinity, temperature, and food abundance (Evans and Rice, 1974; NRC, 1985).

The effects on and the extent of damage from an oil spill to Gulf commercial fisheries is restricted by time and location. Oil spills that contact waters of the OCS when pelagic eggs and larvae are present have the greatest potential to affect commercial fishery resources. Migratory species, such as mackerel, cobia, and crevalle, could be impacted if oil spills contact nearshore open waters. An oil spill contacting a low-energy inshore area would affect localized populations of commercial fishery resources, such as menhaden, shrimp, and blue crabs. Chronic oiling in an inshore area would affect all lifestages of a localized population of a sessile fishery resource such as oysters.

For OCS-related oil spills to have an effect on a commercial fishery resource, whether estuary dependent or not, eggs and larvae would have to be abnormally concentrated in the immediate spill area. Oil components also would have to be present in highly toxic concentrations when both eggs and larvae are in the pelagic stage (Longwell, 1977). There is no evidence at this time that commercial fisheries in the Gulf have been adversely affected on a regional population level by spills or chronic oiling.

Development abnormalities in juveniles occur naturally in wild fish populations, and the frequency of these abnormalities is increased in populations chronically exposed to oil. These abnormal fish do not survive long in the struggle for existence. Such delayed death is likely to have an equally negligible impact on commercial fisheries as are the immediate deaths following an oil spill.

Surface spills from any accidental source are unlikely but not impossible. The estimations of impacts on fisheries from hydrocarbon spills can be calculated from examinations of recent spills such as the *North Cape*, *Breton Point*, *Sea Empress*, and *Exxon Valdez* (Brannon et al., 1995; Maki et al., 1995; Mooney, 1996; Pearson et al., 1995). The amount of oil spilled by each event and its estimated impact to fishing practices, fish resources, and fisheries economics can be used as a guideline to estimate the impacts on deepwater fisheries. A surface or seafloor oil spill greater than 1,000 bbl but less than 10,000 bbl will likely cause less than a 2-3 percent decrease in commercial populations or in commercial fishing. At the expected level of effect, the resultant influence on fisheries within the area would be negligible and indistinguishable from natural population variations.

If chemical spills occur, they will likely occur at the surface and most will rapidly dilute, affecting a small number of fish in a highly localized environment. Many of the chemical products that may be used offshore, such as methanol or hydrochloric acid, would chemically burn all exposed surfaces of fish that come in contact. The concentration of the chemical and the duration of exposure determines the extent of the chemical burn. Rapid dilution in seawater will limit the effects, and the impacts should be inconsequential. Other compounds such as zinc bromide will not readily dilute in seawater and will likely form slowly dissolving piles on the seafloor. Although these compounds may be toxic, mobile fishes will avoid them as they do oil spills. Nonmotile fish and slow-moving invertebrates could be killed. The areal extent of the impacts will be highly localized and the impacts should be inconsequential.

e. Blowouts

Seafloor blowouts of oil wells have the potential to affect commercial fishery resources adversely. Loss of well control and resultant blowouts seldom occur on the Gulf OCS (7 blowouts per 1,000 well starts; 23% will result in some spilled oil). If they occur at all, blowouts in deep water at subsea completions may result in the spillage of large amounts of liquid hydrocarbons. This event, though highly unlikely, could cause extensive damage to the nearby bottom and render the affected area closed to bottom fisheries, such as tilefish, for some period of time. There are numerous natural oil seeps from the bottom of the Gulf that do not render the bottom closed to fisheries. Although a blowout would spill much more than a natural seep, it is expected that the affected bottom would recover from the spill.

f. Discharges

Produced-water and drilling fluids and cuttings discharges contain components and properties detrimental to commercial fishery resources. Moderate petroleum and metal contamination of sediments and the water column can occur out to several hundred meters downcurrent from the discharge point. Offshore discharges are expected to disperse and dilute to very near background levels in the water column or on the seafloor within 3,000 m of the discharge point and are expected to have a negligible effect on fisheries.

g. Suggested Research and Information Synthesis

In discussing deepwater fisheries and the potential impacts of oil and gas development, additional research and information synthesis topics that could augment the planning process have been suggested. This has led to the development of a list of issues that could be addressed to ensure continuance of both fisheries and hydrocarbon production in deepwater areas. Some of the major issues and topics suggested for study are listed below. All of the following topics are under consideration as major studies funded through MMS. The first of these studies was awarded in the summer of 1999.

- The physical presence of oil- and gas-related structures and associated operations will likely both conflict with and enhance fishing activity (both commercial and recreational) especially in, but not limited to, areas south and east of the Mississippi River Delta.
- As in many other worldwide locations, the physical presence of large structures in deep water will likely act as fish attraction devices (FAD=s) that may seriously impact conservation of highly migratory fish species.
- As in many other worldwide locations, the physical presence of large structures in deep water will likely act as FAD=s that may impact populations of highly migratory fish species through changes in their feeding and spawning behavior.
- Oil and gas development in deep waters of the Gulf of Mexico will present unique site abandonment challenges and will raise questions concerning artificial reef planning, as well as impact traditional fisheries in the area.

3. Conclusions

Operations resulting from oil and gas development in deepwater areas of the Gulf of Mexico have the potential to cause some detrimental effects on fisheries and fishing practices. Activities such as offshore discharge of drilling fluids and produced water are expected to cause negligible impacts and not to affect commercial fisheries deleteriously. Factors such as production platform emplacement, underwater OCS impediments, explosive platform removal, and accidental oil spills could cause greater impacts on fisheries and fishing practices. However, the actual effects from these potential impact-producing factors are expected to be inconsequential. At the expected level of effect, the resultant influence on fisheries should be indistinguishable from natural population variations. Oil and gas exploration and development in deepwater areas of the Gulf of Mexico can proceed in an orderly manner with regard to fish resources and fishing practices.

F. Air Quality

1. Description

Deepwater operations west of 87.5^{o} W. longitude fall under MMS jurisdiction for enforcement of the Clean Air Act. The air over the OCS water is not classified as attainment or nonattainment, but it is presumed to be better than the National Ambient Air Quality Standards (NAAQS) for all criteria pollutants. The Gulf coastal region contains areas attaining and not attaining the NAAQS for ozone; the NAAQS for the remaining criteria pollutants are met in all of the coastal areas (Figure III-4). The Gulf coastal area includes the Breton National Wilderness Area (Figure III-5), which is a Prevention of Significant Deterioration (PSD) Class I Area. Class I Areas are afforded the greatest degree of air quality protection. Very little deterioration of air quality is allowed in these areas. One of the purposes of the PSD program is to preserve, protect, and enhance the air quality in these designated areas.

There are several air quality issues related to deepwater exploration, development, and production activities. These issues are not unique to deepwater operations but are related to the overall OCS Program. What is different about the deepwater operations is that deepwater facilities typically generate large quantities of emissions compared to typical production facilities on the continental shelf.

- *Onshore and Offshore Impacts from SO_2 Emissions from Flaring and/or Burning.* The MMS regulations allow for flaring during well test and well cleanup operations. Normally, only gas is flared, but the regulations do allow for an operator to justify and seek approval to burn liquid hydrocarbons during these operations. These operations may be approved if they will not significantly affect air quality. Substantial emission rates are possible and careful review is necessary to ensure they do not significantly affect air quality.

- *NO_2 and SO_2 Consumption of the Class I Area Increments*. The U.S. Fish and Wildlife Service (FWS) has expressed concern that the NO_2 and SO_2 increments for the Breton National Wilderness Area have been consumed. Work towards an increment consumption study is ongoing, but results will not be available for several years.

- *Hazardous Air Pollutants (HAP).* (1) Glycol still vents emit hazardous air pollutants including benzene, a known human carcinogen. Operators are responsible for ensuring that their workers are protected from hazardous air pollutants in their workplace. These emissions may also impact workers on nearby platforms, boaters, and air-breathing marine animals. (2) Chemical spills may also result in the release of hazardous air pollutants.

- *Ozone Impacts on Ozone Nonattainment Areas*. The *Gulf of Mexico Air Quality Study* (GMAQS) showed that MMS-regulated emissions were minimal in relation to the old ozone standard. Reanalysis of those data show substantial impacts under the new ozone standard. Any additional OCS operations, including deepwater operations far from shore, will add to this impact. Many additional coastal areas are expected to be designated as not attaining the ozone standard in 2000.

- *Hydrogen Sulfide (H_2S) as a Contaminant of Deepwater Hydrocarbons*. Sour gas and oil operations are not unique to shallow-water operations. Sour gas has been reported at a few locations along the continental slope in the Ewing Bank, Mississippi Canyon, Viosca Knoll, and Main Pass Areas. Hydrogen sulfide is regulated under Section 112(r) of the Clean Air Act, which regulates substances that are known or may be anticipated to cause death, injury, or serious adverse effects to human health or the environment from accidental releases.

The above air quality issues associated with deepwater operations may trigger the preparation of a site-specific EA to assess potential environmental impacts, examine alternatives to the proposed activities, and identify appropriate mitigative measures. The MMS has specific criteria that exempt a proposed action from Categorical Exclusion (CE) and require preparation of an EA. The table below lists the CE exemption criteria applicable to these air quality issues.

Categorical Exclusion Exemption Criteria Applicable to Air Quality Issues

Reg. No.	Description of Criteria
2.1	have significant effects on public health and safety
2.2	have adverse effects on such unique geographic characteristics as refuge lands, wilderness areas
2.6	be directly related to other actions with individually insignificant but cumulatively significant environmental effects
2.8	have adverse effects on species listed or proposed to be listed on the List of Endangered and Threatened Species, or have adverse effects on designated critical habitat for these species
2.10	threaten to violate a Federal, State, local, or tribal law or regulation imposed for the protection of the environment

Below is a breakout of the different air quality issues and which of the CE exception criteria they may trigger. The following discussion focuses on the air quality issues with regard to these exception criteria.

Air Quality Issues and Categorical Exclusion Exception Criteria

Exceptions Criteria:	Health	Wilderness	Cumulative Significance	Endangered Species	Laws/Regs
Issue	2.1	2.2	2.6	2.8	2.10
Flaring/Burning	o	o		o	o
Class I Area		o	o	o o	
HAP	o	o		o	
Ozone	o		o		o
H_2S o			o		

2. Environmental Impacts

a. Flaring/Burning

Substantial emissions can occur from the flaring of sour gas or the burning of liquid hydrocarbons. Flaring of sweet gas has not had individually significant impacts on the onshore or offshore environments. The MMS regulations prohibit flaring that significantly affects air quality, and they define the significance levels for evaluating impacts to onshore areas. Most flaring events that have been evaluated have been deemed to be below MMS significance levels. With the distance to shore for some deepwater projects, it is possible for flaring events to be below MMS=s onshore significance levels but still be above levels established by the USEPA for the protection of human health and welfare in offshore areas near the flare. These levels are considered when evaluating a project.

Flaring of sour gas or burning of liquid hydrocarbons can occur at rates and volumes sufficient to raise concern for human health and safety in the offshore environment and to raise concern for impacts on onshore. A few requests have been received for flaring/burning that were determined to be capable of exceeding the MMS significance levels for onshore locations. No such request has been approved at the requested levels. Flaring of sour gas or burning of liquid hydrocarbons always requires a written request to, and subsequent approval by, the Regional Supervisor of Production and Development. Prior to that approval being granted, an analysis of the air quality impacts is made, as well as a determination regarding the destruction of the nonrenewable natural gas and oil resources. To conserve these resources, high-volume, long-term flaring is prohibited.

The Aworst-case@ analysis below demonstrates that significant SO_2 emissions could result from the burning of liquid hydrocarbons. At present, the highest reported sulfur content in deepwater oil is 3.57 percent by weight. The maximum requested liquid burn rate has been 9,000 bbl of oil per day. Combining these two factors results in a potential SO_2 emission rate of approximately 7,870 lb/hr. This emission rate was used in SCREEN3 modeling runs to get approximations of SO_2 impacts as indicated in the table below. (Results using Pasquill-Gifford Stability Classes A and F were not included in the table below.)

Height of Receptor	Maximum Concentration at Any Distance μg/m³	Concentration at 50 km μg/m³	Concentration at 100 km μg/m³
Platform Height (28 m)	42,610	688	170
Sea Surface (0 m)	9,098	696	171

To put these impact concentrations in a frame of reference, the following table of ambient air quality standards is provided. Please note that the SCREEN3 results are for 1-hr, or less, average concentrations, and the following standards are for different averaging periods. A 1-hr average standard, if it existed, would logically fall somewhere between the 3-hr NAAQS and the 5-min Intervention Level (IL).

National Standards for SO_2 Concentrations in Ambient Air

Reference Standard	Averaging Period	Concentration (μg/m³)
NAAQS	Annual	235
NAAQS	4-hour	365
NAAQS	3-hour	1,300
IL	5-minute	1,565

Although most flaring events that have been evaluated have been deemed to be below MMS significance levels, the above shows that impacts well in excess of those established for the protection of public health and welfare (NAAQS and IL) are possible. With the increase in number of high-rate wells coming online in the deepwater areas, requests having substantial emissions may increase.

Because the specific information needed to evaluate the impact of a well test or cleanup operation is not known well in advance of the activity, the evaluation and approval, with or without mitigation, of these operations are best handled with the current procedure of evaluation at the flare permit stage.

b. Class I Area

The FWS has raised the concern that the NO_2 and SO_2 increments for the Breton Wilderness Class I Area (Figure III-5) have been consumed. Work was begun years ago to try to determine the exact status of the increment at Breton. Unfortunately, the baseline was never established for the Breton National Wilderness Area, and this has stymied the efforts so far.

The concern for the SO_2 increment grew out of two PSD permits filed with the State of Alabama for the Mary Ann Gas Sweetening Plant and by an operational upset at Freeport McMoRan Main Pass 299 operations. The first PSD permit application for the Mary Ann Plant showed that the proposed operations would nearly consume the increment. In this application, Mobil Oil Exploration and Producing Southeast, Inc. used a chemical decay calculation in their modeling that FWS did not agree with. Correction for the chemical decay would have resulted in this one application exceeding the available increment. The second PSD application for the Mary Ann Plant was for a modification and was much smaller than the first filing. The Freeport McMoRan upset, although it was a temporary event, resulted in modeled exceedances of the 3-hr and 24-hr increments for SO_2. The Freeport McMoRan incident has been mitigated, and any future upsets at that facility are not expected to exceed any increments.

Concern for the NO_2 increment stems from modeling of Entre Energy=s Chandeleur Block 29 operations. In a memorandum dated March 30, 1994, to MMS, the FWS wrote, AThe screening analysis indicates that the Entre operation could consume between 25 to 55 percent of the annual Class I nitrogen dioxide (NO_2) increment. We are concerned that the cumulative impact of the many small sources in the vicinity of Breton WA may result in a NO_2 increment exceedance.@

This issue cannot be settled until after the Breton Air Quality Study is completed. The increment analyses are not expected to be completed until at least 2001.

Until the increment question is cleared up, MMS has been recommending that operators of stationary and mobile diesel engines within 100 km of the Breton National Wilderness Area (Figure III-5) voluntarily use low-sulfur diesel fuel. This mitigation measure reduces SO_2 emissions from these sources by about 87 percent. Additionally, MMS has been recommending the use of NO_x controls on all operations within 100 km of the Breton National Wilderness Area. There are various methods of reducing NO_x, with varying degrees of efficiency and cost. An analysis of some of these methods was presented at the 1996 MMS Information Transfer Meeting (Rooney et al., 1997). The cheapest method was timing retardation, which costs approximately $10,000 per rig and results in a 15-40 percent NO_x reduction for jack-up rigs (Rooney et al., 1995). The number of operators applying these recommendations has been low. In 1996, only 25 plans indicated they were using any form of emissions control technology. In 1997, there were 36 plans using emission controls. As of May 1998, there were only four plans using controls. Most of these voluntary controls were for the use of low-sulfur fuel to reduce SO_x emissions.

Of all the forms of emission controls reported in the Gulf of Mexico region for all emissions, the use of low-sulfur fuel is the most common, particularly for mobile sources. Of the sour gas operations within 100 km of the Breton National Wilderness Area, there are one existing and one proposed LoCat unit, one proposed Sulfa-Treat facility, one existing Claus facility, and several smaller operations using chemical scavengers to treat the H_2S. These mitigation measures appear to be sufficient for now, since modeling in support of the MMS multisale EIS=s did not show exceedances of the MMS significance levels for SO_2 in the Class I Area.

c. Hazardous Air Pollutants (HAP's)

(1) The USEPA has done a lot of background work and studies to support their development of the National Emission Standards for Hazardous Air Pollutants (NESHAP). Some of this work applies directly to the oil and natural gas exploration and development industry. The primary HAP associated with oil and natural gas that have been identified include benzene, toluene, ethyl benzene, xylenes (BTEX), and n-hexane. Exposure to these chemicals has been demonstrated to cause both short-term and long-term adverse health effects (*Federal Register*, Vol. 64, No. 116, June 17, 1999, page 32611), and benzene is a known carcinogen. For the oil and natural gas industry, glycol dehydration units are estimated to account for up to 90 percent of HAP emissions (*Federal Register*, Vol. 63, No. 25, February 6, 1998, page 6300). Of particular note is that, of all point sources in the U.S., process vents on glycol dehydration units, called glycol still vents, were found to be the largest single source of BTEX emissions.

