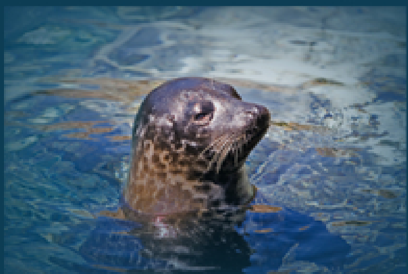
OCS Report
MMS 2009-015



# Report to the Secretary, U.S. Department of the Interior

# Survey of Available Data on OCS Resources and Identification of Data Gaps

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## Executive Summary

## Introduction

In response to President Obama's vision for energy independence for our Nation, Secretary of the Interior Ken Salazar announced on February 10, 2009, a four-part strategy for developing a new, comprehensive approach to energy resources of the Outer Continental Shelf (OCS):

(1) Extending the public comment period 180 days until September 21, 2009, on the Draft Proposed 5-Year Oil and Gas Leasing Program announced by the previous Administration.

(2) Development of a report by the Department's Minerals Management Service (MMS) and United States Geological Survey (USGS) on conventional and renewable offshore energy resources.

(3) Hosting four coastal regional meetings in April (Atlantic Coast, Gulf of Mexico, Pacific Coast, and Alaska) to review the findings of the USGS/MMS report and to gather input from all interested parties on whether, where, and how the Nation develops its conventional and renewable energy resources of the OCS.

(4) Expediting the Department of the Interior's (DOI's) renewable energy rulemaking for the OCS that was required under the Energy Policy Act of 2005 (EPAct), but which was never accomplished by the previous Administration.

The OCS refers to 1.7 billion acres of Federal jurisdiction lands submerged under the ocean seaward of State boundaries, generally beginning 3 geographical miles off the coastline (for most States) and extending for at least 200 nautical miles to the edge of the Exclusive Economic Zone and further as the continental shelf is extended. As the Secretary explained in his announcement, the DOI should establish an orderly process that allows us to make wise decisions based on sound information, in a way that provides States, stakeholders, and affected communities the opportunity to provide input on the future of our offshore areas.

This report is the result of the Secretary's directive to MMS and USGS, and has been prepared by the MMS in collaboration with the USGS. The report surveys information that is currently available regarding the nature and scope of offshore oil and gas and renewable energy resources on the OCS and identifies information regarding sensitive environmental areas and resources in the OCS. The report also identifies information gaps regarding available data on conventional and renewable resources on the OCS and environmental issues connected with OCS development.

The report's three main sections are: (1) renewable energy resources, (2) oil and gas resources, and (3) sensitive environmental areas and resources. They draw on information from technical reports and publications produced by the DOI bureaus, other Federal Agencies, academia, and the private sector. This document serves as a first step in summarizing information and identifying data gaps that may need to be addressed to make future informed decisions.

The information collated in this report regarding oil and gas resources has been drawn primarily from the 2006 report prepared by MMS, as directed by the EPAct. Information on OCS renewable resources has been drawn from a variety of sources including data collected from the U.S. Department of Energy, the National Renewable Energy Laboratory (NREL) , and other sources. Information on environmental issues was synthesized by MMS and USGS scientists based on the decades of research that has been conducted by MMS and USGS, as well as other Federal Agencies, universities, private industry, and research institutions.

As this report indicates, there are a number of important gaps in available data relating to all of these issues. The report, compiled in 45 days, does not purport to present new information or fill in existing data gaps. The primary purpose of the report is to present a survey of available data on the OCS so that the public and interested stakeholders can participate more effectively, and with greater access to potentially relevant information, in the public meetings on OCS development.

## Energy Resources on the U.S. Outer Continental Shelf

The Outer Continental Shelf Lands Act (OCSLA) of 1953, as amended (Public Law, 43 U.S.C. 1331 *et seq.*), provides authority for mineral leasing on the OCS and guidance for balancing orderly oil and gas resource development with protection of the human, marine, and coastal environments. The OCSLA Amendments of 1978 established the requirement for developing an OCS oil and natural gas leasing program based on a 5-year cycle.

Section 388 of EPAct amended the OCSLA, giving the DOI discretionary authority to issue leases, easements, or rights-of-way for activities on the OCS that produce or support production, transportation, or transmission of energy from sources other than oil and gas, except where activities are already otherwise authorized in other applicable law. This authority was delegated to the MMS, which was charged with developing regulations intended to encourage orderly, safe, and environmentally responsible development of renewable energy resources and alternate use of facilities on the OCS.

The MMS has the lead role for developing wind energy on the OCS—leasing, exploration, development, production, and decommissioning. For hydrokinetic resources, the Federal Energy Regulatory Commission (FERC) is the lead for issuing licenses authorizing construction and operation of generating facilities. The MMS's role for hydrokinetic resources is to provide appropriate input to FERC's licensing process and to issue necessary leases, easements, and rights-of-way.

## Renewable Energy

Estimating the potential of a given resource is a fairly straightforward process. However, it is often difficult to estimate the amount of renewable energy that is extractable or developable given the many uncertainties in societal preferences, technological developments, environmental sensitivities, transmission capacity, grid connection availability, and potential space-use conflicts in the ocean environment. Additionally, while certain geographic locations may possess economically developable resources and adequate transmission and grid capacity, the ultimate development of that potential is dependent on citizen interest and local, State, and Federal governmental policies.

**Wind power** is a renewable, low-carbon dioxide energy source located on the OCS that has the potential to become a significant source of electricity in the United States. Over the past two decades, land-based wind energy has seen a significant reduction in cost, making it a viable source for electric power generation in some areas of the United States. Offshore winds are typically stronger and more consistent than on land, and are frequently located near high-energy demand centers. Of the 48 contiguous States, 28 have a coastal boundary (including Great Lakes), and electric-use data show that these coastal States use 78 percent of the Nation’s electricity.

Offshore wind resources have substantial potential to supply a large portion of the Nation's electricity demand (Figure 1). According to estimates by the NREL, developing shallow water (typically 0-30 meters) wind resources, which are the most likely to be technically and commercially feasible at this time, could provide at least 20 percent of the electricity needs of almost all coastal States.

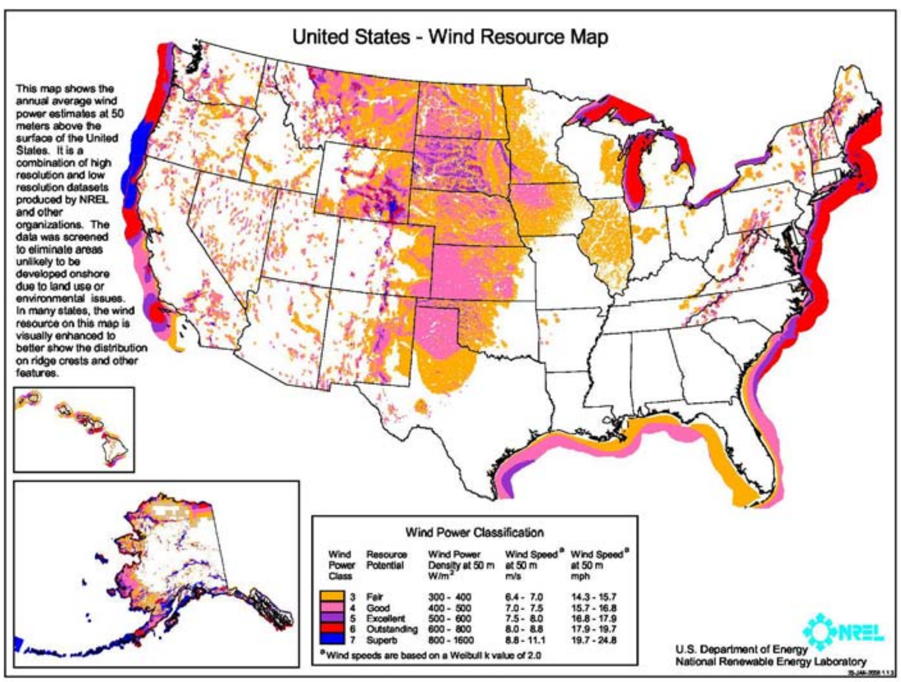


Figure I. United States Wind Resource Map (Source: NREL)

**Wave energy** also is a potentially significant OCS renewable energy resource, but wave energy is in the developmental stage. Given the current state of technology, the proximity to dense population and high energy load centers, and initial interest by select States, it does not appear that wave power is likely to become a major contributor to the national energy picture in the near future. Development is most likely to be focused in areas along the Pacific Northwest or off the coast of Hawaii.

**Tidal energy** technology development appears to be moving more quickly than wave energy technology development because its characteristics, such as predictable currents and location in shallow nearshore waters, make it more accessible to development. However, tidal projects typically occur close to the coast, within State boundaries.

Relative to wind, wave, and tidal energy, the resource potential for **ocean current power** is the least understood, and its technology is the least mature. The most viable potential opportunities for ocean current energy development in the United States are located off the southeast coast of Florida, in the Gulf Stream. However, analyses are incomplete at this time, so there may be other areas that have potentially viable current energy resources as well. To date, there is no comprehensive nationwide estimate on the current energy resource potential.

The Atlantic OCS has the greatest **renewable energy potential** relative to other OCS Regions in the Gulf of Mexico, Pacific, and Alaska. In the short-term (the next 5-7 years), this is most likely to be from offshore wind power. Substantial wind resources exist offshore the Atlantic Coast, near high-energy demand centers. Strong wind resources also exist offshore California, Oregon, Washington, and Hawaii, but it appears that the majority of this resource lies in deep waters where technology constraints are potentially significant. Alaska has outstanding ocean renewable energy resource potential. However, because of harsh weather conditions and significant distance from high-energy demand centers, it is not anticipated that these resources will be developed on the Alaska OCS in the short term.

## Oil and Gas Resources

Oil and gas development in the OCS is, and will continue to be, an important component of our Nation's energy portfolio. In 2007, the OCS accounted for 14 percent (2,860 billion cubic feet) of the Nation's natural gas production and 27 percent (492,329,179 barrels) of its oil production. This production was from 3,795 production facilities on 8,124 MMS-administered leases, covering more than 43 million acres.

This report summarizes the results of a regional assessment of the entire U.S. OCS that was completed by MMS in 2006, as well as assessments of new areas identified for inclusion in the 2010-2015 Draft Proposed Oil and Gas Leasing Program.

It is important to recognize that estimates of undiscovered oil and natural gas resources are just that: *estimates*. Resource assessments are an attempt to quantify something that cannot be accurately known until the resource has been developed and essentially depleted. The estimates presented in this report should be considered general indicators and not predictors of the absolute volumes of petroleum potential of the areas.

The MMS assessment of the hydrocarbon potential of the OCS is based on the analysis of published information and proprietary geologic, geophysical, and engineering data obtained by industry from operations performed under permits or mineral leases and furnished to the MMS. These estimates of undiscovered *technically* recoverable resources (UTRR) are subjected to a separate analysis incorporating economic and engineering parameters to estimate the undiscovered *economically* recoverable resources.

Regional-level UTRR results from the 2006 National Assessment are shown in Table 1. The estimates are presented as a range of estimates, and include the mean estimate and the 95th and 5th percentile levels. This range of estimates corresponds to a 95-percent probability (a 19 in 20 chance) and a 5-percent probability (a 1 in 20 chance) of there being more than those amounts of petroleum present, respectively. The 95- and 5-percent probabilities are considered reasonable minimum and maximum values, and the mean is the average or expected value.