The USEPA recently published the *National Emissions Standards for Hazardous Air Pollutants (NESHAP): Oil and Natural Gas Production and Natural Gas Transmission and Storage; Final Rule* (*Federal Register*, 1998). The USEPA requires all process vents at glycol dehydration units located at major HAP sources be controlled unless the actual flowrate of natural gas through the unit is less than 3 million standard cubic feet per day or the benzene emissions are less than 1 ton per year. Under the Clean Air Act (CCA) section 328(a)(1), the USEPA was given jurisdiction over air quality off the east and west coasts and in the eastern Gulf of Mexico east of 87.5^{o} W longitude.

The MMS regulations do not address HAP except H_2S. The Outer Continental Shelf Lands Act (OCSLA) section 1334(a) states: AThe regulations prescribed by the Secretary under this subsection shall include, but not be limited to, provisions . . . (8) for the compliance with the national ambient air quality standards pursuant to the Clean Air Act (42 U.S.C. 7401 et seq.), to the extent that activities authorized under this subchapter significantly affect the air quality of any State.@ The MMS current regulations require detailed information only on the criteria pollutants (NO_2, SO_2, VOC, TSP, and CO) and, to a lesser extent, H_2S.

At present, the air quality-related information required from OCS operators proposing new or revised operations calculates total hydrocarbon emissions and does not separate out the BTEX emissions. This information is insufficient to determine BTEX emissions. The MMS has an emissions inventory scheduled for the year 2000 to gather sufficient information to estimate the BTEX emissions from offshore oil and gas production platforms. The Gas Research Institute developed a software application to calculate the BTEX emissions from dehydrator still vents. The application GRI-GLYCalc™ has become an industry standard and is the procedure recommended by the USEPA=s Emissions Inventory Improvement Program for estimating glycol still vent emissions. Nonetheless, OCS operators are not routinely required to submit their BTEX emissions or information adequate to run any of the available applications, such as GRI-GLYCalc™, to calculate their BTEX emissions.

The hub facilities being installed to support deepwater operations are relatively large operations that generally emit several hundreds of tons of air pollutants per year. The glycol dehydrators installed on these hub facilities generally are designed to process 100 million or more standard cubic feet per day of natural gas. This is well above the 3 million scf/d that the USEPA established as the threshold for requiring control technology.

The offshore environment is a multiuse resource. Pollutants from one facility may impact other facilities, fishermen, mariners, cruise passengers, marine mammals, sea turtles, birds, and, to a lesser extent due to dispersion, the onshore environment. The OCSLA charges the MMS with the responsibility for protecting the offshore, coastal and human environments, and to consider available relevant environmental information in developing regulations. The CAA also tasks the Secretary of the Interior to consult with the Administrator of the USEPA to ensure coordination of air pollution control regulation for OCS emissions.

There are essentially two criteria for determining the potential hazard associated with hazardous chemicals: dose and exposure. Adverse impacts from HAP emissions require that individuals be exposed to sufficient quantities to cause health impacts. Potential receptors that could be exposed to HAP are workers on the source facility, workers on other nearby OCS facilities, non-OCS workers such as commercial fishermen, recreational fishers and boaters, and offshore air breathing animals. OSHA regulates oil and gas worker exposure. Non-occupational exposure s are not presently controlled and there has been no coordinated effort to evaluate the extent of non-occupational exposures or whether controls are needed. The MMS regulations address effects of OCS emissions on air quality.

(2) Another source of hazardous air pollutants is accidental releases of chemical products. Deepwater facilities are using relatively large volumes of chemicals to support their operations. The toxicity of the chemicals involved will determine the severity of the impacts within the affected area. At present, information on the types and quantities of chemicals being used is not sufficient to determine the potential impacts on air quality from accidental releases. There is a current MMS study to collect information about the chemical classes and typical volumes that are stored on platforms or drilling rigs located on the shelf and in deep water. The resultant database will include information about chemical properties, such as volatility, which can be used to evaluate the potential contributions of hazardous chemicals to air emissions. For the most part, the majority of these chemicals are contained in relatively small tanks, which, if ruptured, would result in short duration, localized air quality impacts regardless of the chemical involved. Some chemicals, such as methanol and ethylene glycol, are being used in large enough volumes that pipelines are being used for transport. Therefore, large spills of these chemicals seem feasible. Methanol and ethylene glycol are identified as hazardous air pollutants and are regulated under 40 CFR 63.

On the basis of H_2S modeling, it is unlikely for onshore deaths to result from a release related to activities in Federal waters. A possible exception to this would be the nearshore or onshore rupture of a supply pipeline. Further analysis would require better identification and analysis of chemical pipelines from shore as part of the postlease pipeline permitting process. Applications for chemical pipelines should include a complete identification of the chemicals, their concentrations and maximum spill volumes, and an evaluation of potential evacuation zones, including the areal extent and any anticipated problems associated with evacuating those areas.

d. Ozone

On September 16, 1997, the new ozone NAAQS went into effect. These new standards modified the methods for calculating ozone concentrations and lowered the acceptable ozone concentrations. The new rule established a three-year baseline data collection period, by the end of which all areas would be reclassified as to their ozone attainment status. The redesignation of the Gulf coastal areas will occur in September 2000. The USEPA developed some projections of which areas they expected not to attain the new standard based on the existing data available at the time. Their projections show many areas currently in attainment along the Gulf Coast as not attaining the new standard.

The GMAQS showed that MMS-regulated emissions contributed only minimally to ozone exceedance episodes in the identified ozone nonattainment areas under the old NAAQS. Reanalysis of those data for the new NAAQS show the MMS-regulated emissions substantially contribute to concentrations in onshore areas projected not to attain the new ozone standard. The revisions to 40 CFR 50 require that the States use regional modeling to determine the sources of the pollutants for the areas not attaining the standard and to address these sources in their State

Implementation Plans. The States are required under this regulation to work together (i.e., cross-border) to correct the problem sources.

NO_x and VOC are the primary precursors of ozone. Substantial reductions in VOC emissions are possible by installing condensers in the glycol still vents in the production platforms in the Gulf of Mexico. The technology is relatively cheap and collects saleable product, which is then sold, generating profits for industry and royalties for the Government. Controlling the still-vent emissions is also beneficial in reducing the hazardous air pollutants (see discussion above), including benzene, emitted by these vents. Generally, the units pay for themselves over a short period of time and do generate real profits for the operators.

Accidental releases of VOC=s can contribute substantially to ozone formation. The GMAQS showed the impact of VOC=s evaporating from an oil spill in Galveston Bay upon ozone formation. Even short duration oil spills can result in notable increases in ozone formation. A large or extended duration spill could result in ozone formation, impacting potentially large areas of the Gulf of Mexico region and nearby coastal areas.

A critical question here is whether a large or sustained deepwater subsea blowout will result in a large atmospheric VOC release. There is a possibility that the gas could form hydrates at the seafloor. If this were to occur, then the impact on ozone formation would be very minimal.

e. Hydrogen Sulfide

H_2S is a colorless gas with the characteristic odor of rotten eggs at low concentrations. It is nearly as toxic as hydrogen cyanide and 5-6 times more toxic than carbon monoxide. The principal threat of H_2S gas to humans is poisoning by inhalation (Dosch and Hodgson, 1986). Around 300 ppm, or higher, the gas paralyzes the olfactory nerve. Concentrations of H_2S around 500 ppm cause nearly instantaneous incapacitation/unconsciousness with death shortly thereafter. Other symptoms of exposure include irritation, breathing disorders, nausea, vomiting, diarrhea, giddiness, headaches, dizziness, confusion, rapid heart rate, sweating, weakness, and profuse salivation. Additionally, H_2S is flammable and corrosive to metals.

Hydrogen sulfide is regulated under Section 112(r) of the Clean Air Act. Section 112(r) regulates substances that are known or may be anticipated to cause death, injury, or serious adverse effects to human health or the environment from accidental releases. H_2S was one of the 16 chemicals required to be included in a list, to be developed by the USEPA, of the 100 substances that pose the greatest risk from accidental releases.

Natural sources constitute approximately 90 percent of the H_2S in the atmosphere. Natural sources of H_2S are decomposition of organic materials by sulfur-reducing bacteria in swamps, bogs, and other stagnant or polluted waterways; and natural constituents or contaminants of natural gas, petroleum, sulfur deposits, volcanic gases, and mineral springs. The estimated ambient air concentration of H_2S, due to natural sources, is between 0.11 and 0.33 ppb (0.15 and 0.46 $\mu g/m^3$) (USEPA, 1993a). At present, on the Gulf of Mexico OCS, there are sour gas operations with naturally occurring H_2S concentrations as high as 25,370 ppm (Mobil Exploration and Production U.S., Inc., 1997) in the Mobile area.

Sour gas is not unique to shallow-water operations. H_2S has been encountered along and near the continental slope in the Mississippi Canyon, Ewing Bank, and Viosca Knoll Areas. To date, there have been no reported occurrences of high concentrations (greater than 1.0%) of H_2S in the deepwater areas. High concentrations of H_2S may be encountered in deep water in the future. In the event that high concentrations of sour gas are discovered in deep water, the number of people at risk can be greatly reduced by sweetening the gas offshore and transporting only sweet gas to shore. The resulting, highly concentrated waste gas stream (from the sweetening process) could then be routed to a sulfur recovery unit, reinjected, or, in rare instances, incinerated. Since the actual locations and concentrations of H_2S cannot be accurately forecasted, evaluation of sour gas operations is currently best handled at the postlease stage in a site-specific environmental review.

The MMS is conducting a study of H_2S in the Gulf of Mexico. It is hoped that this study, once completed, will facilitate the review process of future H_2S operations.

f. Suggested Mitigation Measures for Further Evaluation

Flaring/Burning

Mitigation Measure: Except in emergency situations, limit the rate of flaring to ensure the SO_2 emission rate is below significance levels.
Anticipated Benefit: Reduce SO_2 emissions for those isolated events that would otherwise cause SO_2 emission rates that are too high.

Mitigation Measure: Disallow burning of liquid hydrocarbons; require barging, except when high seas or emergency situations contraindicate barging.
Anticipated Benefit: Reduce SO_2 emissions.

Class I Area

Mitigation Measure: Require the use of low-sulfur fuel in all diesel engines located on Amajor@ (per the Clean Air Act Section 169(1) emitting greater than 250 tons of SO_2) facilities within 100 km of the Breton National Wilderness Area.
Anticipated Benefit: Reduce SO_x emissions from diesel engines up to 87 percent.

HAP=s

Mitigation Measure: The MMS currently lacks a regulatory framework for requiring control of HAP emissions. Voluntary installation of condensers on large-volume glycol still vents is recommended because of the anticipated benefits described below.
Anticipated Benefits: Condensers are an economical control device for BTEX emissions from the vents. These devices typically have efficiency ratings over 90 percent and, with the addition of water cooling or flash tanks, have occasionally achieved ratings of 100 percent. Dehydrators for deepwater Ahubs@ are typically large units with emissions of several hundred tons of emissions per year. Sale of the recovered liquids typically pays for the condenser in a matter of a few months. Condensers should be considered for all deepwater processing hubs with dehydrators.

Mitigation Measure: For large volumes of hazardous chemicals, require operators to install control devices capable of limiting spill volumes or release rates.
Anticipated Benefit: Reduce the potential volume of accidental chemical spills, thus reducing potential associated emissions.

Ozone

Mitigation Measure: Implement controls for NO_x.. Some simple options for controlling NO_x emissions are engine-timing retardation for diesel engines or the use of turbines or Aclean-burning@ engines instead of uncontrolled natural-gas-fired reciprocating engines for new Alarge@ sources.

Anticipated Benefit: Reduce OCS contribution to current ozone nonattainment areas and areas projected for non-attainment under the new NAAQS. Modeling analyses would indicate which areas not meeting the NAAQS might benefit from such emission reductions.

Mitigation Measure: Control VOC emissions through the use of condensers on large-volume glycol still vents.
Anticipated Benefit: Reduce ozone impacts on current ozone nonattainment areas and areas projected for nonattainment under the new NAAQS. Modeling analyses would indicate which areas not meeting the NAAQS might benefit from such emission reductions.

H_2S

Mitigation Measure: Require Asweetening@ of produced sour gas production offshore; require extensive justification for consideration of installing sour gas pipelines.
Anticipated Benefit: Reduce potential release of sour gas as a result of damage to sour gas pipelines.

g. Suggested Research and Information Synthesis

Flaring/Burning: Information on the sulfur content (by weight) of hydrocarbon liquids and of the H_2S concentration in the gas, along with the maximum flow rates for the 3- and 24-hr averaging periods, as a minimum, would allow quantification of the potential SO_2 emission rates. This information could be included in the flare request and in the plan (EP, DOCD/DPP) as well. If the sulfur content is unknown, the Acurve@ technique (Scalfano, 1999) has proven itself as a useful tool to provide information to the MMS decisionmakers regarding flare requests.

The use of temporary sulfur recovery units for flaring/burning operations has been discussed in the past; although this is technologically possible, it has not been chosen as a preferred alternative primarily due to cost, time, and/or safety concerns. This technology needs further investigation and evaluation to determine its feasibility and potential effectiveness.

Class I Area: A cumulative increment consumption study, like the proposed Breton Air Quality Study, should be conducted. Such a study would enhance MMS analysis of potential impacts of OCS activities on the Class I Area, and would assist MMS in refining current mitigation measures and identifying any additional mitigation measures.

HAP=s: (1) An accurate accounting of the BTEX emissions is needed. To accomplish this, gas analyses, as well as an accurate inventory of emission sources (glycol still vents, fugitives, tanks, vents, etc.) and control devices, are needed. These data are to be collected in a Gulfwide emissions inventory scheduled for the year 2000. Modeling of HAP dispersion from OCS facilities would provide information on how far concentrations travel so that potential offshore exposures can be evaluated. (2) An accounting of hazardous chemicals, tank sizes, and flow rates of concern for identified hazardous chemicals is also needed. These data are being collected in an MMS study. Once these analyses are completed, appropriate controls can be developed if such a need is indicated.

Ozone: An accurate emissions inventory geared towards collecting sufficient data for ozone modeling should be conducted. Such an inventory is planned for the year 2000. In addition, modeling is needed to identify the source areas as either NO_x limiting or VOC limiting, to support decisions on control strategies. Photochemical modeling to determine the relative contribution from different OCS areas (e.g., nearshore versus deepwater) and to evaluate the effectiveness of various potential mitigating measures is suggested.

Studies on subsea blowouts and the fate of the releases are suggested to determine the amount of VOC=s reaching the surface and reacting to form ozone. Photochemical modeling could then depict the areal extent and transport of the resultant plume.

H_2S: Further study on H_2S from strictly a deepwater standpoint is unwarranted as it is unlikely that H_2S concentrations from a deepwater well would be high enough to create an evacuation zone that would reach shore. The MMS is reviewing the occurrence of H_2S in the Gulf of Mexico inclusive of shallow and deepwater areas. This review should provide sufficient support for site-specific environmental reviews of proposed deepwater activities.

3. Conclusions

Air pollutants from an OCS facility can impact other OCS facilities, fishermen, mariners, cruise ship passengers, marine mammals, sea turtles, birds, and, to a lesser extent due to dispersion, the onshore environment.

Flaring/Burning: Requests for flares/burns with potentially substantial SO_2 emissions have been received and likely will continue to be received. The MMS regulations do not allow approval of flaring/burning operations that have significant impacts on air quality. The established review process at the flare/burn request stage should continue to be effective in identifying the potentially significant flare/burn requests.

Class I Area: Preliminary work to inventory emissions sources (accomplished as part of the Breton Aerometric Monitoring Program) indicates that stationary OCS sources will not be the major contributor to any exceedance of the allowable increase in SO_2 levels (i.e., will not play a large role in consuming the SO_2 increment) in the Class I area. Although cumulative OCS NO_x emissions do exceed the 1-$\mu g/m^3$-threshold in some areas within 100 km of the Breton National Wilderness Area, this level includes both baseline (existing) and incremental (additional) emissions.

Hazardous Air Pollutants (HAP=s): The MMS currently lacks a regulatory framework for requiring control of HAP emissions. (1) Insufficient information exists to quantify the BTEX emissions from OCS operations. No coordinated effort has been accomplished to estimate exposure to these HAP emissions. The information that is available, specifically that glycol still vents are the primary point source of BTEX emissions in the United States and that the majority of the OCS glycol still vents are uncontrolled, indicates that potentially substantial quantities of BTEX are being emitted. (2) Limited information about the types, quantities, and locations of chemicals transported, stored, and used by deepwater facilities makes it difficult to quantify potential impacts that might be associated with accidental releases of chemical products. Information is lacking on control devices planned or in-place to mitigate accidental releases. Current information indicates that the impacts would be relatively small or of short duration because of the relatively small size of most reported tanks. An exception to this could be a rupture of a supply pipeline near to or on shore; such a release could impact onshore air quality. Chemical pipelines from shore should be thoroughly reviewed prior to permitting to ensure adequate consideration is made of any onshore evacuation zones.

Ozone: Reanalysis of the Gulf of Mexico Air Quality Study data for the 8-hr averaging period indicates substantial contributions to onshore concentrations from OCS sources. Once the redesignation, based on requirements of the September 1997 ozone NAAQS, occurs in September 2000, steps may be needed to control emissions of ozone precursors. Additionally, a subsea blowout in deep water could generate substantial quantities of VOC=s and correspondingly ozone for an extended period. Further research is needed to determine if the VOC=s from a deepwater subsea blowout would reach the air or be trapped in hydrates on the seafloor.

Hydrogen Sulfide: H_2S is the only HAP for which MMS requires a contingency plan. Combining the very low density of non-OCS-related people in the deepwater areas and the very low frequency of H_2S accidents, statistically less than one non-OCS-related person would likely be affected by an accidental release of H_2S.

G. Archaeological Resources

1. Description

Archaeological resources managed by MMS in the northern Gulf of Mexico include both inundated prehistoric sites and historic shipwrecks. An Archaeological Resources Stipulation was included in all leases issued from 1974 through 1994. The language of the stipulation, with few changes, was incorporated into the operational regulations under 30 CFR 250.126, effective November 21, 1994. All protective measures offered in the stipulation have been adopted by the regulation.

Impacts on onshore historical resources may also result from OCS deepwater activities and are considered below. Onshore historic properties include sites, structures, and objects such as historic buildings, forts, lighthouses, homesteads, cemeteries, and battlefields.

Prehistoric sites are thought to exist on parts of the continental shelf that were subaerially exposed between 12,000 and 4,000 years ago. Geologic studies have determined that the shoreline of 12,000 years ago is now covered by approximately 60 m of water (Coastal Environments, Inc., 1986). Since only water depths greater than 1,000 ft (305 m) are being considered in this deepwater EA, prehistoric archaeological sites are not at issue for deepwater operations. Prehistoric sites may be impacted, however, by associated support activities (such as pipelines to shore) or by accidental oil or chemical spills.

The areas of the northern Gulf of Mexico that are considered to have a high probability for historic period shipwrecks were redefined as a result of an MMS-funded study (Garrison et al., 1989) and clarified in LTL=s dated November 30, 1990, and September 5, 1995. The study expanded the database of historically recorded shipwrecks in the Gulf of Mexico to more than 4,000 wrecks. Since historically recorded positions of shipwrecks vary widely both in specificity and accuracy, only a few of these shipwrecks have been physically located. Statistical analysis of shipwreck location data identified two specific types of high-probability areas: the first within 10 km (6.2 mi) of the shoreline, and the second proximal to historic ports, barrier islands, and other loss traps. High-probability search polygons associated with individual shipwrecks were created to afford protection to wrecks located outside of the two aforementioned high-probability areas (cf. Visual 3, Offshore Regulatory Features). These polygons include a number of wrecks located in water depths greater than 200 m (656 ft) in the Mississippi Canyon, Lund, Atwater Valley, and East Breaks Areas (Table IV-3).

Deepwater Shipwrecks

Shipwrecks can occur virtually anywhere in the Gulf of Mexico. The archaeological database contains only 11 known historic period shipwrecks in water depths greater than 200 m (656 ft) in the Gulf of Mexico CPA and WPA.

Before the modern era of wireless telegraph communications, ships that foundered out of sight of land left no record of where they sank. For over 400 years, vessels that failed to make their destination often were simply listed as lost at sea. However, studies conducted by Coastal Environments, Inc. (1977) and Garrison et al. (1989) suggest that these are few in number compared to those that sank within 16 km (10 mi) of shore.

Despite the difficulties associated with assigning a geographic position to an early shipwreck known only through the historic record, Garrison et al. (1989) places several 19th and early 20th century ships in deepwater blocks (Table IV-3). A nine-block search area has been assigned to each of these wrecks on the assumption that the wreck would lie somewhere within 8 km (5 mi) of the reported position.

Table IV-3

19th and Early 20th Century Shipwrecks in Deepwater Blocks
(modified from Garrison et al., 1989)

Ship Name*	Date of Wreck	Lease Area and Blocks Included in Search Polygon
Northern Eagle	1908	East Breaks 154, 155, 156, 198, 199, 200, 242, 243, 244
Carrie Strong	1916	Lund 730, 731, 732, 774, 775, 776, 818, 819, 820
W. H. Marston	1927	Lund 299, 300, 301, 343, 344, 345, 387, 388, 389
Western Empire	1875	Mississippi Canyon 287, 288, 289, 331, 332, 333, 375, 376, 377
Nokomis	1905	Mississippi Canyon 963, 964, 965, 1007, 1008, 1009 Atwater Valley 39, 40, 41

* Garrison et al. (1989) included three additional shipwrecks in the Keathley Canyon Area (*Monroe*, 1826; *Alexa*, 1866; and *Ida Lewis*, 1875). These ships are actually located in Texas State waters at Brazos Santiago Pass. Leaseholders in the Keathley Canyon Area blocks are no longer required to do archaeological surveys.

A large number of shipwrecks in water depths greater than 200 m (656 ft) are the result of German submarine attacks during World War II (Wiggins, 1995; Browning, 1996). More than 100 merchant vessels were attacked by Nazi U-boats in the AGulf Sea Frontier@ between 1942 and 1943. Some 33 vessels were sunk in the northern Gulf of Mexico on the Federal OCS. Six are believed located in water depths greater than 200 m (656 ft) (Table IV-4). In addition, one Nazi U-boat, the U-166, is believed to have sunk off the Mississippi River on May 26, 1942. This wreck may be located somewhere in the Mississippi Canyon Area. Because of the association of these vessels with notable events in American history, they are potentially eligible for listing in the National Register of Historic Places as defined in 36 CFR 60.4.

Table IV-4

World War II Shipwrecks Sunk in Over 200 m (656 ft) of Water

Vessel Name	Date Sunk	Tonnage	Cargo	Lease Area
Gulfoil	5/16/42	5,188	54,000 bbl diesel oil	Mississippi Canyon
*Gulfpenn**	5/13/42	8,862	104,181 bbl fuel oil	Mississippi Canyon
*Robert E. Lee**	7/30/42	5,184	47 tons general, 268 passengers	Mississippi Canyon
*Alcoa Puritan**	5/06/42	6,759	9,700 tons bauxite	Mississippi Canyon
Carrabulle	5/26/42	5,030	42,307 bbl liquid asphalt	Lund
Amapala	5/15/42	--	fruit	Lund

*Shipwrecks believed located by sidescan sonar. In each case, the vessel lies ***outside*** the search polygon.

Aside from their historical importance, the U.S. merchant vessels now resting on the seafloor constitute a potential hazard to oil- and gas-related activities. Vessels, such as the *Robert E. Lee,* that have been identified through remote-sensing surveys, have hulls that are still largely intact and are standing as much as 20 m (66 ft) above the seafloor. Not only do these vessels constitute a physical hazard, but the possibility exists that tens of thousands of barrels of petroleum products are still sealed within their hulls. A rupture of the hull from an oil- and gas-related activity could result in a major oil spill.

Detection of Historic Archaeological Resources

Since the likely locations of historic archaeological sites cannot be delineated without first conducting a remote-sensing survey of the seabed and near-surface sediments, MMS requires that an archaeological survey be conducted prior to development of leases within the high-probability zones for historic archaeological resources (30 CFR 250.126). Typically, the remote-sensing array used for detecting shipwrecks consists of a magnetometer for detecting ferrous metal and a sidescan sonar for generating acoustic images of the seafloor. Use of the magnetometer has typically been waived by MMS in water depths greater than 60 m (197 ft) because the length of cable required to deploy the sensor within 6 m (20 ft) of the seafloor made it impossible to determine where the sensor was in relation to the positioning antenna. Technically, this difficulty has been overcome with the use of radio-telemetry between the sensor and the tow vessel, but industry has been slow to adopt (and MMS has been slow to require) this more costly procedure.

Industry frequently seeks, and is granted by MMS, waiver of the required use of the sidescan sonar in water depths greater than 150 m (492 ft). Current technology permits the acquisition of sidescan imagery in water depth as great as 900 m (2,953 ft), but the equipment and vessel required for operation in such extreme water depths increase the cost of survey. Shipwrecks outside of the historic high-probability areas in water depths greater than 1,000 ft would likely be detected in routine hazard analyses if sidescan sonar is available. Without either the magnetometer or sidescan sonar data for the archaeologist to analyze,, detection of shipwrecks is virtually impossible and it is possible that sites potentially eligible for inclusion in the National Register of Historic Places might go undetected and be adversely affected by a permitted action. Other forms of remote sensing currently employed on the OCS for the detection of hydrocarbon reserves, such as 3D seismic profiling, are largely useless for the detection of shipwrecks. The MMS is in the process of procuring a study to review the historic high-probability areas at the time of this writing. The magnetometer and sidescan sonar surveys are also used to identify ordnance disposal areas, pipelines, and surface expressions of both natural and manmade hazards. Areas of sediment instability may also be detected with sidescan sonar data.

The OCS oil and gas activities generate tons of ferromagnetic structures and debris. Ferromagnetic debris has the potential to mask the magnetic signatures of historic shipwrecks. The task of locating historic resources through an archaeological survey is, therefore, made more difficult. It is expected that most ferromagnetic debris associated with emplaced structures will be removed from the seafloor during site-clearance activities.

2. Environmental Impact Assessment

a. Physical

Emplacement of drilling rigs, platforms/structures, pipelines, or anchors could have a direct impact on a historic shipwreck. In addition, dredging activities in support of deepwater activities could impact archaeological resources. Direct physical contact with a wreck site could destroy fragile ship remains, such as the hull and wooden or ceramic artifacts, and could disturb the site context. The result would be the loss of archaeological data on ship construction, cargo, and the social organization of the vessel's crew, and the accompanying loss of information on maritime culture for the period from which the ship dates.

Direct impacts from drilling rigs and production platforms can vary considerably depending upon the type of installation. Tension-leg platforms, for example, can have a relatively small footprint, less than 100 m (328 ft) in diameter. Other types of platforms may use an anchor array with a 7:1 scope that could impact an area thousands of meters in diameter and even extend outside the operator=s lease block. Since all platform/structure locations within the high-probability areas for the occurrence of archaeological resources are given archaeological clearance prior to setting the structure, removal of the structure should not result in any adverse impact to archaeological resources.

Pipeline placement has the potential to cause a physical impact to both historic (deep and shallow waters) and prehistoric (shallow waters and coastal) archaeological resources. Pipelines greater than 8 5/8 inches and installed in water depths of less than 61 m (200 ft) must be buried to a depth of 1 m (3 ft); burial requirements within shipping fairways and anchorage areas are 3 m (10 ft) and 4.6 m (15 ft), respectively.

Anchoring associated with platform/structure and pipeline emplacement may also physically impact archaeological resources. Deepwater support vessels, including supply vessels, barges, and shuttle tankers, will maintain dynamic positioning, will tie up to deepwater drill rigs or production platforms/structures, or will tie up to permanently established mooring buoys. Pipelines laid in deep water will most likely use dynamically positioned lay barges, so the only impact to the seafloor is the pipe itself. Construction operations for shallow-water portions of pipelines that transport the production from deepwater wells could use an array of eight or more anchors that are continually repositioned around the pipelaying barge as it moves along the pipeline route.

The dredging of new channels, as well as maintenance dredging of existing channels, has the potential to cause a physical impact on historic shipwrecks (Espey, Huston, & Associates, 1990). Navigation channels and port access channels may need to be deepened to accommodate deepwater service vessels.

Onshore development to support deepwater activities could result in the direct physical impact on known and previously unidentified historic sites. Physical contact with a historic site could cause physical damage to, or complete destruction of, information on the history of the region and the Nation. Protection of archaeological resources in these cases is expected to be achieved through the various Federal, State, county/parish, and/or community approval processes involved. There is, therefore, no expected impact on onshore historic sites from onshore activities associated with deepwater operations.

b. Oil Spills

Oil spills have the potential to affect archaeological resources. Impacts on historic resources would be limited to visual impacts and, possibly, physical impacts associated with spill cleanup operations. Impacts on onshore, prehistoric archaeological sites would include hydrocarbon contamination of organic materials, which have the potential to date site occupation through radiocarbon dating techniques, as well as possible physical disturbance associated with spill cleanup operations.

Should an oil spill contact a coastal historic site, such as a fort or a lighthouse, the major impact would be visual because of oil contamination of the site and the associated environment. Impacts on coastal historic sites are expected to be temporary and reversible. It is assumed that inshore spills will occur as a result of OCS oil being transported to shore. Should such an oil spill contact a historic site, the effects would be temporary and reversible.

c. Suggested Mitigation Measures for Further Evaluation

Mitigation Measure: Expand the areal extent of required shallow hazards surveys (NTL 98-20) in deepwater areas to encompass the entire area of potential direct impacts for deepwater operations.

Anticipated Benefits: This measure, along with 300-m (984-ft) line-spacing density for remote-sensing surveys for historic shipwrecks in water depths greater than 60 m (197 ft)(NTL 98-06), should substantially reduce the risk of physical impact to historic shipwrecks by allowing detection prior to any construction activities. These measures would also support implementation of appropriate mitigation measures in areas outside the designated search polygons.

3. Conclusions

The greatest potential impact on an archaeological resource as a result of deepwater operations and support activities would be from contact between an OCS offshore activity (platform/structure installation, drilling rig emplacement, pipeline installation, or dredging project) and a historic shipwreck. OCS activities could contact a shipwreck because of incomplete knowledge on the location of shipwrecks in the Gulf. Although this occurrence is not probable, such an event would result in the disturbance or destruction of important historic archaeological information. Other activities associated with deepwater activities are not expected to impact historic archaeological resources.

Impacts from an oil-spill contact on historic coastal sites would be temporary and reversible.

H. Water Quality

1. Description

Descriptions of the hydrographic parameters found in deep waters of the Gulf of Mexico are provided in Chapter III.E., Physical Oceanography. Data on the condition of the water quality of the deep waters of the Gulf of Mexico is limited. There are no references on the levels of manmade contaminants (e.g., chlorinated organic compounds, PCB=s, and pesticides) in the deep waters of the Gulf. One probable source of contaminants would be natural oil seepage. Gallaway (1988) documented natural oil seepage into shallow sediments on the slope. Superficial sediments with elevated hydrocarbon concentrations may likely serve as an additional natural source of petroleum hydrocarbons to overlying waters.

2. Environmental Impact Assessment

a. Coastal Waters

In general, water quality in coastal waters along the Gulf may be altered by a number of coastal operations supporting offshore OCS oil and gas development. Onshore support facilities cause routine point- and nonpoint-source discharges and chronic accidental spills that impact coastal and nearshore water quality to a certain degree. Trash, discharges, runoff, and spills may be released from onshore facilities and vessel traffic. Saltwater intrusion and sediment disturbances from channel maintenance dredging, pipeline emplacements, and canal widening may adversely affect coastal waters. Offshore spills occurring in association with OCS operations and reaching coastal waters and the disposal of offshore operational wastes at onshore facilities may impact water quality conditions.

Because the level of use of most of the coastal infrastructure is not expected to change, regional changes to water quality are not expected from deepwater operations. Deepwater operations will result in increased use and rapid growth at a small number of facilities located within Texas and Louisiana. These facilities likely include the 14 service bases located along waterways that can accommodate the deep-draft vessels needed in deep water. In particular, the Texas ports of Corpus Christi and Galveston and Port Fourchon in Louisiana are, at present, expanding at rapid rates to provide major support base complexes for deepwater operations. These locations are already showing stress from supporting oil and gas operations. The oil and gas industry and oil spills were listed among the six major causes most influencing water quality degradation in Galveston Bay (Crocker and Koska, 1996). The Fourchon area sediments are impacted from the discharge of produced waters brought onshore from the OCS in the past (Boesch and Rabalais, 1989; Rabalais et al., 1991). Given this history and the fact that changes at these bases are occurring so rapidly, the projected deepwater growth will probably cause an increase in water quality degradation in the Corpus Christi, Galveston, and Pass Fourchon areas. The level of impact to coastal water quality is anticipated to be moderate and localized.