Table 1. Undiscovered Technically Recoverable Resources of the OCS

| Region | Oil (Bbo) | | | Natural Gas (Tcf) | | | BOE (Bbo) | | |
|---|---|---|---|---|---|---|---|---|---|
| | F95 | Mean | F5 | F95 | Mean | F5 | F95 | Mean | F5 |
| Alaska OCS | 8.66 | 26.61 | 55.14 | 48.28 | 132.06 | 279.62 | 17.25 | 50.11 | 104.89 |
| Atlantic OCS | 1.12 | 3.82 | 7.57 | 14.30 | 36.99 | 66.46 | 3.67 | 10.40 | 19.39 |
| Gulf of Mexico OCS | 41.21 | 44.92 | 49.11 | 218.83 | 232.54 | 249.08 | 80.15 | 86.30 | 93.43 |
| Pacific OCS | 7.55 | 10.53 | 13.94 | 13.28 | 18.29 | 24.12 | 9.91 | 13.79 | 18.24 |
| | | | | | | | | | |
| Total U.S. OCS | 66.60 | 85.88 | 115.13 | 326.40 | 419.88 | 565.87 | 124.68 | 160.60 | 215.82 |

(Bbo-billion barrels of oil; Tcf-trillion cubic feet of gas; BOE-barrels of oil equivalent. F95 indicates a 95-percent chance of at least the amount listed; F5 indicates a 5-percent chance of at least the amount listed. Only mean values are additive.)

The total hydrocarbon endowment of an assessment area is defined as the sum of historical production, current reserves, future reserves appreciation, and UTRR. As of the 2006 Assessment (Jan. 1, 2003, cutoff date), mean estimates of the OCS total hydrocarbon endowment were 115.4 billion barrels of oil (Bbo) and 633.6 trillion cubic feet (Tcf) of gas (a total of 228.2 billion barrels of oil equivalent [BBOE]). More than 18 percent of this total endowment (mean estimate barrels of oil equivalent [BOE]) has already been produced, and an additional 11 percent is contained within the various reserves categories, the source of near and midterm production. Notably, even after more than 50 years of exploration and development on the OCS, 70 percent of the mean BOE total endowment is represented by undiscovered resources. More than half of this potential exists in areas of the OCS outside of the Central and Western Gulf of Mexico.

An economic analysis follows the assessment of the UTRR and represents the portion of the mean UTRR that is economically producible under given engineering, commodity price, and development cost scenarios. Results of this economic analysis are called Undiscovered Economically Recoverable Resources (UERR).

For the 2010-2015 Draft Proposed Program, UERR's were generated using oil prices of \$60/barrel (bbl), \$110/bbl, and \$160/bbl. Results are shown in Table 2 and indicate that approximately 53 percent of the total UTRR is economically recoverable on an oil-equivalent (BOE) basis, with an oil price of \$60/bbl and corresponding gas price of \$6.41/thousand cubic feet of gas (Mcf). This increases to about 78 percent with an oil price of \$160/bbl and corresponding gas price of \$17.08/Mcf.

Table 2. Mean Undiscovered Economically Recoverable Resources of the OCS

| Region | \$60/bbl and \$6.41/Mcf | | | \$110/bbl and \$11.74/Mcf | | | \$160/bbl and \$17.08/Mcf | | |
|---|---|---|---|---|---|---|---|---|---|
| | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) |
| Alaska OCS | 4.45 | 7.20 | 5.73 | 11.45 | 30.01 | 16.79 | 15.46 | 50.78 | 24.50 |
| Atlantic OCS | 2.58 | 14.55 | 5.17 | 3.07 | 21.85 | 6.96 | 3.28 | 25.79 | 7.87 |
| Gulf of Mexico OCS | 36.75 | 165.94 | 66.28 | 41.04 | 203.43 | 77.24 | 42.56 | 214.87 | 80.79 |
| Pacific OCS | 8.38 | 13.16 | 10.72 | 9.29 | 15.14 | 11.98 | 9.49 | 15.60 | 12.27 |
| | | | | | | | | | |
| Total U.S. OCS | 52.16 | 200.85 | 87.90 | 64.85 | 270.43 | 112.97 | 70.79 | 307.04 | 125.42 |

(Bbo-billion barrels of oil; Tcf-trillion cubic feet of gas.)

New areas in the Atlantic, Eastern Gulf of Mexico, Pacific, and Alaska OCS have been identified for inclusion in the 2010-2015 Draft Proposed Oil and Gas Leasing Program. Although leasing has not occurred in these areas for about 25 years, previous exploration has occurred in portions of these areas, and some of these areas contain active leases with producing oil and gas fields. Updated research and exploration regarding the likely location of energy resources and environmental impacts are necessary to fill in data gaps.

## Safety and the Environment

### Oil Spill Risks

Oil spills are of major concern to the public, offshore industry workers, and Federal and State regulators. Spill prevention offshore is achieved primarily through required, extensive safety procedures and practices, and engineering requirements such as the use of downhole shut-off valves and blowout prevention devices. The record shows good results in preventing and minimizing spills. In 2003, the National Research Council reported (for the period 1990 through 1999) that offshore oil and gas development was responsible for only 2 percent of the petroleum found in the marine environment for North America. The MMS employs advanced oil-spill risk analysis to inform its environmental assessments of offshore activities. Spill prevention, mitigation, and response plans are required and tested frequently to maintain readiness offshore.

### Geologic and Meteorological Hazards

Seafloor instability is the principle geologic hazard and, thus, engineering constraint to the emplacement of offshore bottom-founded structures. The MMS addresses and mitigates these hazards through the regulatory process. The MMS and USGS also conduct ongoing research that identifies and assesses hazards to offshore infrastructure.

The integrity of offshore infrastructure is also subject to changing ocean conditions and extreme weather events that generate intense winds, strong ocean and tidal currents, large waves, and heavy storm surges. With a large portion of OCS production located in an active hurricane corridor, many changes in industry requirements have taken place due to the recent damages and curtailment associated with hurricanes.

### Global Climate Change

Uncertainty exists about the potential effects of global climate change on energy production and distribution, in part because the timing and magnitude of climatic effects are uncertain. An overarching concern for all coastal and marine areas is how environmental factors such as temperature, sea level, availability of water from precipitation and runoff, wind patterns, and storminess will be affected.

## The Environmental Review Process

The environmental review process for renewable energy or oil and gas development activities includes compliance with various laws and regulations. The National Environmental Policy Act (NEPA) of 1969 requires that all Federal Agencies use a systematic, interdisciplinary approach that will ensure the integrated use of the natural and social sciences in any planning and decision making that may have effects on the environment. The goal of the NEPA process is to help public officials make decisions based on an understanding of potential environmental consequences and take actions that protect, restore, and enhance the environment. The MMS evaluates all aspects of the marine, coastal, and human environments including a detailed oil-spill risk analysis.

A tiered process has evolved for OCS oil and gas activities to evaluate the potential environmental consequences for each successive management decision starting with a proposed program, then individual lease sales, and finally project-specific plans. The 5-Year Programmatic Environmental Impact Statement analyzes the proposed leasing schedule, focusing on the size, timing, and location of proposed lease sales for the 5-year period identified in the proposed program document. Once the lease sale schedule is approved, more detailed environmental analyses are conducted for proposed lease sales in a given area. At that point, lease stipulations protective of the environment are identified and included in the leases granted to industry. After leases are issued, further environmental reviews of specific projects are conducted to ensure that the proper environmental protective measures are employed and site-specific mitigation measures are implemented. The mitigations may include, for example, avoidance of sensitive biological communities and archaeological resources, or inclusion of specialized discharge requirements. It is anticipated that a similar tiered process will be used for renewable energy to ensure that each management decision has undergone an appropriate environmental review with input from stakeholders and the public.

## Biological Habitats and Environmental Resources

### Seafloor Habitats

An understanding of seafloor habitats is an important consideration in making leasing decisions. Some information is available on seafloor habitats for portions of the OCS, but there are significant data gaps for a number of areas. In some cases, exploration seismic surveys for oil and gas production, followed by required site-specific high-resolution "hazard" surveys, could provide detailed information about the seabed with regard to drilling hazards as well as for evaluating benthic habitats. In other cases, additional detailed, high-resolution mapping may be necessary along with ground-truthing with sediment samplers, remotely operated vehicles, or even submersibles in order to verify community makeup to allow for mitigation and avoidance of habitats.

Key challenges for renewable energy activities on the OCS are similar to those for oil and gas activities, such as evaluation for sensitive biological habitats. These activities are initially done through large-scale studies of a particular region using existing information if available, and subsequently site-specific higher-resolution mapping if necessary.

### Coastal Habitats

Coastal habitats can be impacted by OCS development. In the Gulf of Mexico, for example, wetland losses have been associated with onshore energy infrastructure. Utilization of existing onshore facilities is a potential way to prevent further damage. Along the Pacific Coast, the heavily protected or developed coastline reduces options for pipeline or utility corridor sites required to support shore-based construction. While there are refineries and ports capable of supporting heavy industry, for the most part, the Atlantic region lacks existing onshore infrastructure geared to supporting offshore activity. Additionally, a significant portion of the coast, except portions of South Carolina and Georgia, are either developed or are State or federally protected shorelines. In Alaska, coastal environments are considered fragile; thus, it would be essential to accurately identify the sensitive habitats so they can be avoided by proper site selection and routing of support services.

### Fishery Resources

Key challenges for oil and gas development that are common to all OCS areas include accidental oil spills, the threat of space-use conflicts, habitat alteration, and seismic surveys. The threat of oil spills and their direct and indirect effects on fisheries is central to the concerns about offshore oil and gas development. There is extensive information on the detrimental effects of oil on fisheries in coastal and ocean situations. Space-use conflicts, at the dock or offshore, and habitat alteration from pipeline installation are important challenges that should be addressed by working closely with all interested stakeholders, encouraging multiple use of infrastructure and open consideration of alternative locations and routes. Seismic surveys are a challenge, as noise can negatively affect fishing activities and can limit access to an area. Seismic survey mitigations for fisheries include timing and notification so that there is the least amount of interference with fishing; avoidance of fish spawning locations, spawning seasons, and areas of concentrated fishing activity; limitation to the smallest area possible for the shortest amount of time; modifying frequency and duration of air-gun noise emission for least impact; and ramping-up so that sound energy emissions are gradually increased.

Key challenges for renewable energy development common to all OCS areas include offshore space-use conflicts, artificial reef effects, habitat alteration, noise from pile driving, and effects from electromagnetic fields (EMF). The MMS has funded research into the nature of space-use conflicts and offshore oil and gas structure siting, and is in the midst of a major study to delineate commercial fishing space-use conflicts for renewable energy. As with oil and gas, space-use conflicts for renewable energy activities are a challenge that should be addressed by working closely with all interested stakeholders. The artificial reef effect of offshore renewable energy structures will occur, and localized fisheries will likely change, becoming more or less attractive to fishermen. Noise from pile driving is localized, temporary, and potentially can be mitigated by the use of bubble-curtains, air gaps, and the quietest possible equipment and techniques. Habitat alteration, as power cables come ashore, potentially can be minimized by horizontal directional drilling and open consideration of alternative locations and routes. The subject of EMF continues to be studied globally, and MMS has an ongoing study to further address EMF. Mitigations for EMF include cable burial and proper shielding.

## Marine Mammals

Overall, there is some baseline information available for predicting areas of likely presence and absence of marine mammals on the OCS. Information is available on some species (e.g., nearshore movements of baleen whales, bottlenose dolphins, and manatees) while data on other species are limited (e.g., offshore distribution of baleen whales, Arctic species). Effects for some activities are well understood (e.g., contaminants and marine debris, vessel strikes), while less known for others (e.g., anthropogenic noise, climate change).