Dredging operations are expected to increase regionally in the coastal zone to provide more channels with deep-draft access for the deepwater oil industry and to maintain the deep-draft status of the existing channels. Dredging operations release sediments into the water column, resulting in degradation of water quality from increased turbidity, obstructed light penetration, and resuspension of released sediment contaminants that can include organic pollutants, heavy metals, oil and grease, pesticides, and other pollutants, some originating from the support infrastructure. Dredged-material disposal can result in changes in the natural flow or circulation of surface waters, causing secondary water quality effects. Deepwater activities are expected to increase dredging incrementally and to impact where expansion or construction may occur.

Projected onshore construction associated with the expansion of these existing bases and the possible creation of new bases, combined with the dredging, construction, or modification of associated access routes, and dredging for pipeline installation will alter the hydrology and geography of the impacted area. Examples of potential changes include saltwater intrusion, erosion, and runoff. Runoff from oil and gas support facilities (including pipeyards) can contain oil, particulate matter, heavy metals, petroleum products, process chemicals, fecal coliform bacteria, nutrients, and radionuclides. This runoff can affect local streams, estuaries, and bays, causing elevated levels of contaminants, low dissolved oxygen levels, and high turbidity.

If offshore wastes cannot meet NPDES permit requirements, they are transported onshore for disposal. If industry is not permitted to discharge synthetic drilling fluids (SBF) and cuttings (Chapter II.H.) in deep water, SBF-contaminated cuttings would have to be disposed of onshore. Temporary storage at onshore bases could result in some localized contamination. The alternative would be the use of oil-based drilling fluids, which would increase the volume of oil-based fluids needed to be treated and disposed of onshore, thus further contributing to the water quality problems currently being faced at some existing commercial onshore disposal sites, such as the U.S. Liquids site at Grand Bois, Louisiana (*The Times-Picayune*, 1997). At this site, elevated levels of contaminants have been measured in surrounding waters and may be causing serious health effects.

The larger vessels associated with deepwater operations, as well as the addition of shuttle tankers to the deepwater support vessel fleet, will increase vessel bilge water and sanitary and domestic waste discharges, bank erosion, and the likelihood of spills from vessels. Discharged bilge water can contain petroleum and metallic compounds leaked from machinery. Sanitary wastewater usually contains low levels of suspended solids, fecal coliform bacteria, and chlorine from the treatment process. Impacts on water quality from these bilge and sanitary discharges will be greatest in waters neighboring deepwater vessel support bases.

Many questions have been raised about the magnitude, likelihood, and behavior of oil spills in deep water. In general, the frequency and size of spills are the major factors determining water quality degradation. Chapter II.K. discusses what may be expected from oil spills occurring from OCS operations in deep water and the likelihood that spills occurring in deep water would reach coastal waters.

An important factor in assessing the deepwater spill risk is the fact that most deepwater spills occur at production sites far from land and have a low likelihood of reaching coastal waters prior to breakup (Chapter II.K.). Only the largest of spills are expected to result in slicks that would remain on the sea surface long enough for a substantial quantity of oil to reach coastal waters. Although some deepwater oil spills may be larger than those that have occurred on the shelf, the size of the slick reaching and contacting coastal waters may not be any larger than that of a spill originating on the shelf.

Two deepwater areas may pose greater risk of oil spill impact to coastal water quality: the area off the Mississippi Delta and the area off southern Texas. This would be due to a combination of greater size of deepwater spills, the areas' proximity to the shoreline, and projected oil spill trajectory paths. During September through April, the western Gulf of Mexico has a well-developed westward coastal current from Louisiana to Texas waters. Under the physical oceanographic and meteorological conditions during this period, the risk of a deepwater spill contacting the nearest shore line may be extremely low; the higher risks of contact may displaced to areas farther from the spill source. Furthermore, nearshore large spills (average size: 27,500 bbl; e.g., shuttle tanker) could impact coastal waters within a short period (hours, days). Water quality degradation in open waters could last up to six months after the slick is cleaned up and up to five years if a substantial quantity of oil reaches low-energy wetland waters.

Most of the time, the highly toxic components of a deepwater oil spill would be weathered before reaching coastal waters, leaving only the heavier oil components in the water. Although not all deepwater oils have been characterized, preliminary information shows that some of the oils may have more asphaltenes and heavier components than much of the oil on the shelf; therefore, they would persist longer in the environment, resulting in tar patches reaching shallow waters. Perhaps the most notable example of tarball contamination and tar mat formation is the 1979 *Ixtoc* blowout that spilled 30,000 bbl of oil for several months in the eastern Bay of Campeche (Mexico). Thirty days after the spill began, *Ixtoc* oil products began washing up on Texas beaches. Oil was stranded within the intertidal zone and mixed with sand and shell (Flint and Rabalais, 1980). The surf zone was contaminated with tarballs and large tar mats formed in the intertidal zone. Although the tar mats were not directly toxic to the benthic community, they did result in anoxic conditions and changes in the characteristics of the beach environment. *Ixtoc* tarballs were found floating in coastal waters and washing up on beaches as far away as Florida. Almost two decades later, *Ixtoc* spill products continue to be a problem in the coastal waters of the Gulf of Mexico.

b. Marine Waters

In general, routine activities related to deepwater operations that could result in marine water quality degradation include the emplacement and removal of rigs, production facilities, and pipelines on the seafloor; and the discharge of operational wastes. Accidental loss of debris to the seafloor, and blowouts or spills of oil and chemicals also have the potential to alter offshore water quality. There is no indication that coastal water quality degradation due to deepwater activities could have influence water quality in deep waters.

The potential for regional marine water quality degradation from deepwater operations is much less than the potential for regional impacts from shelf operations. Any contaminates in deepwater would be mixed and diluted within the extremely large volume of water encountered. Bottom area disturbance from structure emplacement and removal or pipeline installation would be limited. The area disturbed during these operations would be small, and the disturbance would produce only a localized, temporary resuspension of bottom sediments. This resuspension could result in increases of turbidity, a problem primarily because it decreases light penetration. However, the seafloor in deep water is below the photic zone. Sediment quality in deep water is expected to be pristine; therefore, the resuspension of sediments should not contain settled pollutants such as trace metals, chlorinated hydrocarbons, and excess nutrients, which could be found in a nearshore environment.

The major operational wastes expected to be generated during deepwater operations are the same as those in shallower waters. Section IV.A.3.d. of the Final EIS for Lease Sales 169, 172, 175, 178, and 182 (USDOI, MMS, 1997b) provides information on the characteristics, levels, and known impacts of OCS discharges in general. Chapter II.H. provides information about regulatory requirements for discharging future wastes and provides an in-depth discussion of drilling mud and produced-water discharges related to deepwater operation.

In general, the level of impact caused by operational waste discharged during drilling or production operations is proportional to the dispersal of the discharged plume and the deposition potential of the discharge. When discharging water-based drilling muds and cuttings from the drillship, impacts on the water column are expected to be the same as those currently projected in shallower waters. For produced water, the plume is only expected to be toxic when the effluent is present at levels greater than 10 percent of the receiving waters. This has only been shown to occur in very shallow water depth and is not expected to occur in deep water. Although levels of discharges per deepwater surface facility would be higher than shallower-water facilities, there would be fewer locations where discharges would take place because water treatment would occur at central processing facilities.

The major impact from OCS discharges is the contamination of superficial sediments close to the drill site or platforms. Discharges in deep water are expected to have little impact. Drilling discharges from facilities located in waters deeper than 400 m could reach the seafloor but in extremely low concentrations and cause low levels of sediment contamination, if any at all. Drilling muds and cuttings that do reach the seafloor will probably be distributed in very thin accumulations across broad areas of the seafloor. Because information on potential impacts to chemosynthetic communities is limited, the MMS is proposing an NTL that will prohibit industry from locating discharge points for drilling muds and cuttings within 330 m (1,000 ft) of a feature or area that could support high-density chemosynthetic communities. A produced-water plume is not expected to reach the seafloor in water depths greater than 100 m, and thus no seafloor sediment contamination is expected beyond this water depth.

The notable difference between drilling mud usage in deep water and shallow water is the use of synthetic-based drilling fluids (SBF). Almost all deepwater wells are drilled using SBF. The USEPA, Region 4 (which covers the area east of the Mississippi River), has banned the discharge of SBF and SBF-cuttings until effluent limitations are in place. The USEPA, Region 6 (which covers the area west of the Mississippi River), has not banned the discharge of SBF-cuttings. Synthetic mud discharges (or rather the cuttings with adhered mud discharges) sink rapidly and do not disperse easily into the water column. Existing toxicity monitoring found in the current NPDES permits is not applicable to SBF because the monitoring procedures determine the water-column toxicity of dissolved and suspended particulate phases of discharged muds and cuttings and not sediment toxicity. Although water quality criteria and toxicity requirements are not in place for SBF, it is expected that the plume resulting from SBF cuttings should have less water-column effect than water-based muds and cuttings (Burke and Veil, 1995; Daly, 1997). Water quality effects would be indirect and result from sediment contamination. Rapid biodegradation of the cutting piles on the seafloor may cause high biochemical oxygen demand and localized anoxia. The organic loading of the synthetic materials on the seabed may adversely affect sediment quality. Industry, USEPA, MMS, and others are conducting research to examine possible impacts of SBF in the marine environment. Several screening surveys funded by industry and USEPA (Fechhelm et al., 1997; CSA, 1998) have already taken place. MMS is funding a literature review that will summarize existing information on environmental impacts and frequency of use of SBF and will conduct a risk assessment. The MMS is participating in a joint industry study of the environmental effects of the discharge of SBF on benthic communities. Until these studies are completed, MMS is proposing an NTL that will prohibit industry from locating discharge points for SBF or SBF-cuttings within 330 m (1,000 ft) of a feature or area that could support high-density chemosynthetic communities.

Historically, changes in offshore water quality from oil spills have only been detected during the life of the spill and up to several months afterwards. Most of the components of oil are insoluble in water and therefore float. Change in water quality is a function of the amount of petroleum hydrocarbons dispersed or dissolved within the water column. It is difficult to predict the fate of oil that would be spilled on the deepwater seafloor (e.g., blowout and pipeline break). Factors affecting the ascent of an oil plume through the water column would include ambient temperature and pressure, chemical behavior of the oil, phase changes, and transport. The MMS, in collaboration with industry, is funding a study that will provide an in-depth analysis of oil-spill behavior from seabed spills in deep water. How large quantities of oil entering the marine environment from thousands of feet below the surface will affect water quality is unknown. A recently completed modeling effort showed that solid methane/water hydrates might form from some of the gaseous components in a blowout fluid (S.L. Ross Environmental Research Ltd., 1997). Field trials and modeling efforts recently completed by IKU (Rye and Brandvik, 1997) showed that stratification of watermasses may prevent a subsurface plume from reaching the sea surface. If the oil released were to reach the sea surface, the surface signature of the spill may be distanced from the subsea origin. The field trials also showed that oil droplets from a subsea spill will form a very thin surface slick spread out over a larger area, accelerating the speed that the slick breaks up and dissipates. Not all of the oil originally released is expected to reach the surface in the form of a surface slick.

Industry routinely uses a variety of chemical products during deepwater operations, remote well intervention, and multiphase flow regime. These chemicals may be stored at shoreline facilities, transported by vessel or piped long distances, and stored on offshore surface structures prior to usage. Of concern is the risk of chemical spills, especially large ones, and their impact on water quality. Chemical spills may, in many cases, pose a more serious threat to marine water quality than oil spills. Cleanup of spilled chemicals is frequently not possible because many of the chemicals are water soluble. A study that is being contracted by MMS will characterize the types, volumes, and frequency of use of chemical compounds used in deepwater operations. The study will also describe what criteria trigger the use of individual chemical products and evaluate potential environmental effects in case of a spill.

c. Suggested Mitigation Measures for Further Evaluation

Mitigation Measure: Prohibit the discharge of SBF and SBF-wetted cuttings until uncertainties regarding their impacts on the environment are answered through research programs or until the USEPA provides guidelines for discharge.

Anticipated Benefit: Avoidance of marine quality degradation from potential SBF sediment contamination.

Mitigation Measure: Issue an NTL prohibiting the discharge point of muds and cuttings within 330 m (1,000 ft) of features or areas that could support high-density chemosynthetic communities.
Anticipated Benefit: Protection of potentially sensitive bottom communities until uncertainties regarding the impacts of muds and cuttings are answered through research programs.

Mitigation Measure: Require operators to provide information on the use of high-volume chemicals in all EP=s, DOCD=s, and pipeline applications.
Anticipated Benefit: Enhanced site-specific evaluation and development of mitigation measures for potential spill impacts.

Mitigation Measure: Require operators to provide information in all EP=s and DOCD=s on vessel transport and storage of chemical products, operational wastes, and oil and gas production.
Anticipated Benefit: Enhanced evaluation of the potential environmental risk caused by the transport of these substances and development of mitigation measures for potential spill impacts.

Mitigation Measure: Require operators to provide information on the chemical and physical characteristics of produced deepwater oil in DOCD=s and pipeline applications.
Anticipated Benefit: Enhanced evaluation of potential differences in environmental risk or impacts due to differences in the chemical composition of deepwater crudes. Aid in the development of the most appropriate mitigation and response measures in the event of an oil spill.

d. Suggested Research and Information Synthesis

Additional research on the vertical transport through the water column of surface-discharged water-based drilling muds and cuttings and produced waters to determine their potential interaction with the seafloor would assist MMS in refining current mitigation measures and identifying any additional mitigation measures. This topic is being addressed through MMS analyses with support from industry.

Information on the potential impacts of SBF=s on benthic communities and the long-term fate of SBF discharged material is limited. Additional research and information synthesis on these topics would enhance the analysis of potential impacts, and assist MMS in refining current mitigation measures and identifying any additional mitigation measures.

Collection and analysis of data and information on the onshore disposal of OCS-related wastes would enhance the analysis of potential onshore impacts from OCS activities and assist MMS in identifying any appropriate mitigation measures. This effort might include data on known water quality impacts, on the volumes and types of deepwater operational wastes expected to be brought onshore for disposal, on the capacity of currently utilized onshore disposal facilities for managing increased waste from deepwater operations, and on industry practices and reasons for disposing of OCS-generated operational wastes onshore. These information-gathering efforts could be conducted jointly and cooperatively with state agencies.

The environmental effects and fate of chemical product usage and spills in the deepwater marine environment are poorly understood. An MMS-funded study that will assess the risk to the deepwater environment from the increased use of chemicals for deepwater activities is underway. Additional studies may be needed to refine and develop appropriate mitigation measures.

3. Conclusions

Deepwater activities are expected to incrementally increase support activities and the expansion or construction of support bases. The impacts resulting from this growth are common to all OCS support facilities (point-source waste discharges, runoff, dredging, vessel discharges) and not specific to deepwater activities. Moderate, short-term, water quality degradation may increase at a few support base locations expected to grow as a consequence of deepwater activities (including Corpus Christi, Galveston, and Port Fourchon). Existing onshore waste disposal practices may change. If synthetic-based drilling fluids (SBF) and associated cuttings cannot be disposed of offshore, temporary storage and onshore disposal may result in some localized contamination at onshore bases and commercial waste-disposal facilities. Additionally, prohibiting the discharge of cuttings containing SBF could increase the use of oil-based drilling fluids that will eventually have to be treated and disposed of onshore, thus aggravating water quality problems currently being faced at some existing commercial onshore disposal sites, such as the U.S. Liquids site at Grand Bois, Louisiana (*The Times-Picayune*, 1997).

The probability of deepwater-related spills occurring and contacting coastal waters is very low, and generally, because of the distance from shore, deepwater spills are not expected to cause impacts different than from spills from shallow water operations. Some deepwater operations have the potential to result in very large oil spills that, even after weathering, could remain on the sea surface long enough for a substantial quantity to reach coastal waters. There are two deepwater areas from which a larger volume of oil may reach coastal waters and coastal habitats than volumes expected from spills occurring on the shelf. This would be due to a combination of greater size of deepwater spills, the areas' proximity to the shoreline, and projected oil spill trajectory paths. These areas are off the Mississippi Delta and off southern Texas. During September through April, the western Gulf of Mexico has a well-developed westward coastal current from Louisiana to Texas waters. Under the physical oceanographic and meteorological conditions during this period, the risk of a deepwater spill contacting the nearest shore line may be extremely low; the higher risks of contact may displaced to areas farther from the spill source. Shuttle tankering of oil from deepwater operations has the potential to result in spills that could impact coastal waters in a very short time period if the spill were to occur near port.