One of the major challenges for OCS energy development activities to coexist with marine mammals is the issue of anthropogenic sound. Sound is of vital importance to marine mammals, and anthropogenic sound can temporarily or permanently impair their ability to process and use sound. Potential threats from noise include seismic airguns, explosive removals of structures, and pile driving. It appears that the use of ramp-up as a mitigation tool may reduce or prevent the sudden exposure of marine mammals to maximum airgun output levels, and allows for them to leave the immediate vicinity. More data are needed regarding impacts on marine mammals as a result of noise produced by OCS energy activities. Behavior impacts have been documented from traditional and renewable energy activities, although these types of effects are still not well understood. Other threats to marine mammals include marine debris such as lines from ships and garbage, vessel strikes, oil spills, contaminants, and construction activities.

### Sea Turtles

Sea turtles are highly migratory with a wide geographic range. The key challenges for both renewable energy and oil and gas development in relation to sea turtles are similar to those for marine mammals, and include anthropogenic sound resulting from the use of seismic airguns, explosive removals of structures, and pile driving; the release of marine debris such as lines from ships and garbage; vessel strikes; oil spills and contaminants; and construction activities that disturb the bottom floor. The available information on sea turtle behavioral responses to sound levels from anthropogenic activities indicates that individuals are likely to actively avoid ensonified areas. However, the biological importance of behavioral responses to construction noise is unknown, and there is little information regarding short-term or long-term effects of behavioral reactions on sea turtle populations.

### Marine and Coastal Birds

Large oil spills from oil and gas development activities could have a large impact to birds. The prospects for near-term wind energy developments off the mid-Atlantic coast of the United States has created concern about potential impacts of wind turbines on marine and coastal birds. In addition to legally protected species, millions of migratory birds traverse the Atlantic Flyway twice each year, and thousands more either nest on the Atlantic coast of the United States or overwinter in nearshore and offshore waters of the Atlantic OCS. The challenge is to locate and operate wind energy facilities in such a way as to minimize bird mortality.

### Socioeconomics

Socioeconomic effects of the OCS program have been studied by MMS and others over many years. In addition to substantial revenues generated by offshore oil and gas development, the offshore oil industry is comprised of a great number of enterprises that provide innumerable goods and services in support of the exploration, development, and production of offshore oil in U.S. waters and abroad. Overall, an adequate baseline of information exists to address the socioeconomic effects of the OCS oil and gas program and the renewable energy program for leasing decisions. However, predictions of future industry activities are best built on past industry behavior. Therefore, as the renewable energy industry develops, new data on OCS operations will be needed to improve MMS estimates of the economic and demographic consequences.

## Information Data Gaps

As we move into an era of renewable energy in some areas and the continued development of more traditional energy sources in others, our information base is not always complete. Additional geographically-based, targeted research will be required in some areas and for some disciplines. The data and information gaps identified in this report must be viewed in terms of a broad range of decisions – over broad geographic areas - that will need to be made in the future. Note too, that data gaps identified in this report will be supplemented with input from stakeholders at the Federal, State and community levels as regional and project-level decision making proceeds.

**Renewable Energy Resources:** Quantifying the potential offshore renewable energy resource is reasonably straightforward, and great strides are being taken to map the offshore wind, wave, and tidal resources. However, there is a high degree of uncertainty in estimating the actual extractable or developable amount of energy given the many uncertainties in societal preferences, technological developments, environmental sensitivities, transmission capacity, grid connection availability, and potential space-use conflicts in the ocean environment. Offshore renewable energy technologies are still developing, particularly for wave, tidal, and current power; and there is a need for standardized protocols and criteria in technical evaluation and design. Also, resource assessment methods for wave, tidal, and current energy are less developed compared to wind energy; resource assessments are incomplete; and the actual amount of developable energy is dependent upon a host of factors that need to be examined more closely.

**Oil and Gas Resource Evaluation:** Seismic surveys are the primary method of exploring for oil and gas. Most of the seismic data acquired in the potential new lease areas are more than 25 years old and may not be adequate for detailed prospect mapping or for lease sale bid formulation and evaluation, especially in geologically complex areas. New seismic and related data will likely be required for some areas (especially in the Atlantic OCS area and Eastern Gulf of Mexico) and is typically used by the oil and gas industry as part of their pre-leasing evaluation. Prior to acquisition of seismic data, NEPA and other environmental analyses may be required to better inform decisions.

**Sensitive Environmental Areas and Resources:** Overall, an adequate baseline of information exists to address the environmental effects of the OCS oil and gas program and the renewable energy program in support of leasing decisions. A key challenge in many areas will be to gather and synthesize existing information. In addition, new information is continually being gathered by MMS, USGS, and others. Once specific areas are identified for development, additional information may be needed for some biological resources. Some of the key information needs follow.

*Seafloor Habitats:* There are some areas with limited information, and additional site-specific high-resolution mapping may be required to allow mitigation and avoidance of sensitive biological habitats such as coral reefs.

*Coastal Habitats:* While there is a large information base that provides a general understanding of coastal habitats, these efforts do not always reflect the most recent conditions of coastal shorelines, where severe weather conditions and changes in sea level may be altering the area.

*Marine Fish Resources:* The key information need related to fisheries is that regarding potential space-use conflicts for commercial fishing, which requires identification of important fishing grounds.

*Marine Mammals:* Key information needs include increasing our understanding of: (1) specific life history traits and critical habitat areas for some key marine mammal species (i.e., important feeding, mating and nursing behaviors and habitat for baleen whales and Endangered Species Act-listed species); (2) potential effects from noise-producing activities; and (3) potential non-acoustic effects from renewable energy technologies (e.g., potential entanglement with anchoring array, large footprint of some facilities, and potential effects on migration).

*Sea Turtles:* Little is known about the effect of noise on sea turtles in the marine environment. In particular, their basic auditory system and hearing mechanisms or the role of sound in their life cycle are not well understood.

*Marine and Coastal Birds:* The existing information on seasonal distribution and abundance of marine birds is sparse. Such information is critical to understanding the potential for exposure to offshore wind energy developments and to analysis of collision risk.

## Conclusion

While we continue to generate a vast majority of our electricity from fossil fuels, renewable energy sources appear more attractive as we look for ways to address environmental, economic, and energy security. The energy resources of the OCS, and specifically renewable energy sources, are particularly attractive options with significant resources located in close proximity to coastal population centers.

The experience, knowledge, and tools exist to ensure that offshore energy is developed in a comprehensive and environmentally sound manner. By obtaining stakeholder input (locally and nationally); compiling existing information and acquiring new data, where needed; conducting objective analyses using monitoring data to manage adaptively; and applying the necessary mitigations and safeguards along the way, we can achieve our national energy, economic, and environmental goals.

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## Introduction

In response to President Obama's vision for energy independence for our Nation, Secretary of the Interior Ken Salazar announced on February 10, 2009, a four-part strategy for developing a new, comprehensive approach to energy resources of the Outer Continental Shelf (OCS):

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The report's three main sections are: (1) renewable energy resources, (2) oil and gas resources, and (3) sensitive environmental areas and resources. They draw on information from technical reports and publications produced by DOI bureaus, other Federal Agencies, academia, and the private sector. This report serves as a first step in summarizing information and identifying data gaps that may need to be addressed to make future, informed decisions.

The information collated in this report regarding oil and gas resources has been drawn primarily from the 2006 report prepared by MMS, directed by the EPAct. Information on OCS renewable resources has been drawn from a variety of sources including data collected from the U.S. Department of Energy, the National Renewable Energy Laboratory, and other sources. Information on environmental issues was synthesized by MMS and USGS scientists based on the decades of research that has been conducted by MMS and USGS, as well as other Federal agencies, universities, private industry, and research institutions.

As this report indicates, there are a number of important gaps in available data relating to all of these issues. The report, compiled in 45 days, does not purport to present new information or fill in existing data gaps. The primary purpose of the report is to present a survey of available data on the OCS so that the public and interested stakeholders can participate more effectively, and with greater access to potentially relevant information, in the public meetings on OCS development.

# I. RENEWABLE ENERGY RESOURCES

## A. Introduction

### 1. Offshore Wind Power

As with land-based wind facilities, offshore facilities consist of a number of interlinked turbines operating independently and delivering power to onshore customers through an undersea cable. The positions of the turbines are selected to reduce cabling costs and to ensure that each turbine operates at peak efficiency by minimizing internal turbulence from adjacent turbines. Careful siting of turbines within a wind facility helps ensure that the facility as a whole operates with the highest possible efficiency, regardless of wind direction.

Offshore wind turbines look similar to those found onshore, but they may have several special design modifications to help adapt the structure to marine use so that its components can accommodate the more demanding climates and conditions of offshore locations. These modifications include structural upgrades to allow the tower to cope with the increased stress of wind-wave interactions, pressurized nacelles and environmental controls to help protect the gearbox and electrical components from corrosive sea air and salt water, and added access platforms for navigation and maintenance (Musial, 2007). Additionally, offshore turbines are typically equipped with corrosion protection, internal climate control, high-grade exterior paint, and built-in service cranes. They also typically have aerial and navigational warning lights and fog signals to alert ships in foul weather. To minimize expensive servicing, offshore turbines may have automatic greasing systems to lubricate bearings and blades, and preheating and cooling systems to maintain gear oil temperature within a narrow temperature range. Lightning protection systems minimize the risk of damage from strikes that occur frequently in some locations offshore. The major portion of the turbines and nacelles are painted light blue or gray to minimize their visual impact, especially at long distances.

The extreme requirements placed on tower foundations are important constraints on offshore wind development as well. The most common offshore technology is deployed in arrays that use monopiles—long, steel tubes that are hammered, drilled, or vibrated into the seabed until secure—at water depths of about 20-25 meters (m). This requires a special class of installation equipment for driving the pile into the seabed and lifting the turbine and tower into place. In the relatively shallow waters off the coasts of Europe, gravity foundations also have been used—concrete structures that rest on the seafloor and are stabilized against any overturning moments by their weight or additional ballast. Gravity foundations are less suitable for the deeper waters off U.S. coasts, and they also have a larger footprint which could increase or magnify environmental impacts. Both monopiles and gravity-based foundations may need to be protected against seafloor erosion, which is often accomplished by installing boulders, cement bags, grout bags, grass mattresses, or other erosion-control devices. Some companies also have begun demonstration projects with trusswork foundations, allowing for installation of turbines in water depths up to 45 m. Perhaps in the future, advanced floating platforms capable of supporting turbines in the ocean's deepest waters will allow access to offshore areas where vast wind resource potential exists.

To take advantage of the steadier and higher-velocity offshore winds and economies of scale, offshore wind turbines are also bigger than onshore turbines—a typical onshore turbine installed today has a tower height of about 80 m (260 feet [ft]) and blades about 40 m (130 ft) long. Most offshore wind turbines are larger in size and generating capacity, and new prototype designs are even bigger. Most offshore wind turbines today have power-generating capacities of between 2 and 5 megawatts (MW), with tower heights between 60 and 80 m (200 to 260 ft) and rotor diameters of 76 to 107 m (250 to 350 ft). RePower Systems (Figure I-1) recently installed two of the world's largest units with rotor diameters of 126 m and 5 MW capacity. RePower's Talisman Project also holds the record for installing wind turbines the furthest offshore—25 kilometers (km) [13.5 nautical miles (nm)] off the east coast of Scotland –and in the deepest waters to date (45-m water depth).[1]

Figure I-1. RePower Systems 5M, The World's Largest Wind Turbine (5-MW, 126m tall, 45m depth)

## 2. Offshore Wave Power

Wave energy devices are highly diverse, and a variety of technologies have been proposed to capture wave energy. The U.S. Department of Energy (DOE) recently created an online database solely dedicated to marine and hydrokinetic technologies, available at http://www1.eere.energy.gov/windandhydro/hydrokinetic/default.aspx. The current state of this industry can be compared to the early stages of the wind energy industry in that many concepts have been proposed with a wide variety of methods for energy capture and conversion; yet, it is difficult at this stage to make an accurate prediction of which technology or mix of technologies will be most prevalent in future commercialization (Musial, 2008). The technology to convert waves into electricity, although in its infancy, has been deployed in

[1] See http://www.repower.de/index.php?id=12&L=1 and http://www.beatricewind.co.uk/home/default.asp

demonstration projects around the world. Commercial-scale projects potentially could be developed in the next 5-10 years as the technologies advance (Bedard et al., 2008).

Ocean wave energy technologies are being developed in the United States and Europe. Perhaps the most advanced or mature example to date is the Pelamis Wave Energy Converter (Figure I-2). Pelamis Wave Power, Ltd.,[2] has built the world's first wave energy facility. It consists of three 750-kilowatt (kW) machines with a combined rating of 2.25 MW located 5 km (2.7 nm) off the coast of northern Portugal. Although wave power technologies are continuing to develop, there are four basic applications that could potentially be deployed on the Outer Continental Shelf (OCS): point absorbers, attenuators, overtopping devices, and terminators. These technologies vary in size, anchoring method, spacing, interconnection, array patterns, and water-depth limitations. Wave energy facilities would also require connection to a transformer as part of the synchronization with the onshore power grid. At this stage of development, large electrical service platforms similar to those for wind facilities are not envisioned, at least not within the next 5 to 7 years.

Figure I-2. The Pelamis Wave Energy Conversion (WEC) Device

## 3. Ocean Current and Tidal Power

Ocean current and tidal technologies are similar in nature in that they both deploy some type of submersible turbine to convert the kinetic flow of water into electricity. In the United States, no operating commercial systems using ocean current technology are connected to an electrical grid at this time. While tidal technologies have been tested and well-demonstrated in numerous locations around the world, current technology is at an early stage of development and may or may not be successful in the ocean environment. Engineering challenges faced by those adapting tidal technology to ocean currents include a lack of slack water, water depths of 300 to

[2] See http://www.pelamiswave.com/

500 m (985 to 1,640 ft), and relatively large distances from shore (20 to 25 km [11 to 13.5 nm]).

Today, two types of turbines—horizontal axis and vertical axis—are generally considered for ocean deployment. Energy can be extracted from the ocean currents and tides by using submerged turbines that are similar in function to wind turbines and capture energy through the processes of hydrodynamic, rather than aerodynamic, lift or drag. These turbines have rotor blades, a generator for converting the rotational energy into electricity, and a means for transporting the electrical current to shore for incorporation into the electrical grid. Although the rotors move at relatively slow speeds, they potentially can produce a significant amount of energy due to the density of water moving over them.

Figure I-3. Artists' Renditions of Current Energy Technology

## B. Overview of the MMS Offshore Renewable Energy Program

### 1. Overview

Section 388 of EPAct amended the OCSLA, giving the DOI discretionary authority to issue leases, easements, or rights-of-way for activities on the OCS that produce or support production, transportation, or transmission of energy from sources other than oil and gas, except where activities are already otherwise authorized in other applicable law. This authority was delegated to the MMS, which was charged with developing regulations intended to encourage orderly, safe, and environmentally responsible development of renewable energy resources and alternate use of facilities on the OCS.

The MMS has the lead role for developing wind energy on the OCS—leasing, exploration, development, production, and decommissioning. For hydrokinetic resources, the Federal Energy Regulatory Commission (FERC) is the lead for issuing licenses authorizing construction and operation of generating facilities. MMS's role for hydrokinetic resources is to provide appropriate input to FERC's licensing process and to issue necessary leases, easements, and rights of way.

Initial interest in offshore renewable energy (e.g., wind, wave, ocean current) in the United States has demonstrated the need for a clear regulatory process to authorize renewable energy development and generation on the Federal OCS. The OCS, as defined by the Federal Government, consists of the submerged lands, subsoil, and seabed, lying between the seaward extent of the States' jurisdiction and the seaward extent of Federal jurisdiction. Federal jurisdiction is defined under accepted principles of international law. Generally, the OCS begins 3-9 nautical miles from shore (depending on the State) and extends 200 nm outward, or farther if the continental shelf extends beyond 200 nm.

## 2. Energy Policy Act of 2005 (EPAct)

On August 8, 2005, the EPAct was signed into law, granting the Secretary of the Interior new responsibilities over Federal offshore renewable energy. Section 388 of the Act provided an initiative to facilitate increased renewable energy production on the OCS by giving the Secretary of the Interior the authority to:

- grant leases, easements, or rights-of way for renewable energy activities and energy-related uses on Federal OCS lands;
- act as a lead Agency for coordinating the permitting process with other Federal Agencies; and
- monitor and regulate those facilities used for renewable energy production.

The EPAct also stipulates that the MMS must issue renewable energy OCS leases on a competitive basis to ensure a fair return to the American public for the use of public lands. Under this new authority, the MMS also may issue leases, easements, or rights-of-way for other OCS project activities that make alternate use of existing OCS facilities for "energy-related purposes or for other authorized marine-related purposes," such as: offshore research, education, recreation, and support for offshore operations and facilities.

## 3. Programmatic Environmental Impact Statement

The MMS issued a Notice of Intent to prepare a Programmatic Environmental Impact Statement (PEIS) on May 5, 2006. The PEIS evaluates the potential environmental impacts associated with renewable energy project development, including all foreseeable activities related to project monitoring, testing, commercial development, operations, and eventual decommissioning in Federal waters. Following a series of scoping hearings, the draft PEIS was published on March 21, 2007, for public comment, and MMS held a number of hearings on the draft EIS in various cities around the country.

The final PEIS was issued in November 2007, and MMS completed a subsequent Record of Decision (ROD) in January 2008. The ROD served to officially establish the MMS Offshore

Renewable Energy Program and included the adoption of 52 Best Management Practices (BMPs) and policies to guide project consideration in the future (for example, minimizing seafloor disturbance during installation and construction activities).[3] The BMPs would be considered as part of the review for any project proposed under MMS' renewable energy authority and would establish minimum requirements for projects through individual lease stipulations and/or mitigation measures applied at the project level. The PEIS will remain a useful tool as the MMS uses its expert analysis and conclusions in subsequent renewable energy project National Environmental Policy Act (NEPA) reviews.

## 4. Rulemaking

The MMS published an Advance Notice of Proposed Rulemaking, asking for comments regarding energy development from resources other than oil and gas on the OCS. In July 2008, MMS published the "Proposed Rule for Alternative Energy and Alternate Use of Existing Facilities on the OCS". A final rule was not issued prior to the change in Administration. The new Administration is expected to release a final rule to establish a clear and comprehensive regulatory roadmap for the development of offshore renewable energy and is intended to provide a "beginning-to-end" approach to authorizing offshore renewable energy projects.

## 5. The Interim Policy

On November 6, 2007, the MMS announced in the Federal Register an Interim Policy for authorization of the installation of offshore data collection and technology-testing facilities in Federal waters. The MMS accepted comments and nominations until January 7, 2008 regarding the authorization of OCS activities involving the installation of meteorological or marine data collection facilities to assess renewable energy resource potential (e.g., wind, wave, and ocean current) or to test renewable energy technology.

The Interim Policy was developed as a measure to initiate resource data collection and technology-testing activities on the OCS in advance of the final regulations. Following the announcement in November 2007, MMS received more than 40 nominations of areas proposed for limited leasing off the west and east coasts of the United States. The nominations expressed interest in resource assessment activities related to wind, wave, and ocean current resource potential. An Interim Policy lease has a term of 5 years and, if awarded prior to the publication of the final rule, is honored for the life of the lease term. However, once the regulations are published in their final form, MMS will not entertain new projects under the Interim Policy.

In April 2008, the MMS identified a subset of 16 proposed lease areas for priority consideration. It provided public notice of those areas for the purpose of determining competitive interest as required by the EPAct and also for receiving relevant environmental or other information. The MMS released for review on December 14, 2007 a draft lease form to

[3] Best Management Practices can be viewed in the PEIS Record of Decision, available at http://www.ocsenergy.anl.gov/documents/docs/OCS_PEIS_ROD.PDF.

collect information pertaining to the limited leasing of submerged lands on the OCS for renewable energy activities under the Interim Policy. The revised lease form and information collection notice was published in the Federal Register on April 21, 2008. This lease form will be used to enter into a leasing agreement between MMS and a lessee, and for the lessee to conduct resource data collection and/or technology testing on the OCS in support of renewable energy activities.

Sections below describe the status of priority-leasing projects under the Interim Policy as of February 2009. To view maps of the proposed Interim Policy lease areas, please visit http://www.mms.gov/offshore/alternativeenergy/InitialInterimPolicyProposedProject.htm.

### a. Interim Policy Projects: Wind

The 10 priority lease areas in the North Atlantic (six offshore New Jersey, one offshore Delaware, and three offshore Georgia) proposed for site-assessment activities (i.e., siting of meteorological towers) relating to wind resources drew no competing nominations and no significant comment in response to the April 2008 notice. In July 2008, MMS announced it would proceed with a noncompetitive leasing process for these sites. As of January 2009, MMS received applications from the nominating developers for four of the six sites offshore New Jersey and one application for the site offshore Delaware.

### b. Interim Policy Projects: Ocean Wave

Two priority lease areas offshore Northern California (Humboldt and Mendocino Counties) were proposed for site assessment and technology testing relating to wave resources. Neither site drew new competing nominations in response to the April 2008 notice. However, based on two original overlapping nominations in the Humboldt area from the initial Call for Nominations in November 2007, MMS determined that there was competitive interest in that proposed lease area. For the Mendocino area, MMS decided to proceed in July 2008 with a noncompetitive leasing process, working with the applicant and local stakeholders to refine the area and scope of proposed activities and to address other local concerns. For the Humboldt area, MMS decided to ask the competing nominators to consider collaborating. If they had agreed to collaborate, the MMS would have proceeded with a noncompetitive leasing process as in the Mendocino area. However, during this process, one of the two applicants withdrew its nomination, leaving only a single area offshore Humboldt County open for consideration under the Interim Policy. In February 2009, the remaining applicant also withdrew its nomination, leaving no further leasing areas under consideration on the west coast under the Interim Policy.

### c. Interim Policy Projects: Ocean Current

Four priority lease areas offshore southeast Florida were proposed for site assessment and/or technology testing activities relating to ocean current power. Three of these four lease areas received competing nominations. The MMS decided in July 2008 to proceed with a noncompetitive leasing process for the sole site that did not receive competing nominations. The competing nominators for the other areas were asked to consider collaborating to enable interested parties to jointly benefit in information gathering under leases issued noncompetitively. Three of the developers that nominated sites withdrew their nominations. As of February 2009, MMS has received a single application for one of the remaining proposed priority lease areas and has begun the environmental compliance review process for this lease area.

## C. Estimated Renewable Energy Offshore Resource

While the United States continues to fulfill a vast majority of its energy needs (including electric power generation and transportation) from fossil fuels, policymakers are looking for ways to address economic, environmental, and energy security. Ocean energy is an available renewable energy option for the United States as significant wind, wave, tidal, and current resources exist in close proximity to coastal population centers—areas where the majority of the Nation's electricity demand is located.