Because studies have yet to be conducted on how discharge plumes under varying oceanographic conditions impact sediments surrounding deepwater discharge sites, the fate of deepwater operational waste discharges cannot be predicted accurately. The types of discharges in deep water will be the same as those on the shelf and the volume of discharges from deepwater locations will typically be greater than in shallow sites. The number of deepwater sites will be comparatively fewer. The impacts caused by deepwater discharges are not anticipated to be consequential. Because information on potential impacts to chemosynthetic communities is limited, MMS is proposing an NTL that will prohibit industry from locating discharge points for drilling muds and cuttings within 330 m (1,000 ft) of a feature or area that could support high-density chemosynthetic communities.

The notable difference between drilling mud usage in deep water and on the shelf is the use of SBF in deep water. The potential effects of SBF are related to their deposition and degradation on the seafloor. The plume resulting from SBF-wetted cuttings, as compared with the discharge of water-based muds and cuttings, should have less water-column effect (Burke and Veil, 1995; Daly, 1997) because the SBF does not disperse in the water column.

More extensive and frequent use of some chemical products to enhance throughput of the oil and gas is anticipated in deepwater because of the temperature and pressures encountered at the seafloor. Spills of some chemicals may pose a more serious threat to marine water quality than do oil spills. Limited information is available about the types and amounts of chemicals being used in deepwater operations or about the potential impact of such spills.

I. Coastal Habitats

1. Description

a. Coastal Barrier Beaches and Associated Dunes

Barrier beaches can be divided into interrelated environments referred to as shoreface, foreshore, and backshore. The shoreface is the margin of water bottom immediately adjacent to land and can extend out 4.5-12 m (15-40 ft) of water. The width of the shoreface is highly variable from one beach to another depending upon the wave energies experienced at each beach. The higher the typical wave energy, the farther the shoreface extends. The nonvegetated foreshore slopes up from the ocean to the beach-berm crest. The backshore is found between the beach berm-crest and the dunes, and may be sparsely vegetated. The backshore may occasionally be absent due to storm activity. The dune zone of a barrier landform is inland of the beach environments and can consist of a single dune ridge, several parallel dune ridges, or a number of curving dune lines that are stabilized by vegetation.

When elevated by storms, Gulf waters can overwash a coastal barrier, creating overwash fans or terraces behind and between the dunes. With time, these terraces will be vegetated by opportunistic species. Along more stable shores, the area behind the dunes generally consists of broad flats that support scrubby woody vegetation. Saline or freshwater ponds may be found among the dunes or on the landward flats. These flats may grade landward into wetlands and intertidal mud flats that fringe the shore of lagoons, islands, and embayments. In areas where no bay or lagoon separates barrier landform from the mainland, the barrier vegetation grades into scrub or forest habitat of the mainland. These habitats provide a variety of niches that support many avian, terrestrial, and aquatic species, few of which are endangered or threatened.

Habitat stability is primarily dependent on rates of change. Changes to barrier landforms are primarily caused by storms, subsidence, delta abandonment, deltaic and littoral sedimentation, and human activity. Barrier landform configurations continually, and sometimes drastically, adjust in response to prevailing or changing environmental conditions. Change can be seasonal, cyclical, or noncyclical. Cyclical movements are usually seasonal, such as when the beach accumulates sand volume in the summer and reduces it in the winter. Noncyclical changes in landforms can be caused by a variety of geologic, hydrodynamic, and man-made changes, which can cause progressive landform movement landward, seaward, or laterally along the coast.

Lateral movement of barrier landform is of particular importance. As headlands, deltas, and beaches erode, their sediments are transported offshore or laterally along the shoreline, extending sand spits that may encape marshes or previously open, although shallow, Gulf waters. By separating inshore waters from Gulf waters and slowing the dispersal of freshwater to the Gulf, the movement of barrier landform can contribute to the areal extent and diversity of estuarine habitat available along a coast.

Accumulation and movement of sediments that make up barrier landforms are often described in terms of transgressive and regressive sequences. Most landforms of the northern Gulf of Mexico are transgressive.

A transgressive sequence moves the shoreline landward, depositing marine sediments over terrestrial ones. Transgressive barriers are usually eroding. They are characterized by low profile and narrow beach widths; low sparsely vegetated and discontinuous dunes; and numerous, closely spaced, active washover channels. A regressive sequence is one in which the shoreline moves seaward. Regressive barriers have high, broad, continuous dune forms that are well vegetated with few, if any, washover channels.

The increase and decrease of open-water areas of bays or sounds, described under "Wetlands" below, also have substantial effects upon the deterioration or growth of barrier islands.

Obstructions to littoral sediment movements compound the problems of both erosion and inadequate sand supply. Hard obstructions, such as jetties, groins, breakwaters, and bulkheads, accumulate sediments on their updrift sides, building the shoreline seaward. Dredged channels obstruct littoral sediment movements by capturing sediments in the channel from where they cannot be easily moved by currents and waves.

b. Wetlands

Wetland habitats of the northern Gulf Coast include fresh, brackish, and saline marshes; and fresh and saline forested wetlands. Coastal wetland habitats occur as narrow bands between uplands and waterbodies, or as broad expanses that fill low, wet basins. They can support sharply delineated botanical zones of monotonous stands of a single species or mixed communities of plants.

Coastal wetlands are characterized by high organic productivity, high detritus production, and efficient nutrient recycling. Wetlands provide habitat for a great number and wide diversity of invertebrates, fish, reptiles, amphibians, birds, and mammals, and are particularly important nursery grounds for many economically important fish and shellfish juveniles.

According to the U.S. Department of the Interior (Dahl, 1990), 4.4 percent of Texas (7,612,000 ac), 28 percent of Louisiana (8,784,000 ac), 14 percent of Mississippi (4,365 ac), and 8 percent of Alabama (2,651,000 ac) were considered wetlands during the 1980's.

Most of the Gulf's coastal wetlands are located in two physiographic settings: the Mississippi River Deltaic Plain and the Chenier Plain. The alluvial and organically rich Wetlands on the Deltaic Plain are subject to high natural subsidence and erosion rates. The effects of subsidence are compounded by sea-level rise (1 cm/yr, van Beek and Meyer-Arendt, 1982); both have been occurring during the past several millennia. The Chenier Plain extends from Port Bolivar on the northeastern Texas coast eastward to Atchafalaya Bay, Louisiana. The Chenier Plain is a series of shell and sand ridges, oriented parallel or oblique to the Gulf Coast.

Estuarine marshes in the rest of Texas, Mississippi, Alabama, and Florida largely occur as discontinuous bands around bays, sounds, and lagoons, including the inshore side of barrier islands. Salt marshes occur at lower elevations and at higher salinities. Brackish marshes occur in less saline areas inland of salt marshes. Broad expanses of emergent wetland vegetation do not commonly occur south of Baffin Bay, Texas, because of the arid climate and hypersaline waters. Sparse bands of black mangroves can be found in southern Texas and in the regions around Grand Isle, Louisiana, and Apalachicola, Florida.

Freshwater marshes and swamps occur primarily along the major rivers and their tributaries. In Louisiana, they may cover broad expanses in the northern portions of coastal basins.

Subsidence and sea-level rise have caused changes in Texas and Louisiana during the past several decades. Open-water areas are appearing and expanding in wetlands, while new wetlands are encroaching onto previously nonwetland habitat along the landward margin of wetland areas on the mainland, on the back side of barrier islands, and onto spoil banks. In addition, wetlands are being affected by canal dredging, impoundment, river channelization, economic development, and accelerated subsidence caused by fluid withdrawal.

The deterioration of coastal wetlands is an issue of concern for the Gulf States. Several factors contribute to wetlands loss in coastal regions. The suspended-sediment loads of rivers have been reduced since the 1950's, because of channelization and farmland soil conservation efforts. The remaining sediments are kept from reaching wetlands by stream channelization and levees constructed for flood control. The construction of ring levees has allowed drainage and development of extensive wetlands. Development activities in low areas, outside leveed areas, fill wetlands. The construction of canals converts wetlands to open water and upland spoil banks. Subsidence and sea-level rise have caused submergence of wetlands. Canals and subsidence have also contributed to increased tidal influence and salinity in freshwater and low-salinity wetlands, which, in turn, increase erosion and sediment export.

c. Submerged Vegetation

Three million hectares of high-salinity, submerged vegetation beds are estimated to exist in exposed, shallow coastal waters of the northern Gulf of Mexico. An additional 166,000 ha are found in protected, natural embayments and considered more protected from OCS impacts. The area off Florida, in the Eastern Planning Area, contains approximately 98.5 percent of all coastal seagrasses in the northern Gulf of Mexico; Texas and Louisiana contain approximately 0.5 percent; and Mississippi and Alabama have the remaining 1 percent of seagrass beds. The Laguna Madre and Copano-Aransas estuaries account for the major portion of submerged vegetation populations in Texas.

Seagrass beds grow in shallow, relatively clear and protected waters with predominantly sand bottoms. Their distribution depends on an interrelationship among a number of environmental factors that include temperature, water depth, turbidity, salinity, turbulence, and substrate suitability. Primarily because of low salinity and high turbidity, robust seagrass beds and the accompanying high diversity of marine species are found only within a few scattered, protected locations in the Central Gulf of Mexico. Inshore, submerged vegetation provides important habitat for immature shrimp, black drum, spotted sea trout, juvenile southern flounder, and several other fish species; and they provide a food source for several species of wintering waterfowl.

The coverage of seagrass beds in the Western and Central Gulf, as well as the Florida Panhandle, has diminished during recent decades. The primary factors believed responsible include dredging, dredged material disposal, trawling, water quality degradation, hurricanes, a combination of flood protection levees that have directed freshwater away from some wetlands, saltwater intrusion that moved growing conditions closer inland, and infrequent freshwater diversions from the Mississippi River into coastal areas during flood stage.

2. Environmental Impact Assessment

a. Impact Analysis

The major factors associated with deepwater development that could adversely impact coastal habitats include oil spills; pipeline construction; construction, deepening and maintenance of navigation channels; and onshore infrastructure construction. In general, their greatest impact on coastal habitats has been wetland loss. Other impacts include altered surface-water hydrodynamics, saltwater intrusion, reduced vegetative productivity, and accelerated erosion, which, in turn, usually causes additional wetland loss as a secondary impact. Most secondary impacts are generated by canals and infrastructure expansion.

With regard to coastal environments, the types of impacts generated by deepwater-related factors are generally indistinguishable from those generated by usual OCS activities as analyzed in MMS=s multisale EIS=s (USDOI, MMS, 1997b and 1998). In brief summary, these analyses indicate that where a spill contacts barrier beaches, oiling is expected to be light to moderate, and sand removal will be minimized, causing no substantial or irreversible, long-term impacts on the physical shape and structure of barrier beaches and associated dunes. Offshore oil spills are not generally expected to damage inland wetlands greatly. Potential inland oil spills related to OCS activities pose a greater problem. Ten years after spill contact, up to 85 percent of oil-impacted wetlands are projected to recover from oil-spill impacts; up to 15 percent of impacted wetlands are projected to be converted to open water. Oil spills are projected to cause minor, short-term dieback of submerged vegetation. The likelihood of impact decreases as water depth over the beds increases.

The probability of OCS-related spills occurring is generally very low. The probability of a spill coming ashore is discussed in Chapter II.K. According to Table 4 of the OSRA analysis (Price et al., 1997), Texas shorelines in Nueces, Aransas, Calhoun, Matagorda, and Brazoria Counties (land segments 4-7) have the greatest probabilities (34-70%) of being contacted by a deepwater oil spill within 30 days of its occurrence. In Louisiana, shorelines of Terrebonne, Lafourche, Jefferson, and Plaquemines Parishes (land segments 16 and 17) were indicated to have the greatest probabilities (22-65%) of being contacted within 30 days of a spill. During September through April, the western Gulf of Mexico has a well-developed westward coastal current from Louisiana to Texas waters. Under the physical oceanographic and meteorological conditions during this period, the risk of a deepwater spill contacting the nearest shore line may be extremely low; the higher risks of contact may displaced to areas farther from the spill source.

If deepwater oil are similar in composition and volume to spills analyzed in MMS=s multisale EIS=s is spilled and contacts a beach, the impacts upon that beach will be similar to impacts as analyzed in the multisale EIS's. Deepwater-related spills occurring at or near the Gulf=s surface have the potential of being larger than OCS spills previously analyzed in MMS=s multisale EIS=s (see also Chapter II.K.) and could retain a larger volume of oil in the slick at the time of a contact with land. Generally, if a larger volume of spilled deepwater oil contacts a beach, its impacts will be proportionally greater. In general, beaches, intertidal shorefaces, and the organisms that use these habitats would be more heavily impacted for the short term. A die-off of poorly mobile organisms living in or on the sand would be greater geographically and in number, depending upon the nature of the oil contacting the beach. Still, populations of these organisms will usually recover within a year of the beach cleanup, if residues subside below their lethal concentrations. Similarly, beach use by organisms that occasionally use the beach will resume within a year of cleanup, if remaining residues are not too great a nuisance.

Oil spills from shuttle tankers may occur close to land. Tanker spills usually occur near port in State waters (Chapters II.F. and K.). The potential for closer proximity to land of shuttle-tanker spills also represents a potential that less weathering, slick dispersion, and cleanup would occur prior to landfall, compared with a similar spill occurring farther from shore. Hence, a tanker spill has the potential to cause more severe impacts on coastal environments.

Some deepwater oils may have different chemical and physical properties than oils typically produced on the shelf. Until these characteristics are better known, their influences upon the nature of oil-spill impacts cannot be determined. Asphaltene or paraffin content and oil density affect the behavior of spilled oil and the characteristics of resulting impacts. Asphaltenes can clump together, forming Atarballs.@ The size and nature of the tarballs would depend upon weathering, composition, and materials trapped in the oil. They may be buoyant or may sink to the bottom. When deposited on beaches, tarballs may remain on the sand surface, may be buried, or may be returned to the Gulf with a heavy load of sand. When the sun raises the temperature of beached tar enough, it will liquefy and ooze into or over the sand. Usability and habitability of the beach by organisms and people can be adversely impacted.

Formation of submerged tar or asphalt mats can have critical and permanent adverse impacts if they coat large areas of water bottom with an impenetrable asphalt sheet that may remain in place indefinitely. Coastal environments that may be most threatened by this are submerged vegetation beds, oyster reefs, and sand flats, as well as other benthic habitats. Large mat areas may also change the dynamics of sand movement.

As an extreme example, the *Ixtoc* spill occurred in Mexican waters and flowed for most of a year during 1979 and 1980, with some oil slicks reaching the Texas shoreline. The spilled oil contained high asphaltene concentrations and formed large tarballs and mats. Tar was transported onto foreshores and backshores of barrier beaches and probably into bays of the Texas and Mexico coasts. In the region around the Island of Media, resulting tar mats were observed to blanket grass beds. A year later, some submerged vegetation was observed growing through spaces in the tar mat (Baca et al., 1991). Tar from *Ixtoc* had been deposited here and there on beaches between the vicinities of Veracruz, Mexico, and Galveston, Texas, including Mustang and Padre Islands (Pease, personal communications, 1998). On these beaches, the tar consolidated and incorporated sand and shells to form large asphaltic-concrete mats. Later, storms moved the mats offshore, to rest on the shoreface under 0.6-3.0 m (2-10 ft) of water. These mats remain there today.

Spills of asphaltene or high-density oils into inland channels, nearshore waters, or wetlands may impact smaller areas of coastal habitats and waterways than would the same volumes of lighter crude oils because they would not spread as quickly. However, their impacts on the coastal habitats they contact are potentially more severe and longer term.

Chapter II.J. discusses possible lengthening and deepening of navigation channels in and around some ports to support deeper-draft vessels. Some of those vessels will support OCS deepwater activities. Impacts associated with expansion, deepening, and subsequent maintenance of deeper navigation channels will be the same as for any expanding ports and have been described in MMS=s multisale EIS=s. In summary, expansions of ports surrounded by wetlands will both temporarily and permanently impact wetlands adversely. Wetlands will be destroyed by dredging, placement of dredged materials, and land-development activities induced by port expansion. New business developments will use dredged and imported materials to fill wetlands and water bottoms. Subsequent increases in navigational traffic and the greater water volume displaced by deep-draft vessels will increase erosion rates in navigation channels and adjacent wetlands and submerged vegetation.