This section (Section I.C.1) highlights the United States' potential ocean energy resource availability. Regional resource estimates (Atlantic, Gulf, Pacific, and Alaska) are given in Section I.C.2. Estimates are based on existing and available data and analysis and, thus, vary in their level of detail and completeness. Estimating the *potential* of a given resource is fairly straightforward; however, there is a high degree of uncertainty in estimating the amount of renewable energy that is *extractable* or *developable* given the many uncertainties in societal preferences, technological developments, environmental sensitivities, transmission capacity, grid connection availability, and potential space-use conflicts in the ocean environment.

Additionally, while certain geographic locations may possess economically developable resources and adequate transmission and grid capacity, the degree to which coastal states will embrace offshore renewable energy also must be considered. Section I-C.2 details some of the initiatives that certain coastal States have begun in an effort to encourage development of renewable resources in State and Federal waters. Though many caveats and uncertainties about ocean energy development and technology exist at present, marine renewables do have the *potential* to contribute a significant amount of the Nation's electricity needs in the future (Figure I-4).

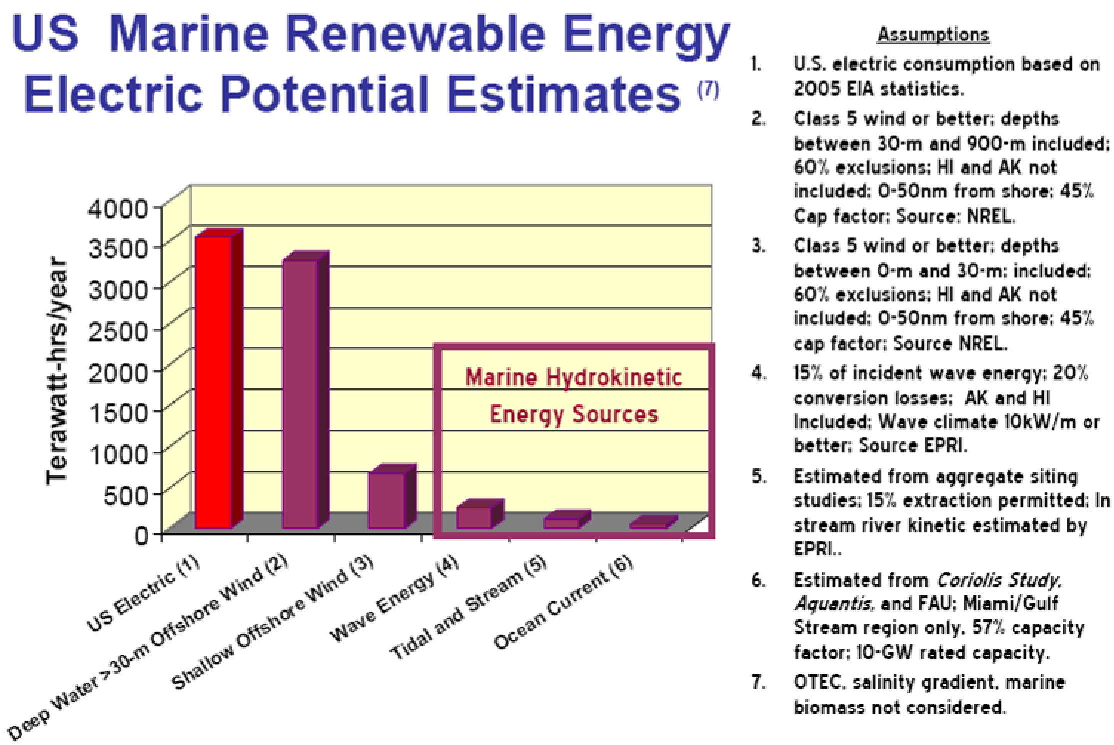



Figure I-4. U.S. Marine Renewable Energy Potential (Source: Musial, 2008a)

## 1. Renewable Energy Resources

### a. Offshore Wind Power

#### (1) Background:

Currently, offshore wind power is the only ocean-based commercially-available renewable energy source that is large enough to become a significant fraction of the electric supply (Kempton et al., 2005). During the past two decades, land-based wind energy has seen a significant reduction in cost, making it competitive with other sources of electric power generation in many areas of the United States (Musial, 2007). The current installed capital cost of offshore projects is higher compared to land-based wind installations, but this has potential to decline as the offshore industry becomes more mature (Black and Veatch, 2007; Pace Global, 2007).

While the United States has yet to install any wind turbines offshore, it now leads the world in land-based installed capacity. According to the American Wind Energy Association (AWEA), 35 states account for over 25,170 MW installed capacity (with another 4, 451 MW currently under construction).[4] Though offshore wind power has higher installation and maintenance

[4] See http://www.awea.org/projects/ for a map and listing of all U.S. current installed capacity.

costs compared to land-based sites,[5] offshore winds are typically stronger and more consistent than on land, and land-based resources are often far from high demand centers. In contrast, the offshore wind resource is frequently located near major coastal cities with extremely high energy demands. Figure I-5 shows nighttime electricity use is concentrated mainly along coastal areas where the majority of the U.S. population resides—one reason why ocean energy of all types may be a viable option for states looking to diversify their energy portfolio and reduce their reliance on traditional sources of power generation. Of the 48 contiguous States, 28 have a coastal boundary (including the Great Lakes), and electric use data show that these coastal states use 78 percent of the Nation's electricity (DOE, 2008c; EIA, 2006).

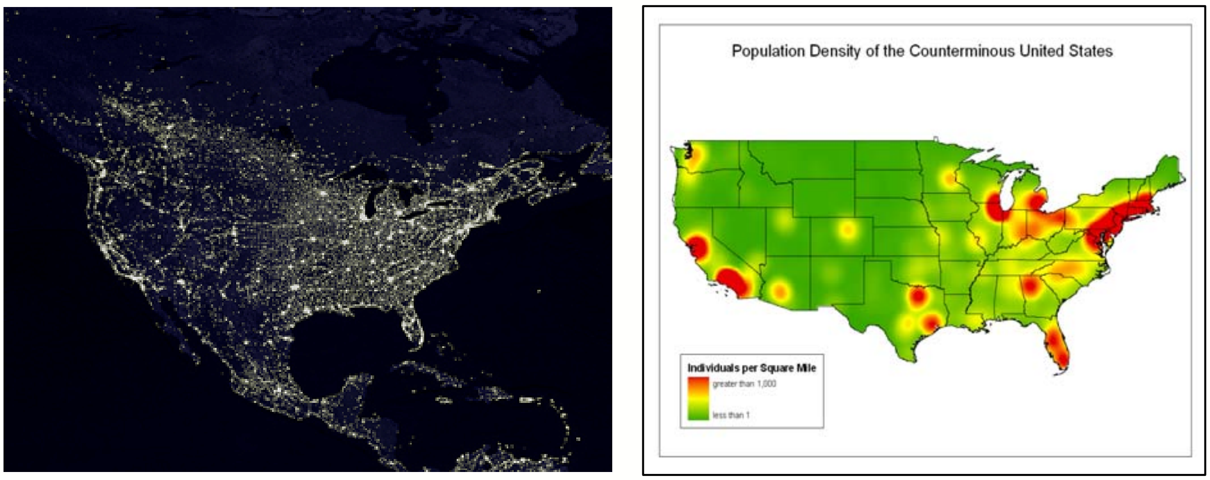



**Figure I-5.** U.S. Night Time Electricity Use is Concentrated Along Coastal Areas

Today, offshore wind may be able to compete in niche U.S. markets with help from production tax credits (PTC) and other incentives, such as State renewable portfolio standards (RPS), State-sponsored system benefit funds, pollution control incentives, or other State-sponsored incentives (Musial, 2007). Following is a list of the current primary economic and technical feasibility determinants that can affect the choice of sites for offshore wind facilities:

- Availability of a substantial, relatively constant wind resource;
- Shallow water, typically less than 30 m deep;
- Proximity to an area of high electricity consumption;
- Onshore infrastructure and electric grid capacity; and
- Distance to shore

No offshore commercial wind facilities operate in U.S. waters today, though there are a number of proposals under consideration and in different stages of Federal and/or State regulatory

[5] Installation cost typically increase as one moves further offshore and into deeper waters.

review. There are a number of reasons for the lack of development, including past regulatory challenges, high and uncertain project costs, public opposition, technology constraints, and supply shortages, among others.

In recent years, interest in developing offshore wind energy in U.S. waters has continued to increase. European developers have clearly demonstrated the viability and technical feasibility of commercial-scale offshore facilities (Figure I-6 shows the world's second largest offshore wind facility—72 turbines and 166 MW total capacity—operating off the coast of Denmark). The continued interest in the offshore sector is evidenced by the over 2,000 MW of offshore wind projects currently proposed in the United States, primarily located off the shores of Texas, New Jersey, Massachusetts, Rhode Island, and Delaware. With continued advancements in wind turbine technology, clearer regulatory pathways, financial incentives, and strong interest from coastal states, offshore wind power has the potential to make a long-term impact in the U.S. energy mix.

**Figure I-6.** Nysted Wind Farm, 14-20 kilometers (km) offshore Denmark, the North Sea (Source: DONG Energy[6])

### (2) U.S. Offshore Wind Energy Resource Potential

The United States appears to have substantial offshore wind energy resource potential based upon recent mapping efforts, time series data from ocean buoys and measurement stations, and estimates of wind speed and power derived from satellite instruments (Elliot and Schwartz, 2006). Figure I-7 shows the U.S. Department of Energy's (DOE) National Renewable Energy Laboratory (NREL) wind speed map for the entire United States, including coastal areas.[7] Wind speeds are categorized into seven different wind power classes and shown in different colors on the map. Data show that wind speeds, and thus energy potential, are highest in the Midwest plains and in the offshore waters.

[6] See http://www.hornsrev.dk/Engelsk/default_ie.htm
[7] See http://www.windpoweringamerica.gov/wind_maps.asp

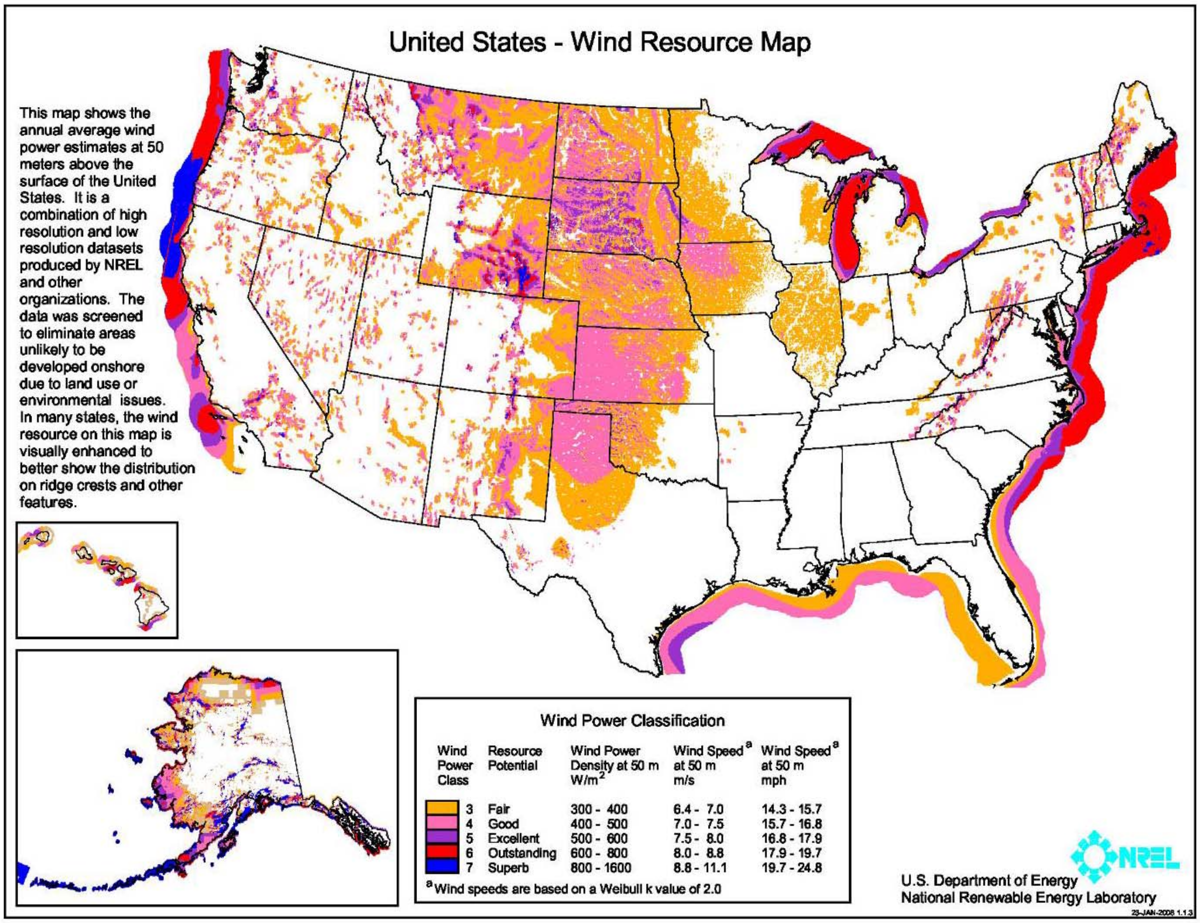



Figure I-7. United States Wind Resource Map (Source: NREL)

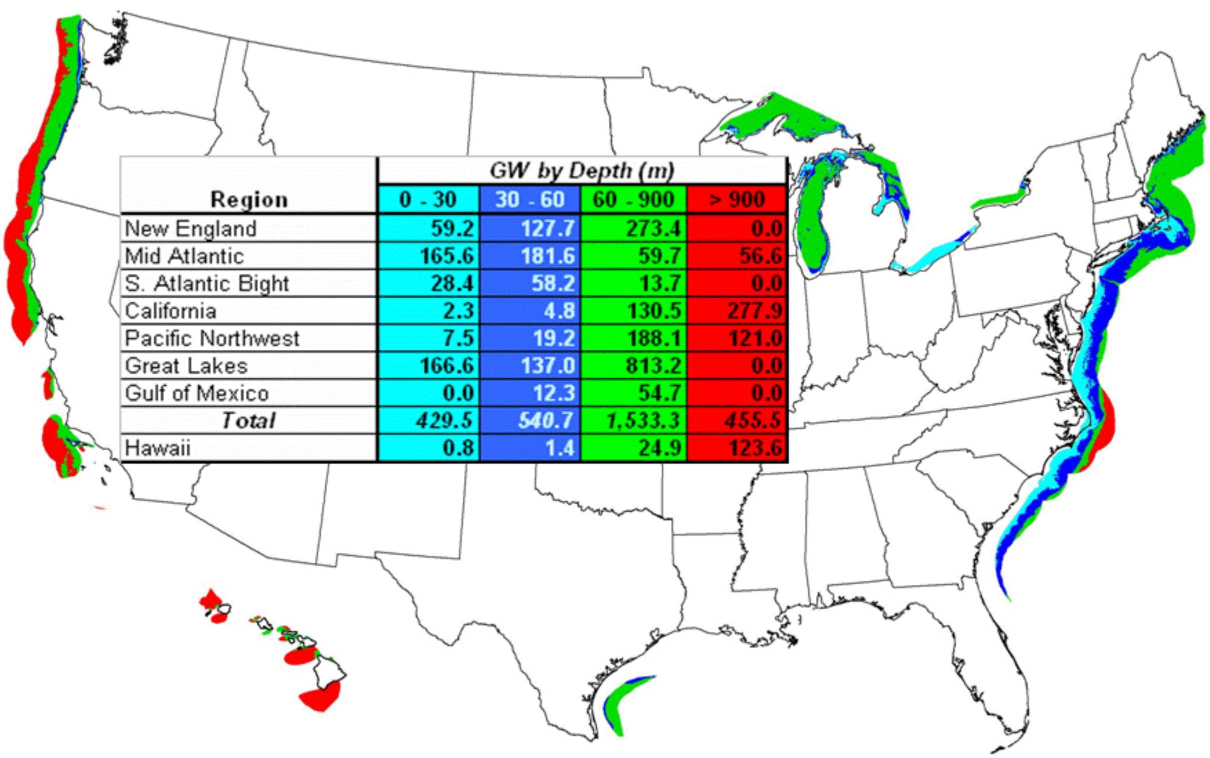
Site-specific offshore wind resource estimates have been performed for various parts of the United States, including the Mid-Atlantic Bight (Kempton et al., 2007), Georgia (Elliott and Schwartz, 2006), and California (Musial and Butterfield, 2004; Dvorak et al., 2007). The NREL has started a program to produce validated wind resource maps for priority offshore regions of the United States. These maps will estimate the U.S. wind resource potential out to 50 nm and are scheduled to be completed over a period of several years.[8] The NREL's most recent estimates (see Musial, 2007) fill in many of the gaps that were present in earlier studies, and include all the wind resource in the 48 contiguous States and Hawaii.[9] The wind energy resource potential estimates are generated from meso-scale wind models, and the parameters of the study include potential installed capacity, bathymetry, distance from shore, and wind

[8] Preliminary offshore wind resource maps are produced by AWS Truewind using its proprietary MesoMap system. See http://www.awstruewind.com/

[9] NREL anticipates publishing updated offshore wind resource estimates in 2009.

class.[10] Geographic Information System (GIS) technology was used to combine each parameter and derive state and regional estimates of offshore wind potential.

Figure I-8 shows the NREL's estimated available resource for Class 5 winds or greater by region and water depth. Because higher wind regimes are required for offshore development to achieve favorable economics, Class 5 winds were chosen as the offshore resource cutoff, although lower wind regimes may be economically viable in some energy-constrained coastal areas. The NREL estimates the gross power potential from U.S. offshore wind to be 2,970 GW (or 9,105 TWh/y, assuming 35-percent capacity factor of wind turbines).[11] The estimates are aggregated further in Table I-1. It is important to show these estimates by water depth because development in deeper waters is currently challenged by technology constraints. Also, the gross estimates do not accurately reflect the amount of energy that is realistically developable or extractable. One must take into account that certain areas cannot be developed due to other uses of the ocean. Thus, the NREL suggests about 40-percent of their gross estimate would reflect a more accurate picture of the actual developable wind resource.



| Region | GW by Depth (m) | | | |
|---|---|---|---|---|
| | 0 - 30 | 30 - 60 | 60 - 900 | > 900 |
| New England | 59.2 | 127.7 | 273.4 | 0.0 |
| Mid Atlantic | 165.6 | 181.6 | 59.7 | 56.6 |
| S. Atlantic Bight | 28.4 | 58.2 | 13.7 | 0.0 |
| California | 2.3 | 4.8 | 130.5 | 277.9 |
| Pacific Northwest | 7.5 | 19.2 | 188.1 | 121.0 |
| Great Lakes | 166.6 | 137.0 | 813.2 | 0.0 |
| Gulf of Mexico | 0.0 | 12.3 | 54.7 | 0.0 |
| ***Total*** | ***429.5*** | ***540.7*** | ***1,533.3*** | ***455.5*** |
| Hawaii | 0.8 | 1.4 | 24.9 | 123.6 |

**Figure I-8.** Estimated Gross Offshore Wind Resource (Source: NREL)

[10] Unlike some of the studies cited earlier (Kempton et al., 2007; Dvorak et al., 2007), the NREL studies do not include an exclusionary factor in their derivation of potential resource. Instead, they present gross resource estimates that do not account for other competing uses of the ocean that may conflict with offshore wind development.

[11] This estimate includes potential in the Great Lakes. Excluding the Great Lakes, potential power is estimated at 1993 GW, or 6110 TWh/y.

Table I-1. Estimated Gross Wind Resource by Region in Gigawatts (GW) (Source: Based upon data obtained from NREL)

| Region | Shallow Waters* | Deeper Waters** | Total |
|---|---|---|---|
| Atlantic | 253.2 GW | 770.9 GW | 1024 GW |
| Pacific | 10.6 GW | 891.4 GW | 902 GW |
| Gulf | 0 GW | 67 GW | 67 GW |

*Classified here as 0-to 30-m depth. This likely would be economically and technologically feasible today.
**Classified here as >30-m depth. This likely would not be feasible today given the current state of technology and the increased costs of installation in deeper waters far from the coast.

#### (3) Information Gaps in Resource Assessment

As noted above, great strides are being taken to map the wind resource in U.S. waters. To date there is no comprehensive evaluation of the available wind resource potential in all State and Federal waters (i.e., out to 200 miles). As technology makes it possible to develop further offshore, there will be increased demand and need to evaluate the wind potential in those areas. While validated wind resource maps can help to identify areas of greatest potential along the U.S. coastline, it is the responsibility of the individual developer to examine the wind regime at a specific location in order to determine its true viability for commercial-scale development. Typically, developers will install offshore meteorological towers that gather precise wind speed data for a minimum of 2 to 3 years.

### b. Offshore Wave Power

#### (1) Background

Ocean waves represent a potential form of renewable energy created by wind passing over open water. Ocean waves are generated by the influence of the wind on the ocean's surface. Wind first causes small ripples over the ocean's surface boundary layer, and as the wind continues to blow, the ripples progress into chop, fully developed seas, and ultimately ocean swells. In deep water, the energy in waves can travel for thousands of miles until it is dissipated on distant shores.

#### (2) U.S. Offshore Wave Energy Resource Potential

Generally, wave energy increases with latitude and has greater potential on the west coast of the United States because global winds tend to move west to east across the Pacific Ocean (Musial, 2008b). The total energy contained in the waves is dependent on the linear length of wave crest, the wave height, and the wave period. Figure I-9 presents a broad picture of the average annual wave power across the world's oceans.