Vessels that displace larger volumes because of their design will increase erosion in channels and wetlands that are hydrodynamically influenced by the passage of vessels through navigation canals and streams. Larger vessels, particularly flat-bowed vessels, displace larger volumes of water as wakes. Such vessels function as pistons when traveling down a canal or stream. They literally raise the water elevation ahead of them, forcing water into confluent, or related, wetlands and channels. Water levels in the waterway and close behind these moving vessels are generally lower than undisturbed water levels. As a vessel passes an area, a scouring rush of water leaves the flooded wetlands and channels, thereby raising the water elevation to ambient behind the vessel. These problems are most easily mitigated by reducing the speed of such vessels.

Generally, rates of maintenance dredging and subsequent disposal of dredged materials may increase as erosion rates and areas of erosion increase. Most maintenance dredging will place materials on existing and approved disposal sites. In many cases, runoff from dredged-material disposal sites will inadvertently raise the elevations of adjacent water bottoms, producing shallower water bottoms or new wetlands. Such runoff may also raise the elevations of adjacent wetlands, converting them to more upland habitats. The sites themselves generally become and remain upland habitats until either subsidence or erosion lowers their elevation.

b. Suggested Research and Information Synthesis

Studies on oil-spill behavior, intervention procedures, and cleanup response for spills that occur at the seabed in deep water would increase knowledge of the fate and effects of such an oil release, and assist MMS in refining current mitigation and response measures.

Additional data on the composition of deepwater oils would assist MMS in refining projections and analyses of the behavior and effects of accidental spills of deepwater oil, and assist in refining current mitigation and response measures.

Statistical analysis of data on the frequency, location, volumes, and other appropriate aspects of OCS-related spills occurring in Gulf coastal State territorial waters would assist MMS in determining OCS-related spill frequency, risks, impacts, problem areas, and activities that should be addressed in greater detail in OCS EIS=s and permitting activities.

An historical survey and data collection on the range and severity of tarball and asphaltic mat effects upon coastal environments would enhance the assessment of potential effects and the development of appropriate mitigation measures.

Research and field studies to identify, develop, and test potential methods for retrieving buoyant tarballs under a variety of conditions (e.g., purse nets) would enhance oil spill response capabilities and would be especially applicable to late response to deepwater oil spills that have endured a relatively long period of weathering.

The environmental effects and fate of chemical product usage and spills in the deepwater marine environment is poorly understood. An MMS-funded study that will assess the risk to the deepwater environment from the increased use of chemicals for deepwater activities is underway. Additional studies may be needed to refine and develop appropriate mitigation measures.

3. Conclusions

Four basic conclusions were derived concerning potential deepwater impacts upon coastal habitats. First, most deepwater-related impacts on coastal habitats are largely indistinguishable from those generated by the rest of the OCS Program. OCS Program impacts have been addressed in past programmatic EIS=s. Second, the probability of deepwater-related spills occurring and contacting coastal habitats is very low. Third, deepwater operations have the potential to result in oil spills on the OCS that are greatly larger than those previously analyzed. Fourth, tankering of oil from deepwater operations will have the potential to result in large oil spills that could occur closer to or directly in coastal habitats. The following discusses the third and fourth conclusions.

The probability of deepwater-related spills occurring and contacting coastal waters is very low, and generally, because of the distance from shore, deepwater spills are not expected to cause impacts different than from spills from shallow water operations. Some deepwater operations have the potential to result in large oil spills that, even after weathering, could remain on the sea surface long enough for a substantial quantity to reach coastal waters. A deepwater spill off southern Texas or deltaic Louisiana has the highest probability of making landfall within 30 days. This range of risk is related to combination of greater size of deepwater spills, the areas' proximity to the shoreline, and projected oil spill trajectory paths. During September through April, the western Gulf of Mexico has a well-developed westward coastal current from Louisiana to Texas waters. Under the physical oceanographic and meteorological conditions during this period, the risk of a deepwater spill contacting the nearest shore line may be extremely low; the higher risks of contact may displaced to areas farther from the spill source.

Tankering of OCS crude could result in larger OCS spills than those previously analyzed. Such spills could heavily oil wetlands, waterways, and beaches. Important impacts of such oil contact include irreversible wetland loss and large reductions in habitat productivity for an extended period. These impacts would be more severe in areas with highly organic soils and where other environmental stressors are involved, such as in Louisiana.

The chemical and physical characteristics of deepwater oils may substantially differ from oils typically produced on the shelf. Some deepwater oils may contain higher asphaltene concentrations. Spills of such oils may permanently cover water bottoms and wetlands, thereby impacting submerged vegetation, oysters, other benthic habitats, beach habitats, and navigation. Such spills may also greatly increase the occurrence and volume of tar on barrier beaches and in other coastal habitats around the Gulf. There, tar is an environmental nuisance as well as a financial drain on industries such as trawling and recreational use of beaches.

J. Socioeconomic Resources

1. Description

Analysts predict that hydrocarbon production from the Gulf of Mexico OCS will increase steadily over the next 10 years. Much of the increase should come from deepwater wells once technology and logistical support allow full-scale production operations in water depths greater than 1,524 m (5,000 ft). The amount of increase in hydrocarbon production will be directly affected by the price of oil and gas. The Aspot market@ crude oil price was listed at $25.80 per barrel on the New York Mercantil Exchange, as of November 15, 1999 (*The Times-Picayune*, 1999). That price may speed up the planning cycle for deepwater prospects, as it is more than a 100 percent increase since December of 1998. But until this phase of the business cycle is more secure, several companies involved in deepwater projects may reduce their oil and gas properties onshore, in State territorial waters, and on the Gulf continental shelf to maintain their presence in the deepwater areas of the Gulf. Deepwater prospects may hold the potential for a greater rate of return for their investments than the Atraditional@ development areas. Recent announcements of reductions in force from several oil and gas companies focused on limiting the number of positions in shelf-related activities.

The MMS=s Gulf of Mexico OCS Region projects an increase in oil production from an actual production rate of 1.0 MMbbl per day in December 1996 to 1.7-2.0 MMbbl per day by the year 2002 (Melancon and Roby, 1998). The MMS=s projections for gas production from the Gulf of Mexico OCS are less certain. The gas production rate for the Gulf was 14.14 Bcf per day in December 1996. The MMS projects this production rate may range from 12.43 to 17.54 Bcf per day in 2002 (Melancon and Roby, 1998).

Given the present international configuration of the oil and gas industry, no one country or company is responsible for the total range of activities from exploration to production. This makes the identification and evaluation of the human components of the process difficult. For example, a recent news item reported that a company with headquarters in Jackson, Mississippi, bought a French manufacturer. This purchase gives the parent company control over the fabrication of offshore oil rigs in Newfoundland and on the U.S. Gulf Coast, plus two rig equipment manufacturing plants in France, plus ties to servicing and parts companies in 45 countries throughout the world (*The Times-Picayune*, 1998). Worldwide disbursement of everything from design to fabrication to installation to maintenance makes complex any analysis of socioeconomic effects.

Region of Influence

Figure II-10 shows the relation of deep water (represented by the 305-m or 1,000-ft isobath) and the shoreline of the states along the Gulf of Mexico. One can see readily that distances to deep water vary markedly. The variation of distance combined with channel depth dictate which ports are the most attractive locations for onshore support activities. Table II-9 lists all of the U.S. ports along the Gulf of Mexico with projected water depths of 6.1 m (20 ft) or more. These ports are assumed to be capable of accommodating deepwater support activities. There are 28 such ports, including 4 in Florida. Given the State of Florida s opposition to oil and gas activities and the fact that appropriate existing ports in the other Gulf Coast States are, in most cases, closer to potential deepwater development, this assessment assumes that no Florida ports will be used in support of deepwater OCS activities. Short distances to deep water and channel depths of 6.1 m (20 ft) or more to accommodate larger service vessels were the two criteria used to select ports where deepwater support service centers will most likely be located and also where localized, community effects will be felt most strongly. These selected ports are indicated on Figure II-10. We also demarcate an area of 80.5 km (50 mi) surrounding each selected port; the American Automobile Association sets a 80.5-km (50-mi) driving radius as a standard, one-way commute. Table IV-5 translates that radius for each of five port-centered regions into affected counties or parishes. Statistical data are more readily available and accurate at the county/parish level. Table IV-5 also gives population estimates for 1997 of each county or parish, subtotals for each state, and a grand total for the four-state region.

2. Socioeconomic Impact Assessment

a. Land Use and Infrastructure

Issues that may be important and that reflect the difference between deepwater activities and current OCS Program activities on the shelf include changing patterns of land use and the affected infrastructure. For example, Port Fourchon has brought development and prosperity to the southernmost portion of Lafourche Parish in Louisiana. It also has brought ready access to the Gulf of Mexico for ships with 6.1-m (20-ft) drafts and has spurred the installation of Aone-stop shopping@ for deepwater service vessels, i.e., a cargo brokering center that handles everything the vessels need, from equipment to food to fuel to drinking water. This development has negative consequences, too. A local publication claims that over 6,000 people use the port to travel to and from offshore facilities. More than double that number depend on the port for jobs, supplies, working facilities, and as an important node in the hurricane evacuation route (LA 1 Coalition, 1997). All who depend on the port depend as well on one two-lane highway to carry goods and people to and from Port Fourchon. Water, electricity, gas, food, building materials, and offshore equipment must be imported over extensive marsh and fragile wetlands in southern Louisiana. But ascribing all of this growth and the attendant land use and infrastructure problems to deepwater activities clouds the picture. The port has grown as a multiuse marine center, meaning that offshore mineral extraction is but part of the reason for the problems. How large a part and the implications for the future are the focus of a study being completed for MMS by economists at nearby Louisiana State University.

Public services, as used in this assessment, include commonly provided public, semipublic, and private services and facilities, such as education, police and fire protection, sewage treatment, solid-waste disposal, water supply, recreation, transportation, health care, other utilities, and housing. Furthermore, deepwater-related, impact-producing factors include workforce fluctuations, both in-migration and out-migration and the effects of relative income. These impact-producing factors are interrelated and derive from or result in increased or decreased population.

Table IV-5
Population Projections

County/Parish	State	Port	Population by Year in 1000s 1996	2000	2010	2020
Jim Wells	Texas	Corpus Christi	40.03	40.35	41.16	42.24
Bee	Texas	Corpus Christi	27.15	28.14	30.65	33.4
San Patricio	Texas	Corpus Christi	66.35	66.62	67.31	68.45
Kleberg	Texas	Corpus Christi	30.80	31.40	32.90	34.64
Nueces	Texas	Corpus Christi	314.24	320.19	337.30	355.99
Refugio	Texas	Corpus Christi	7.83	7.80	7.71	7.66
Aransas	Texas	Corpus Christi	21.38	22.08	23.82	25.72
Total for Corpus Christi:			507.78	516.58	540.85	568.1
Brazoria	Texas	Galveston	219.84	234.54	270.86	308.8
Galveston	Texas	Galveston	240.56	252.11	280.70	311.15
Chambers	Texas	Galveston	22.20	22.76	24.19	25.78
Total for Galveston:			482.60	509.41	575.75	645.73
Chambers	Texas	Port Arthur/Lake Charles	22.20	22.76	24.19	25.78
Hardin	Texas	Port Arthur/Lake Charles	47.15	49.21	54.37	59.94
Jefferson	Texas	Port Arthur/Lake Charles	244.19	247.05	254.01	262.61
Orange	Texas	Port Arthur/Lake Charles	85.00	86.03	88.50	91.56
Beauregard	Louisiana	Port Arthur/Lake Charles	32.08	33.18	35.91	38.94
Calcasieu	Louisiana	Port Arthur/Lake Charles	176.69	179.54	186.52	194.78
Cameron	Louisiana	Port Arthur/Lake Charles	8.88	9.16	9.86	10.64
Jefferson Davis	Louisiana	Port Arthur/Lake Charles	31.88	32.39	33.66	35.18
Allen	Louisiana	Port Arthur/Lake Charles	23.73	24.10	25.01	26.08
Acadia	Louisiana	Port Arthur/Lake Charles	57.45	57.61	57.99	58.75
Total for Port Arthur/Lake Charles:			729.25	741.03	770.02	804.26
Terrebonne	Louisiana	Port Fourchon/Venice	101.26	101.39	101.73	102.90
LaFourche	Louisiana	Port Fourchon/Venice	87.98	89.41	92.91	97.06
Jefferson	Louisiana	Port Fourchon/Venice	462.04	479.77	523.03	569.20
St. Bernard	Louisiana	Port Fourchon/Venice	67.67	68.99	72.24	75.97
Plaquemines	Louisiana	Port Fourchon/Venice	25.66	25.51	25.14	25.00
Total for Port Fourchon/Venice:			744.61	765.07	815.05	870.13
Harrison	Mississippi	Mobile/Pascagoula	178.49	191.56	223.74	257.17
Stone	Mississippi	Mobile/Pascagoula	12.44	12.59	12.98	13.48
George	Mississippi	Mobile/Pascagoula	18.32	18.61	19.36	20.24
Jackson	Mississippi	Mobile/Pascagoula	128.82	129.86	132.44	135.97
Greene	Mississippi	Mobile/Pascagoula	11.50	11.57	11.75	12.02
Mobile	Alabama	Mobile/Pascagoula	399.87	409.17	431.95	457.51
Washington	Alabama	Mobile/Pascagoula	17.47	17.75	18.41	19.20
Baldwin	Alabama	Mobile/Pascagoula	123.60	136.90	169.93	204.11
Escambia	Florida	Mobile/Pascagoula	275.54	283.29	303.69	327.34
Total for Mobile/Pascagoula:			1,166.05	1,211.30	1,324.25	1,447.04
Total for Eight-Port Area:			3,630.29	3,743.39	4,025.92	4,335.26

Source: Woods & Poole Economics, Inc. 1997.

Land use also will be affected by new demands on waste-disposal facilities. The need for new facilities will be dependent on the capacity of the existing facilities to handle future wastes. In 1993, as input into USEPA=s effluent limitation guideline regulations, MMS completed an analysis of the total capacity of the Gulf=s commercial, waste-disposal industry (USDOI, MMS, 1993; USEPA, 1993b). The analysis indicated that there would be sufficient capacity at existing commercial waste-disposal sites for receipt of all future OCS-generated wastes expected as a result of the new regulations. Since that time, however, estimates of offshore production and associated wastes have increased. The ability to determine future capacity is complicated by the fact that these facilities do not just receive OCS-generated wastes but service other domestic oil and gas operations, some as far away as California, as well as some foreign operators. Furthermore, in the last five years or so, there has been a tremendous amount of competition among operators of commercial, waste-disposal facilities with facility ownership changing hands and new facilities opening. There does not appear to be any reasonable indicator that can be used to project new facilities. Given that waste disposal is likely to continue to be very competitive and that the OCS industry will continue to grow, it is assumed that both Texas and Louisiana will have new waste-disposal facilities sometime in the next 10 years. In the meantime, the MMS is sponsoring an inventory of infrastructure that is being and can be used for OCS-centered oil and gas activities. That inventory should be completed in the year 2001.

b. Population

Socioeconomic effects onshore will increase commensurately with the increase of offshore activities--both in deep water and on the shelf. Those effects will be exacerbated by population growth along the Gulf Coast. According to research sponsored by NOAA, coastal areas throughout the United States will become visibly more crowded with densities increasing from the 1994 average of 273 persons per square mile to a projected 327 by the year 2015. This means a rise of almost 1 percent per year over the next 20-year period. Beyond these averages, however, is the prediction that the largest concentrations of people in the U.S. will be along the coasts, an area comprising a mere 17 percent of the contiguous United States. Demographers also assume that these concentrations will be in already established cities such as Seattle, Washington; Los Angeles, California; and Florida s Gold Coast, i.e., Palm Beach south to Miami.

Within the next 10 years, however, those assumptions may need to be modified. As ports are centers of commerce and social activity, they also attract people for the number and diversity of jobs. While Houston, in Harris County, Texas, is now the only major metropolis on the Gulf Coast, newcomers to the area may well prefer to settle in less crowded cities and in unincorporated places. The cost of living in these areas is less; housing is available to a wide spectrum of wage-earners; and recreation, libraries, and community arts supporters are increasingly visible.