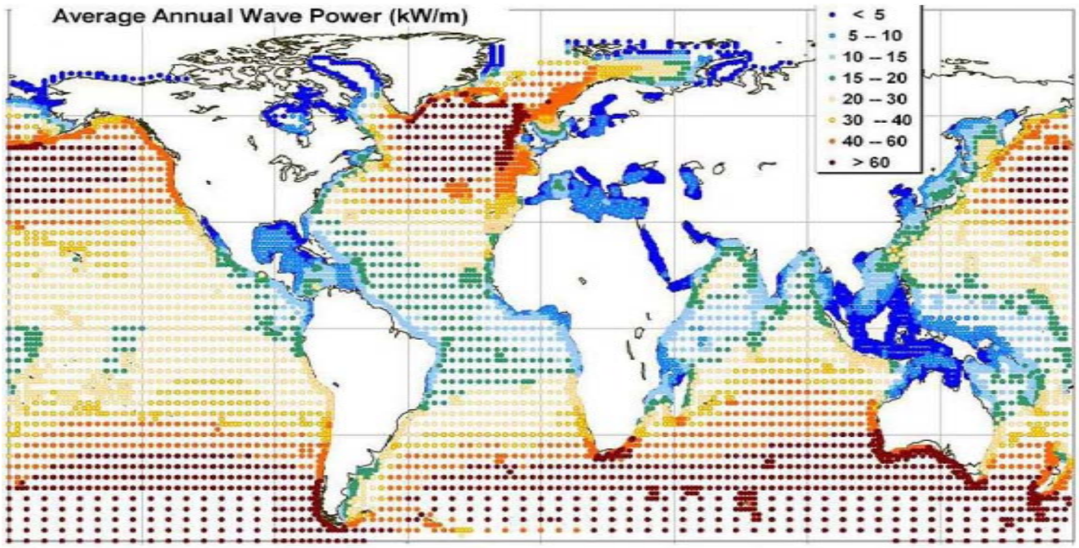



Figure I-9. Average Annual Wave Power (Source: European Centre for Medium-Range Weather Forecasts)

Using decades of wave height and period measurements from the National Oceanic and Atmospheric Administration (NOAA) and Scripps Institute of Oceanography ocean data buoys, the Electric Power Research Institute (EPRI) has made preliminary estimates of the U.S. potential wave energy resource,[12] and the methods for calculation are well documented (Bedard, 2008; Hagerman, 2001; Hagerman et al., 1989; Hagerman, 1992; Kane, 2005). The EPRI estimates a significant resource—about 2,100 terawatt hours per year (TWh/y)—of gross wave energy potential along the U.S. coastline, with over 75-percent of the available wave energy potential located in the waters off Alaska and Hawaii (Figure I-10).[13] From that gross total, EPRI estimates about 255 TWh/yr could realistically be harnessed.[14] These estimates are only preliminary, and they have yet to be validated, but they are the best estimates that exist to date. It is especially difficult to predict with confidence the amount of available wave energy that can be extracted from the overall potential given the uncertainties in technology, environmental impacts, and space-use conflicts. To help fill this information gap, EPRI currently is under contract with the DOE for a comprehensive 2-year study to determine the actual available and extractable wave resource estimate. The final product will include a geospatial database that displays wave power densities for specific GIS coordinates and data that are needed by developers to estimate the annual and monthly energy yield of their devices and projects.

[12] See EPRI WP-001 "Wave Energy Resource Assessment and Power Production Methodology" available at www.epri.com/oceanenergy

[13] Coastal areas with wave resources below 10 kilowatts per meter were not included in the estimates. This estimate also excludes the Bering Sea.

[14] The calculations assume an extraction of 15-percent wave to mechanical energy (which is limited by device design, spacing, and environmental and space-use constraints), typical power train efficiencies of 80 percent, and a plant availability of 90 percent.

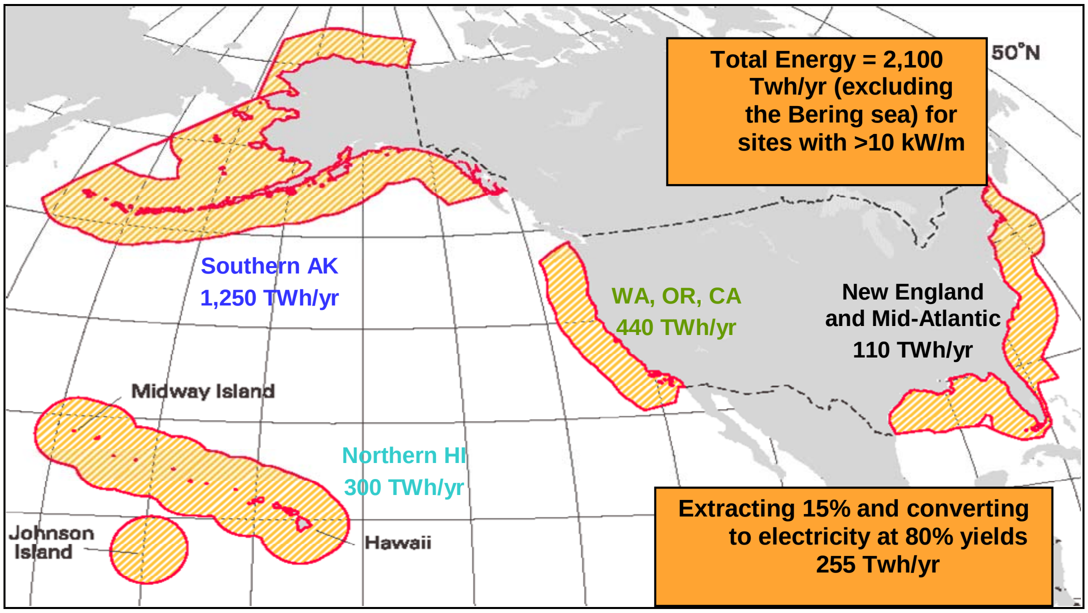



Figure I-10. Estimated Wave Power Potential by Region (Source: EPRI)

Given the current state of technology, the proximity to dense population and high-energy load centers, and initial interest by select States, wave power is most likely to be deployed along the Pacific Northwest or off the coast of Hawaii, at least in the short term. Although no full-scale wave energy projects are operational, several proposed commercial-scale and demonstration projects are in the initial permitting or demonstration phases in Oregon, Washington, and Hawaii, mostly in state waters. Internationally, wave energy projects are operating on a small scale or are in development in Portugal, Japan, the United Kingdom, and Australia.

### (3) Information Gaps in Resource Assessment

Today, significant information gaps exist in terms of resource assessment, siting, and research and development. Each is described briefly below. In general, these same challenges may apply to offshore ocean current power as well.

***Resource Assessment:*** The potential U.S. wave energy resource is reasonably well-understood, but there is a high degree of uncertainty in estimating the actual extractable amount of energy. Gaps in our understanding of the wave resource do exist: resource assessment methods are less developed compared to wind technologies; resource assessments are incomplete; and the potential for energy extraction is highly dependent upon the device type (Musial, 2008a). Possible solutions to help fill these data gaps include establishing uniform methods and conducting detailed assessments of the ocean energy resources, identifying the most appropriate areas for commercial development, and determining the extractable energy potential for the most promising and mature devices (ibid). The assessment of U.S. wave energy resources currently underway by EPRI should certainly help to provide quality data and analysis to inform decision making. Though nationwide or regional estimates are useful for planning purposes, ultimately it will be up to the individual developer to invest time and resources in studying the viability of energy extraction at a specific site.

***Marine Environment and Siting:*** Understanding how these new technologies will affect the marine environment is a key component in determining appropriate siting and effective regulation. Ocean wave (and ocean current) technologies are new, unproven (on a commercial scale), and their cumulative environmental impacts are unknown at this time, mainly due to a lack of projects operating in the ocean environment for significant periods of time. An added challenge faced by developers of offshore wave power is that these devices are space-use intensive and thus have a greater potential to exclude other uses of the ocean. This is in contrast to offshore wind facilities, for example, that can more easily accommodate multiple uses like commercial and recreational fishing due to the large spacing requirements between turbines. Launching initial pilot and demonstration projects in coastal waters should help to fill these knowledge gaps, and establishing monitoring protocols for early projects, as well as assessing the ecological risks associated with different technology types, will help regulators understand the impacts that accompany commercial deployment. This also will provide an opportunity to establish proper mitigation strategies early on.

The MMS is continuing to work with stakeholders from State, Federal, and local agencies as well as nongovernmental organizations on various siting issues. Currently the MMS is working with the DOE and the Federal Energy Regulatory Commission (FERC) in an international effort to study the environmental effects of various renewable ocean energy technologies. The effort, part of the International Energy Administration's (IEA) Ocean Energy Systems Implementing Agreement,[15] will be a 3-year study resulting in a publicly available, searchable database that highlights case studies from around the world and focuses specifically on environmental impacts, monitoring efforts, and lessons learned. The primary objective of this internationally-based study is to provide members of the public, developers, and government regulators a central depository of literature and analyses that can be used to make informed decisions.

***Research and Development***: Wave technologies face research and development (R&D) challenges as well (Scruggs and Jacob, 2009). Because of this field's nascent stage of development, dozens of companies are trying to develop and deploy a host of different prototypes, with no convergence of technology in sight for the short term. A major challenge is the lack of standards and protocols for technical evaluation and design, and the substantial economic cost of deploying full-scale prototypes.

One solution is to form partnerships to establish R&D programs that could provide long term fundamental technology leadership, funding, and facilities needed to accelerate innovation and spur industry growth. New laboratories, field test facilities, design tools and standards, and collaboration with international partners to gain collective experience would help to bridge these gaps. The Wave Hub Project, off the southwest coast of the United Kingdom, is a good example of such a long term R&D project;[16] it is the first offshore facility for demonstration and technology testing of wave energy generation devices (Figure I-11).

[15] See http://www.iea-oceans.org/
[16] See http://www.wavehub.co.uk/

Ocean wave energy technologies are being actively developed in Europe and the United States (Oregon, Washington, and Hawaii, in particular). The Government of Scotland recently launched a grant program for wave technology development and established the European Marine Energy Centre (EMEC). Located in the Orkney Islands north of Scotland, it will serve as a test facility for wave energy and tidal energy technologies and maintains meteorological and oceanographic monitoring centers and test berths to deploy prototype technologies. In the United States, the Oregon State University and the University of Washington recently were awarded a DOE grant to co-establish the Northwest National Marine Renewable Energy Center. The Center will establish a full range of capabilities to support wave and tidal energy, including: device commercialization, informing regulatory and policy decisions, and filling key gaps in technical and environmental understanding. Hawaii also has been active in researching wave power, and was the first state to host the installation of an electricity-generating prototype in State waters.[17] The University of Hawaii also recently was awarded a DOE grant to establish the National Renewable Marine Energy Center. Further development of research facilities will be necessary before data and information gaps related to wave energy can be filled.

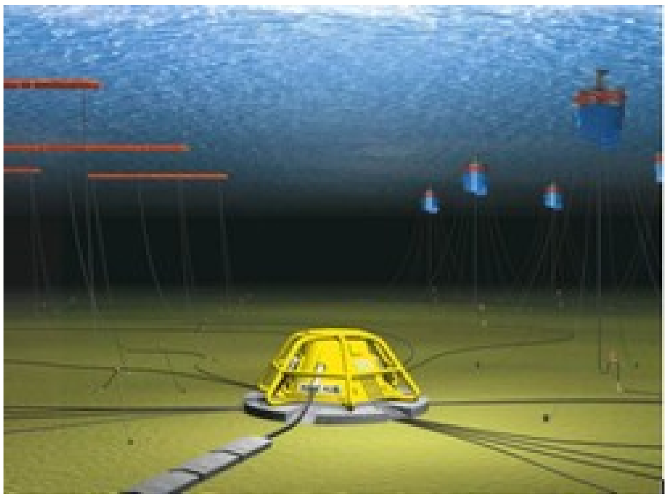


Figure I-11. Artist's Rendition of Wave Hub Research and Testing Facility

### c. Tidal and Ocean Current Power

#### (1) Background

***Tidal:*** Tidal currents ebb and flow on a prescribed time schedule and are controlled by the gravitational pull of the Moon and the Sun on the Earth's oceans. Tidal currents are strongest along ocean beaches, bays, inlets, and estuaries—locations typically within State waters and,

[17] Ocean Power Technology's (OPT) 40-kW Powerbuoy wave system was installed offshore a U.S. Marine Corps' base near Oahu, Hawai in 2004, and since that time period OPT has been conducting technology testing and environmental assessment. See OPT's site at http://www.oceanpowertechnologies.com/index.htm.

thus, outside of the Federal offshore jurisdiction. Places where water movement is constricted (i.e., between channels or small island chains) can show extreme tidal fluctuations, and these could be prime areas for tidal power development. Figure I-12 shows the mean tidal averages for the world's oceans, with the southeastern portion of Alaska showing the highest fluctuations in the United States. Tides are also different from wind, wave, and coastal ocean currents in that they can be accurately predicted years into the future, whereas predictions of wind and waves rely on less predictable weather forecasting (Bedard et al., 2007).