Ports assumed to be capable of accommodating deepwater support activities are shown on Figure II-10. The circles around these ports represent a 80.5-km (50-mi) radius around each port, with 80.5 km (50 mi) being regarded as an easy one-way commute for the local labor force. The counties within these areas are listed in Table IV-5. Table IV-5 also gives population estimates for these counties and parishes for 1996 and population projections through the year 2020 (Woods & Poole Economics, Inc., 1997). The projected population growth over the 24-year period ranges from highs of 34 percent for the counties around Galveston Harbor, 24-31 percent per year for the Mobile/Pascagoula environs, and 17 percent for Port Fourchon=s region of influence; to lows of 12 percent for Corpus Christi and 10 percent for Port Arthur/Lake Charles. The rate of growth for the entire area is 19 percent. How important these changes are will be clear once MMS receives interim and final analyses from a series of ongoing and planned studies.

c. Employment

Deepwater oil and gas development has far-reaching employment implications. According to testimony given before the Senate Committee on Energy and Natural Resources (August 11, 1992) by the Assistant Secretary for Domestic and International Energy Policy and testimony before the Oceanography, Gulf of Mexico, and OCS Subcommittee of the Merchant Marine and Fisheries Committee (September 14, 1993) by the President of the National Ocean Industries Association, for every $1 million invested offshore, 20 jobs are created. And for every 10 jobs created offshore, 37 jobs are created onshore. Full-field, deepwater drilling and development costs can exceed $1 billion, thereby creating over 20,000 new jobs (for one field).

A typical TLP project in the Gulf of Mexico may create about 3,000 jobs directly and indirectly involved with the project. The MMS estimates that about 60 percent of those jobs are in Louisiana and Texas; the remainder may occur all over the world. Ongoing studies will give us more refined data in 2-3 years.

An average subsea project may employ about 400 employees at an estimated 25,700 person-days per project life. As with TLP projects, the majority of those employees are estimated to reside in the Gulf of Mexico coastal region. In addition, as with TLP projects, there will be employment impacts outside of the Gulf of Mexico coastal area.

Drilling in deep water has special requirements in terms of both equipment and labor (depending on the water depth). In some cases, an additional anchor boat may be required. In other cases, drillships are needed with a drilling crew and navigation crew to dynamically position the ship at the well site. Computerized machinery is used, requiring specialized labor needs. The length of time to drill a well increases for deep water as well. Rig availability and labor availability have been (in recent years) limiting factors.

In general, MMS has used the following in its analysis of the effects of drilling in deep water: semisubmersibles can drill eight wells per rig per year with an average crew of about 150, and drillships can drill six wells per rig per year with an average crew of about 190. The MMS is managing a study to survey employment needs of the offshore industry and will update its employment assumptions with the availability of this new information.

Current total employment for the five port areas is estimated at 1.8 million for the year 1996, with the urban centers of Corpus Christi, Galveston, part of New Orleans, and Mobile showing the highest job rates. Table IV-6 lists those rates and also gives projections from the years 2000 to 2020.

d. Sociocultural Issues

Environmental Justice

On February 11, 1994, President Clinton issued Executive Order 12898, entitled AFederal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations.@ The Order directs Federal agencies to assess whether their actions have disproportionate environmental effects on people in ethnic or racial minorities or with low incomes. Those environmental effects encompass human health, social, and economic consequences. The Federal agency in charge of the proposed action must provide opportunities for community input in the NEPA process. Community involvement includes identifying both potential effects and mitigation measures developed in consultation with the affected communities.

Table IV-6
Employment Projections

County/Parish	State	Port	Employment by Year in 1,000s 1996	2000	2010	2020
Jim Wells	Texas	Corpus Christi	16.07	16.43	17.09	17.93
Bee	Texas	Corpus Christi	11.42	12.04	13.51	15.03
San Patricio	Texas	Corpus Christi	21.65	21.81	22.06	22.53
Kleberg	Texas	Corpus Christi	14.82	15.85	18.37	21.18
Nueces	Texas	Corpus Christi	166.75	170.36	188.69	207.59
Refugio	Texas	Corpus Christi	3.47	3.45	3.37	3.36
Aransas	Texas	Corpus Christi	8.28	8.64	9.45	10.36
Total for Corpus Christi:			242.46	248.58	272.54	297.98
Brazoria	Texas	Galveston	97.55	103.71	120.07	137.43
Galveston	Texas	Galveston	112.86	120.29	142.39	169.83
Chambers	Texas	Galveston	8.69	8.98	9.87	10.80
Total for Galveston:			219.10	232.98	272.33	318.06
Chambers	Texas	Port Arthur/Lake Charles	8.69	8.98	9.87	10.80
Hardin	Texas	Port Arthur/Lake Charles	14.37	15.17	17.13	19.29
Jefferson	Texas	Port Arthur/Lake Charles	141.52	144.19	154.72	172.45
Orange	Texas	Port Arthur/Lake Charles	32.13	32.70	34.17	36.12
Beauregard	Louisiana	Port Arthur/Lake Charles	12.47	13.16	14.69	15.74
Calcasieu	Louisiana	Port Arthur/Lake Charles	91.30	93.69	99.74	106.66
Cameron	Louisiana	Port Arthur/Lake Charles	4.59	4.77	5.24	5.83
Jefferson Davis	Louisiana	Port Arthur/Lake Charles	11.05	11.35	12.43	13.97
Allen	Louisiana	Port Arthur/Lake Charles	7.63	7.74	8.12	8.74
Acadia	Louisiana	Port Arthur/Lake Charles	20.01	20.02	20.33	21.05
Total for Port Arthur/Lake Charles:			343.76	351.77	376.44	410.65
Terrebonne	Louisiana	Port Fourchon/Venice	48.46	19.28	51.52	55.46
LaFourche	Louisiana	Port Fourchon/Venice	34.58	35.67	38.59	42.38
Jefferson	Louisiana	Port Fourchon/Venice	255.69	273.35	317.92	367.97
St. Bernard	Louisiana	Port Fourchon/Venice	21.03	21.37	23.10	26.58
Plaquemines	Louisiana	Port Fourchon/Venice	20.01	20.60	21.98	23.73
Total for Port Fourchon/Venice:			379.77	370.27	453.11	516.12
Harrison	Mississippi	Mobile/Pascagoula	113.31	122.21	148.56	174.81
Stone	Mississippi	Mobile/Pascagoula	4.86	5.04	5.35	5.62
George	Mississippi	Mobile/Pascagoula	5.49	5.75	6.25	6.63
Jackson	Mississippi	Mobile/Pascagoula	64.72	66.83	70.39	72.63
Greene	Mississippi	Mobile/Pascagoula	2.88	2.92	3.02	3.11
Mobile	Alabama	Mobile/Pascagoula	204.92	212.90	237.02	266.25
Washington	Alabama	Mobile/Pascagoula	7.12	7.37	7.92	8.52
Baldwin	Alabama	Mobile/Pascagoula	53.90	60.18	76.79	94.94
Escambia	Florida	Mobile/Pascagoula	149.26	156.38	178.70	204.37
Total for Mobile/Pascagoula:			606.46	639.58	734.00	836.88
Total for Eight-Port Area:			1,791.55	1,843.18	2,108.42	2,379.69

Source: Woods & Poole Economics, Inc. 1997.

The impetus behind this Executive Order was the long history of companies siting hazardous, unsightly, or dangerous factories in or near communities with politically ineffective constituencies, e.g., African-American, Hispanic, Native American, or Asian enclaves with few marketable skills and earnings at or below poverty level. And while locating such factories or manufacturing plants near cheap, unskilled labor often resulted in jobs for local residents, hindsight also reveals neighborhood cohesion undermined, social ties to the wider community weakened, health endangered, and toxic sites allowed to remain.

The scenarios developed for this assessment are of a programmatic nature, meaning that no specific action, project, or proposal is being evaluated and recommended to a decisionmaker. As with other industrial location strategies, the siting of onshore facilities related to OCS deepwater activities is usually based on economics, logistical considerations, zoning restrictions, and permitting requirements. Because of the need for multiple acres of contiguous land and lower land values, such facilities, with their concomitant environmental implications, often are near low-income or minority populations. In the case of federally sponsored actions, potential impacts on these populations would come within the purview of Executive Order 12898. These populations can be found across the Gulf Coastal Plain in multiethnic as well as homogenous communities. Within the region of influence addressed in this assessment are primarily Hispanic communities and neighborhoods in Texas, African-American populations across the northern Gulf rim; two federally recognized American Indian tribal lands in Louisiana; and Asian-American communities and neighborhoods in Texas, Louisiana, and Alabama (USDOI, MMS, 1997b).

Each facility that may be constructed onshore must receive approval from the pertinent Federal, State, county/parish, and/or community involved. All onshore pipelines must obtain similar permit approval and concurrence. The MMS assumes that projected construction will be approved only if consistent with the regulatory processes of the involved parties. Should a conflict exist, MMS further assumes that approval will either not be granted or that appropriate mitigating measures will be enforced by the appropriate political entities. The MMS assumes that new sites will be in accordance with appropriate land-use plans, zoning regulations, and other State/regional/local regulatory mechanisms.

e. Suggested Research and Information Synthesis

Most socioeconomic effects of deepwater OCS exploration, development, and production operations and support activities cannot be distinguished from those of the entire OCS Program. Several research studies are ongoing and planned with the common goal of documenting the people and the range of their behaviors in the counties and parishes immediately adjacent to the Gulf of Mexico. These research efforts include and are not limited to (1) analyzing the effects on the individual and family of offshore oil and gas employment; (2) gauging labor needs of the industry over the next 20 years; (3) calculating multiplier effects of OCS spending on both income and employment and delineating the geographic scope of those multipliers; (4) determining if and how OCS mineral extraction influences local public institutions along the Gulf; (5) delineating production functions for each discrete phase of the process of extraction; and (6) tracing the process of design, manufacturing, transporting, siting, maintaining, and decommissioning an oil or gas structure, and comparing and contrasting the work arrangements at each step. These studies are scheduled to produce useful data and information during the next five years. Follow-up studies may be suggested by the results of these current projects.

3. Conclusions

The MMS expects employment projected to occur in association with Gulf deepwater activities to be filled primarily by persons already engaged in OCS oil- and gas-related jobs and by unemployed and underemployed persons living in the area. The coastal counties and parishes of Texas and Louisiana should provide the greatest support and, hence, incur the greatest potential impacts. Inasmuch as local residents will take some of these jobs, including high-paying positions, positive effects should occur. Given the present amount of OCS-related jobs along the Gulf Coast, there should be only minor workforce fluctuations. Population throughout the region of influence will increase, but at markedly different rates, which may or may not be causally related to deepwater activities. Some importation of skilled labor may be required. Social and cultural problems typically associated with migration may occur but should be minor. Several different possible scenarios may result in the siting of new supporting onshore facilities, with their concomitant economic and environmental implications, near low-income or minority populations. Existing onshore facilities may be expanded to handle additional work requirements.

Economic and logistic considerations, as well as local zoning and permitting requirements, drive the choice of where to site onshore facilities. There should not be disproportionately high or adverse human health or environmental effects on minority or low-income populations. Lack of information, however, on potential locations of future onshore infrastructure makes it impossible to dismiss potential disproportionate impacts.

K. Transboundary Effects

On July 1, 1997, the Council on Environmental Quality provided guidance on analyses for transboundary effects (CEQ, 1997). The guidance clarifies applicability of NEPA to proposed Federal actions in the United States that may have effects extending across the border and affecting another country's environment.

The MMS has leased blocks in the southernmost portions of the CPA and WPA of the Gulf of Mexico, i.e., Port Isabel, Alaminos Canyon, Keathley Canyon, and Walker Ridge. Bids were received in NG 15-9 for Sale 169 in March 1998. The southern limits of these map areas lie along or close to the U.S./Mexican boundary. The largest group of active OCS leases adjoining the U.S./Mexican boundary is located in Alaminos Canyon at water depths greater than 2,500 m.

During the EA=s scenario interval from 1998 to 2007, limited exploratory drilling is expected to occur in water depths greater than 2,000 m. Development and production activities are not expected to occur at those water depths within the next 10 years. Development and production activities have lagged behind exploratory drilling technology. Drilling, development, and production activities are anticipated from the Port Isabel area and in the western portion of Alaminos Canyon in water depths of less than 2,000 m.

Transboundary effects from deepwater operations could result from oil spills, air emissions, and discharges from drilling activities. The MMS=s Oil Spill Risk Analysis (OSRA) model run for the 1998-2002 Central and Western Gulf of Mexico lease sales include land segments in Mexico (Tamaulipas) (Price et al., 1997). The spill size for the model runs was 1,000 bbl. Data suggest a very low probability of a spill reaching the Mexican coastline within 30 days (approximately 3% probability for a spill from a hypothetical pipeline segment near the Texas/Mexican border). The OSRA probabilities of shoreline effects are based on the assumption that no cleanup operations will occur during the 30-day interval.

Air emissions and discharges from deepwater drilling operations would be temporary and are not expected to affect the Mexican coastline. The environmental effects from these impact-producing factors will be localized and limited in time. Therefore, no substantial effects are expected to the air or water quality of Mexican waters or their coastal zone.

Potential effects to benthic organisms are expected to be localized to the area of the operations. Anchoring and discharges are the primary impact-producing factors of concern related to benthic organisms. No substantial effects are expected to Mexican benthos.

Other resources that may be affected by a deepwater-related spill or a discharge are discussed in Chapter IV. The effects of a spill or a discharge on other offshore resources (e.g., fish, marine mammals, and sea turtles) are expected to be similar whether in U.S. or Mexican waters. These mobile offshore resources cross international boundaries at will. No substantial impacts are expected to these resources.

CHAPTER V

CONSULTATION AND COORDINATION

V. CONSULTATION AND COORDINATION

A. Scoping

Although formal public scoping is not required for the preparation of an EA, MMS has actively sought information and data on the technologies, risks, potential impacts, issues, and concerns related to deepwater activities in the Gulf of Mexico.

- *August 1, 1996*: The Call for Information and Nominations (Call) and the Notice of Intent (NOI) to Prepare an Environmental Impact Statement (EIS) for the proposed 1998-2002 Central Gulf of Mexico lease sales was published in the *Federal Register*. In response, the Louisiana Department of Natural Resources requested an analysis of new development patterns associated with deepwater exploration and development on the socioeconomic environment of Louisiana.
- *January 29, 1997*: The Call for Information and Nominations and the Notice of Intent to Prepare an Environmental Impact Statement (Call/NOI) for the proposed 1998-2001 Western Gulf of Mexico lease sales was published in the *Federal Register*. In response, the Louisiana Department of Natural Resources requested an analysis of new development patterns associated with deepwater exploration and development on the socioeconomic environment of Louisiana.
- *February 1997*: The MMS published a report (Cranswick and Regg, 1997) describing the extent and types of oil and gas exploration and development activities that are taking place in the deepwater portion of the Gulf of Mexico OCS. The report acknowledges the challenges of effectively managing and regulating exploration and development activities in the frontier deepwater areas of the Gulf.
- *April 1997*: The MMS and the industry group DeepStar jointly sponsored a workshop to gain a better understanding of floating production, storage, and offloading (FPSO) technology and the scope of operations around the world. Presentations were given by industry experts, contractors, offloading/transport operators, MMS, and the U.S. Coast Guard (USCG). Discussions focused on the advantages and disadvantages of FPSO=s, technology and scope of operations projected for the Gulf of Mexico, MMS requirements for use of FPSO=s, USCG requirements for use of FPSO=s, lightering and shuttle tanker operations, and the risks and hazards associated with tanker-supported FPSO=s. Technical challenges identified were the ability to handle increasing numbers of wells, production riser design, alternatives to transporting produced gas by pipeline, and mooring systems for water depths over 4,000 ft (1,219 m). The proceedings of this workshop have been published by MMS as OCS Report MMS 98-0019 (Regg, 1998).
- *April 1997*: Recognizing the magnitude of the activities in deep water, MMS and Louisiana State University (LSU) hosted a AWorkshop on Environmental Issues Surrounding Deepwater Oil and Gas Development@ (Carney, 1998). Discussions were focussed on four disciplines: environment, physical oceanography, socioeconomics, and geohazards. Discussions ranged from physical oceanography to socioeconomics. A total of 254 participants from academia, State and Federal agencies, and the oil and gas industry attended. Concurrent with the review of the workshop proceedings, the

Deepwater Subcommittee of the MMS Scientific Committee met in New Orleans on October 1 and 2, 1997, to assist the Region in identifying and prioritizing its short-term and long-term deepwater study needs. The results of the workshop and our dialogue with the Deepwater Subcommittee have helped focus the development of environmental studies addressing the environmental and socioeconomic issues related to deepwater development. In FY 1998, ten studies specifically devoted to deepwater studies issues were procured. In FY 1999, seven deepwater studies were initiated. An additional five studies are in planning for FY 2000 and a number other studies will be initiated over the next few months through the Gulf Region=s Coastal Marine Institute located at LSU.

- *June 1997*: Public hearings on the Draft EIS for proposed 1998-2002 Central Gulf of Mexico lease sales were held in Houma and New Orleans, Louisiana, and in Mobile, Alabama. The only comments related to deepwater activities in the Gulf of Mexico were presented at the Houma hearing. Approximately 60 people attended the hearing, with 19 individuals presenting testimony. The presenters represented local government agencies, industry groups, private landowners, a newly formed coalition (La. 1 Coalition), and other concerned individuals. The primary focus of the testimony presented to MMS was the infrastructure needs of Lafourche Parish south of U.S. Highway 90 because of increased deepwater activities. Increases in traffic (local vehicular traffic as well as heavy truck traffic supporting OCS activities) are placing heavy repair and maintenance stresses on the highway itself and on the economic capabilities of parish and local governments. More frequent traffic delays and increasing traffic safety risks occur because of the volume of traffic and the conditions of the road. In-migration is having a substantial impact on a local scale. Increased demands for freshwater supplies are adding considerable stress to the Parish Water district.

- *October 1997*: Public hearings on the Draft EIS for proposed 1998-2001 Western Gulf of Mexico lease sales were held in Austin, Corpus Christi, and Houston, Texas, and in New Orleans, Louisiana. No comments related to deepwater operations or activities were offered at these meetings.

- *December 1997*: The Gulf of Mexico Region's annual Information Transfer Meetings (ITM) included several sessions related to deepwater activities in the Gulf of Mexico. The ITM included a full-day session on *Deepwater Operations* and a half-day session on *Environmental & Socioeconomic Information in Deep Waters*. There were additional presentations on the recent effects on Port Fourchon from deepwater support activities. The ITM also provided an opportunity for EIS analysts to attend and meet with representatives from Federal, State, and local agencies; industry; MMS contractors; and academia.

- *February 1998*: The MMS placed a notice in the *Federal Register* (February 23, 1998) announcing the preparation of the environmental assessment on exploration, development, and production operations and activities in the deepwater Gulf of Mexico. Concurrently, letters were sent to the Governors of the Gulf of Mexico coastal States and to industry groups.

- *June 1999*: A Notice of Intent to prepare an EIS on the potential use of floating production, storage, and offloading (FPSO) systems in the deepwater areas of the Western and Central Planning Areas of the Gulf of Mexico OCS and announcement of public scoping meetings were published in the *Federal Register* on June 10, 1999. Letters announcing the EIS and scoping meetings were also sent to the Governors of the Gulf of Mexico coastal States, to appropriate State and Federal agencies, and to interested parties. Meetings notices were also published in newspapers within the communities where the meetings were to be held. The public scoping meetings were held June 21-28, 1999, in Corpus Christi, Houston, and Beaumont, Texas, and in Lake Charles and New Orleans, Louisiana.

- Ongoing meetings with various stakeholders occur frequently. The MMS environmental analysts, subject-matter experts, and management regularly meet with their counterparts in other Federal, State, and local agencies. Key agencies include the National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Fish and Wildlife Service, Department of Defense, Coast Guard, Corps of Engineers, U.S. Environmental Protection Agency, and State Governors' offices. Numerous meetings with operators and industry groups have included discussions of their intentions and concerns related to deepwater activities. The MMS analysts have visited ports, shipbuilding yards, fabrication yards, and gas processing plants to gather information about the influence of deepwater activities.

B. Related NEPA Documents

There are several existing NEPA documents prepared by MMS and other Federal agencies that address issues or activities similar to or related to those analyzed in this EA.

- *MMS Outer Continental Shelf Oil & Gas Leasing Program: 1997-2002 Final EIS (OCS EIS/EA MMS 96-0043)*: The 5-year EIS includes discussions of some aspects of deep water, although no specific deepwater activities section was prepared for the EIS. Examples of topics covered are the geology and hydrocarbon potential for deepwater areas in the Gulf, deepwater benthic communities, the possible deepening of the navigation channel to Port Fourchon, and the potential impacts from additional pipeline landfalls to support specific deepwater projects.

- *MMS Gulf of Mexico OCS Lease Sale EIS=s*: In recent multisale EIS's, the deepwater scenario and impact discussions are more fully developed to a level of detail consistent with the level provided for shelf-based operations. The MMS=s lease sale EIS's adequately and appropriately address deepwater issues to meet NEPA requirements for the lease sale decisions in the Central and Western Gulf of Mexico. Deepwater issues identified in the lease sale EIS=s include the timing and scale of deepwater operations, potential environmental impacts associated with the new technologies for drilling and production in deepwater areas, oil spills due to tankering from deepwater areas, expansion of the pipeline system, wetlands impacts due to the increasing number of landfalls, air and water pollution from extended well testing, noise associated with 3D seismic surveying, compatibility of the current infrastructure with anticipated larger support vessels and possible deepening of navigation channels and ports to accommodate these larger vessels, increased demand for fresh water, increased economic and industrial activities in the coastal zone, additional service vessels and helicopter traffic, increased traffic on existing roadways, and Ain-migration@ of workers. Potential impacts from deepwater activities are addressed in both the proposed action and cumulative analyses. Environmental resources that may be impacted are chemosynthetic communities, commercial fisheries, marine water quality, air quality, and coastal infrastructure.

- *MMS Postlease Environmental Evaluations:* A NEPA review and evaluation are done on all Exploration Plans, Development Operations Coordination Documents, Development and Production Plans, and lease-term and right-of-way pipeline applications submitted to MMS. These plans are evaluated against MMS=s guidelines and criteria for Categorical Exclusion Reviews (CER=s) and Environmental Assessments (EA=s) to determine whether a CER, EA, or EIS is required to assess the potential effects from the proposed operations and supporting activities. The CER=s are routinely done on uncomplicated proposals. The MMS has prepared EA=s on specific deepwater projects, including TLP=s, a compliant guyed tower, subsea completions, and deepwater pipeline tows. As of June 1998, an EIS had not been prepared for any proposed deepwater project.

- *USCG EA for Designation of Lightering Zones:* Informal lightering zones have been used in the Gulf of Mexico for decades. With the passage of the Oil Pollution Act of 1990 (OPA), shipping interests petitioned the USCG to establish designated lightering zones in the Gulf of Mexico. On January 18, 1994, the USCG held a public hearing to receive comments regarding the creation of lightering zones. On October 25, 1994, the USCG prepared an EA for the designation of three lightering zones within the Gulf of Mexico. In these zones, the discharging of cargoes of newly built, single-tank vessels and older, single-hull-tank vessels would be allowed. These vessels would otherwise be banned by the phase-out provisions of OPA from operating in waters under U.S. jurisdiction, except at the Louisiana Offshore Oil Port (LOOP). In the EA, the USCG proposed regulations establishing operating requirements, and weather and sea state restrictions to govern lightering activities within the designated zones. The USCG also proposed prohibited areas over the Flower Garden Banks and other banks to protect ecologically sensitive areas from anchor damage or accidental discharges that might occur during lightering operations. The final rule designating four lightering zones in the Gulf of Mexico was published in the *Federal Register* on August 29, 1995 (60 FR 67, pp. 45006-45018).

- *Louisiana Offshore Oil Port (LOOP) EA:* In October 1975, Dames and Moore prepared a three-volume environmental analysis for the proposed LOOP facility. Volume 1 provided a description of the proposed project and discussed the baseline conditions. Volume 2 discussed the probable impacts of the proposal, reasonable alternatives, accident potential and spill analyses, economic impact analysis, measures to ameliorate, and adverse impacts and risks. Volume 2 also contains a summary comparison of anticipated impacts of the proposed port and key alternatives. Volume 3 contained all of the appendices. Though much of the information is no longer current, sections of the EA do provide useful information, including description of the project, probable impacts of the proposed project, accident potential and oil spill analysis, and measures to ameliorate adverse impacts and risks.

C. MMS=s Environmental Studies Program and Technical Analysis and Research Program

In addition to identifying issues related to deepwater operations and activities, the scoping opportunities listed above helped to identify potential data gaps and information needs related to the deepwater areas of the Gulf of Mexico. The MMS will look at technological developments and assess the effects these new technologies may have on the workforce, communities, and economies of the U.S. Gulf coastal region. Both the MMS Environmental Studies Program (ESP) and the Technical Analysis and Research (TA&R) Program have initiated or planned studies and research focused on the deepwater areas of the Gulf. These efforts will aid in understanding the effects of deepwater operations and support activities on the marine and human environment. Current deepwater activities provide an opportunity to study many of the effects as they are occurring, rather than the more traditional documentation after the fact. The information collected will also be extremely useful to Federal, State, and local governments in planning for and mitigating the effects of this current surge in offshore activity.

CHAPTER VI

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VI. BIBLIOGRAPHY AND SPECIAL REFERENCES

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APPENDIX A

DECISION DOCUMENT

DECISION DOCUMENT

Gulf of Mexico Deepwater Operations and Activities Environmental Assessment

Minerals Management Service Gulf of Mexico OCS Region

The Minerals Management Service (MMS) is mandated to manage the development of Outer Continental Shelf (OCS) oil and natural gas resources, while also ensuring safe operations and protection of the human and natural environment. To meet these objectives, MMS is using the National Environmental Policy Act (NEPA) process as a planning tool in managing these activities and ensuring appropriate environmental reviews. The MMS=s overall objective is to ensure that the oil and gas activities in the deepwater Gulf of Mexico (GOM) occur in a technically safe and environmentally sound manner.

I have reviewed and considered the information and analyses in the Environmental Assessment (EA) regarding the potential impacts of exploration, development, and production of oil and natural gas resources in the deepwater areas of the GOM OCS. The components of deepwater operations and associated activities are listed in the summary matrix in the EA. The EA analyzes potential impacts on chemosynthetic communities, nonchemosynthetic benthic communities, marine mammals, sea turtles, fishing and fisheries, air quality, archaeological resources, water quality, coastal habitats, and socioeconomic resources, as well as environmental justice and transboundary effects.

After reviewing the information and analyses in the EA, I find that a programmatic environmental impact statement (EIS) on regional deepwater activities on the Gulf of Mexico OCS is not required. I find that existing NEPA documents, established project-specific and programmatic NEPA review processes, and established mitigation measures are fully sufficient to address most of the components and activities associated with deepwater operations. As indicated below, some deepwater components have been addressed by requiring specific mitigation measures, initiating a more in-depth EA, and initiating an EIS.

Objectives in preparing this EA were to determine (1) which deepwater activities are substantially different from those associated with conventional operations and activities on the continental shelf; (2) which deepwater activities are substantially the same as those associated with conventional operations and activities on the continental shelf; (3) which aspects or components of deepwater operations and activities potentially impact the marine, coastal, or human environments of the GOM OCS and adjacent coastal areas; (4) which aspects or components of deepwater operations and activities are adequately addressed by current MMS NEPA analyses; and (5) what level of NEPA analysis is appropriate to evaluate potential impacts not adequately covered by current NEPA analyses.

Most components and activities associated with the exploration, development, and production of oil and natural gas resources in the deepwater areas of the GOM OCS are similar to OCS operations on the continental shelf. These deepwater components and activities include anchoring, mooring, stationkeeping, most drilling and well completion activities (the exceptions are discussed below), well test and cleanup operations, flaring/burning, facility installation and production operations, host facilities, pipeline installation and operations, alternative transportation options, operational emissions, routine produced-water discharges, support service activities, decommissioning, and site clearance. Existing NEPA documents, established project-specific and programmatic NEPA review processes, and established mitigation measures are fully sufficient to address these deepwater components and associated activities.

After reviewing the EA, I find that the use and discharge of synthetic-based drilling fluids (SBF) and cuttings wetted with SBF may pose potentially significant, localized impacts to chemosynthetic communities. A mitigation measure has been developed to reduce the potential for impacts from SBF. Deepwater wells using SBF must be at least 1,000 ft away from any potential high-density chemosynthetic communities. Notice to Lessees and Operators (NTL 98-11) is being modified to include this 1,000-ft buffer zone around all deepwater well sites. As the NTL goes through the formal review and implementation process, this mitigation is being applied on a site-by-site basis.

I further find that seafloor discharges from pre-riser and riserless drilling operations may pose potentially significant, localized impacts to chemosynthetic communities. An appropriate mitigation measure has been developed to avoid significant impacts from pre-riser and riserless drilling discharges. Pre-riser and riserless drilling discharges must be at least 1,000 ft away from any potential high-density chemosynthetic communities. NTL 98-11 is being modified to include this 1,000-ft buffer zone around all deepwater well sites. As the NTL goes through the formal review and implementation process, this mitigation is being applied on a site-by-site basis.

I further find that the accidental subsea release of oil is a very low-probability event, and extensive mitigation measures for oil-spill prevention and response are already required. Although the behavior and transport dynamics of subsea oil releases are not completely understood, the potential effects of the oil once it reaches the surface are extensively analyzed in MMS lease sale EIS=s and will also be analyzed in the EIS on floating production, storage, and offloading systems that is being prepared. To understand better the potential fate and effects of subsea oil spills, the MMS has begun several studies and is participating in joint research projects with industry and other Federal agencies.

I further find that the accidental spill of chemical products used in support of deepwater operations is a low-probability event, and extensive mitigation measures for chemical spill prevention are already required. Because the fate and effects of chemical products in the marine environment are not completely understood, MMS has begun studies to address these issues.

I further find that deepwater seismic surveying operations are not essentially different from seismic surveying operations on the continental shelf. The technology used for high-energy geophysical surveys has evolved in the past several years, and the potential impacts of the newer source systems are controversial. In recognition of these factors, the MMS has initiated a separate EA to analyze geological and geophysical (G&G) activities, including seismic surveying operations, on the GOM OCS.

I further find that the use of floating production, storage, and offloading (FPSO) systems represents new and unusual technology for the GOM OCS and poses potentially significant impacts to the marine and coastal environments. The need for an EIS was recognized early during the preparation of the EA. A Notice of Intent to Prepare an EIS was published in the *Federal Register* on June 10, 1999.

An objective of this EA was to develop, for further consideration, measures to mitigate impacts from deepwater activities on the marine, coastal, and human environments. All of the mitigation measures identified in this EA are environmentally viable measures. Some of the potential mitigation measures suggested during the preparation of the EA were eliminated from further consideration as they either posed unacceptable constraints to safe operations or they would be impractical to implement in the deepwater areas of the GOM OCS. A multidisciplinary team will be established to evaluate the technical feasibility, economic feasibility, and potential effectiveness of all of the remaining mitigation measures. The evaluation team will forward their findings along with their recommendations for implementation to MMS management for decision. A series of decision documents will be prepared on mitigation measures in relation to specific issues or specific impact-producing factors. Some of the mitigation measures developed via this EA have already been implemented. Mitigation measures are listed in the Executive Summary of the EA, as well as discussed in appropriate sections of the text.

An objective of this EA was to identify potential studies or research related to deepwater activities and environmental resources that will enhance and improve the impact assessment or help develop and refine mitigation measures. I find that none of the suggested studies, research, or information synthesis represents a critical information need requiring suspension of decisions on specific deepwater activities. All of the suggested studies and research will be forwarded to the MMS Environmental Studies Program or the MMS Technical Assessment and Research Program, as appropriate, for consideration and prioritizing for funding and procurement. Many of the studies suggested via this EA have already been funded or are in procurement. Suggested studies and research are listed in the Executive Summary of the EA, as well as discussed in appropriate sections of the text.

Regional Supervisor
Office of Leasing and Environment
Gulf of Mexico OCS Region
Minerals Management Service

5/5/00
Date

TOPIC	DECISION MECHANISM/TIMING
Deepwater components that are essentially the same as those associated with operations on the continental shelf	Lease sale EIS=s and project/site-specific environmental review and mitigation.
Synthetic-based drilling fluids and cuttings	Project/site-specific environmental review and mitigation. Additional mitigation measures pending completion of contracted studies.
Pre-riser and riserless drilling operations	Project/site-specific environmental review and mitigation. NTL revised to implement no activity zone as an interim mitigation measure. Additional mitigation measures pending completion of contracted studies.
Accidental release of crude oil in the deep subsea environment	Lease sale EIS=s and project/site-specific environmental review and mitigation. Additional mitigation measures pending completion of contracted studies.
Accidental spill of chemical products	Lease sale EIS=s and project/site-specific environmental review and mitigation. Additional mitigation measures pending completion of contracted studies.
Noise associated with high-energy seismic surveying	Decisions and mitigation pending completion of Geological and Geophysical EA and contracted studies.
Use of floating production, storage, and offloading (FPSO) systems	Decisions and mitigation pending completion of FPSO EIS. Project/site-specific environmental review and mitigation.
Suggested mitigation measures	Series of topic-specific decision documents based on evaluation and recommendations by multidisciplinary team.
Suggested research and information synthesis	Prioritization for procurement via established Environmental Studies Program Strategic Planning Process.