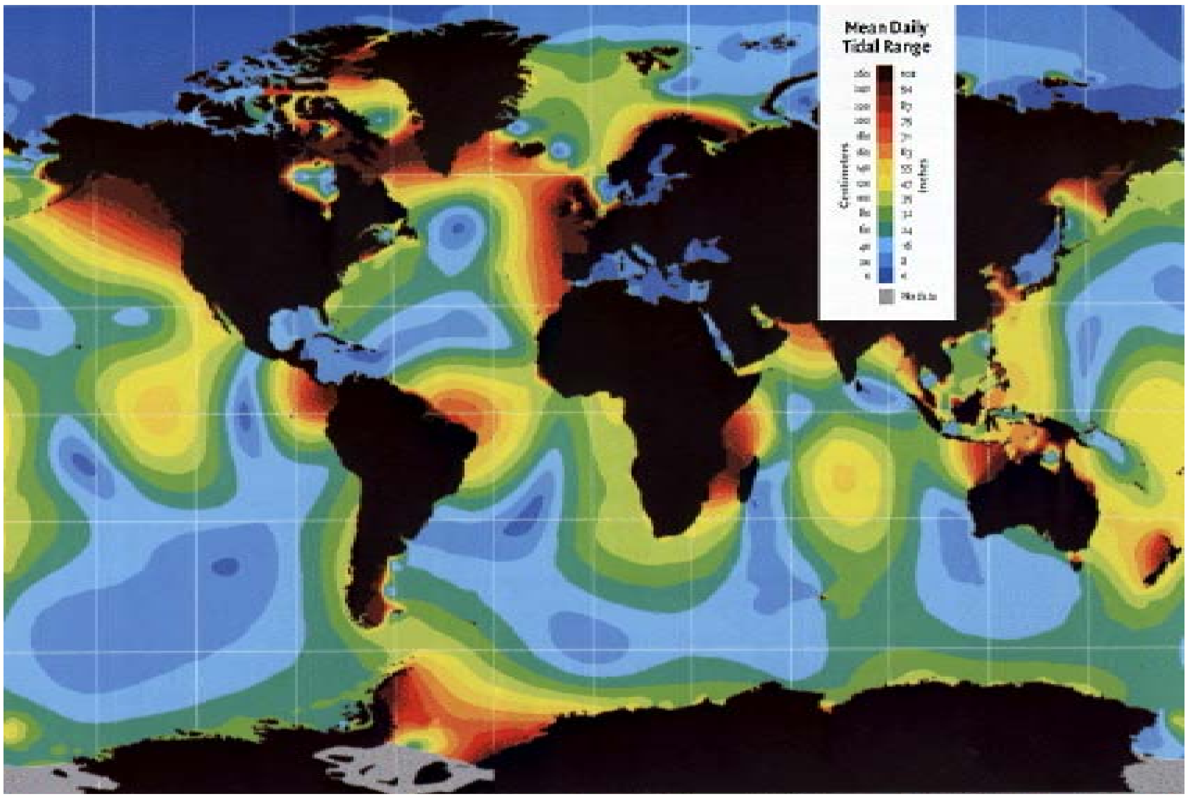



Figure I-12. World Map of Mean Tidal Range (Source: Musial, 2008a)

***Ocean Current:*** Ocean current energy is the kinetic and potential energy available from moving water of marine currents. Currents are primarily driven by wind, solar heating of ocean waters, and tidal forces, although some ocean currents result solely from variations in water density and salinity. Global circulation patterns result in currents that may shift seasonally in strength and location, but are relatively constant and typically flow in one direction. In contrast, tidal currents are more variable in strength and direction.

Some of the better-known ocean currents off the United States are the Gulf Stream, the Florida Straits Current, and the California Current (see Figure I-13 for common currents and their relative velocities). The Florida Straits Current flows only 8 km offshore in the southern part of Florida, close to Miami, and sustains relatively large speeds over significant distances in relatively unchanging patterns. In contrast, the California Current has relatively slow speeds and shifts periodically. Ocean current speeds are generally lower than wind speeds, but water is about 835 times denser than wind, so the energy contained in a 12-mile per hour (mph) water flow is equivalent to that contained in an air mass moving at about 110 mph. Because of this physical property, ocean and tidal currents represent a potentially significant, yet currently untapped, reservoir of energy.

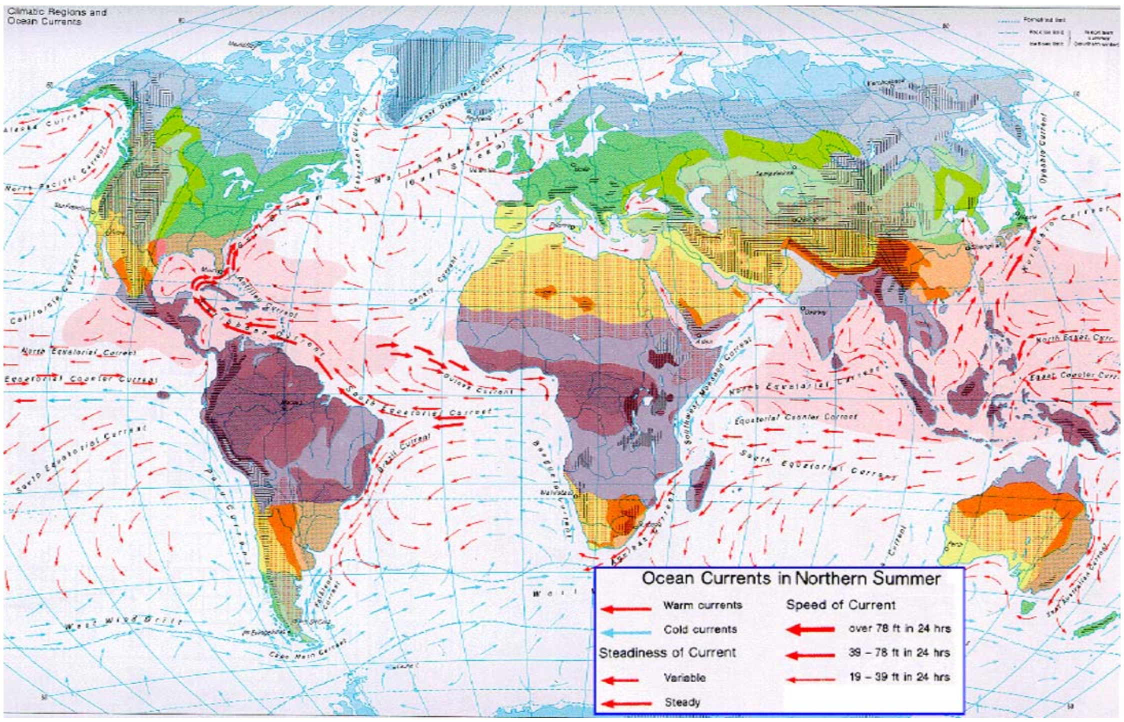



Figure I-13. World Map of Ocean Currents (Source: Hagerman, 2008)

### (2) U.S. Ocean Current and Tidal Energy Resource Potential

***Ocean Current:*** Relative to the resources discussed thus far (i.e., wind, wave, and tidal), the energy resource potential for ocean current power is the least understood, and its technology is the least mature. For this reason, limited information is presented here. The total worldwide power in ocean currents has been estimated to be about 5,000 GW, with power densities up to 15 $kW/m^2$. According to early estimates by Isaacs and Schmitt (1980), the actual extractable energy worldwide may be in the order of 100 to 300 GW (876 to 2,628 TWh/y). To date, there is no estimate of the total potential current energy resource in U.S. Federal or State waters. Estimates will be refined as more data is collected about the world's ocean current resources and as current energy technologies advance.

Analysis to date shows the best location to harness ocean currents in the United States is in the Gulf Stream off the coast of southeast Florida (Bedard et al., 2007; Florida Atlantic University, 2009). The Gulf Stream flows northward past the southern and eastern shores of Florida, funneling through the Florida Straits, and stretches from the Gulf of Mexico up the East Coast of the United States. It departs from North America just south of the Chesapeake Bay, and heads across the Atlantic to the British Isles. In Figure I-14, the core of the Gulf Stream is apparent as the warmest water, dark red, departing from the coast at Cape Hatteras, North Carolina. Even though the Gulf Stream current cools as its water travels thousands of miles into higher latitudes, it remains strong enough to moderate the Northern European climate.

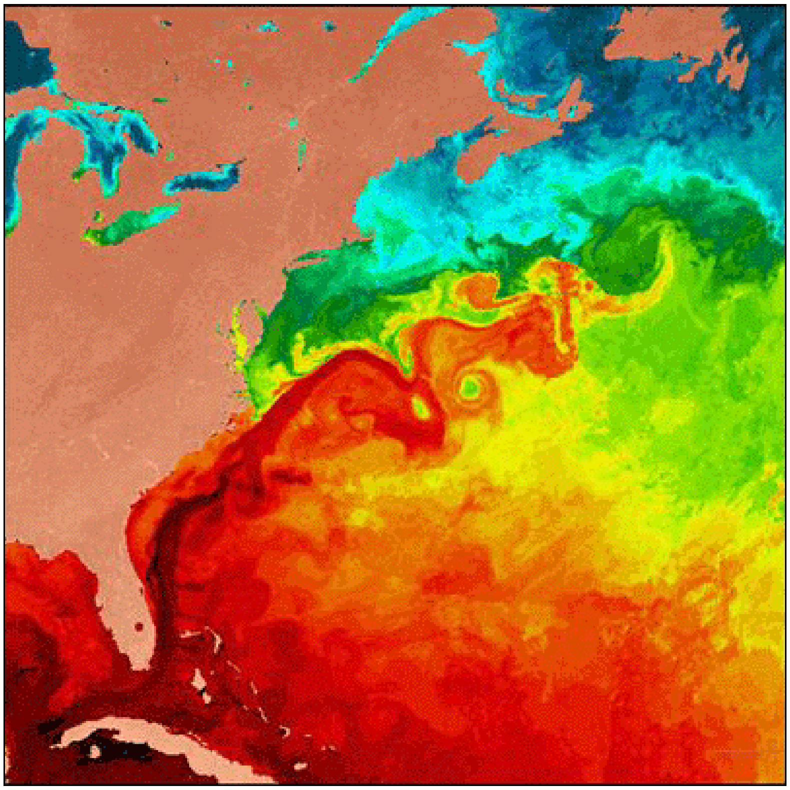


Figure I-14. Sea Surface Temperatures Show the Gulf Stream Current (Source: NOAA)

***Tidal:*** Tidal energy resources are not as well understood as wind and wave energy resources in the United States (Bedard et al., 2007). The development of tidal energy technology is moving much quicker than the development of marine current technologies, mostly because tidal resources are located in shallow, nearshore waters, and thus are much more accessible. High energy sites typically occur close to shore (outside of MMS jurisdiction) in narrow passageways between the ocean and large estuaries or bays. The methodology for estimating the available tidal resource for a single transect location is described in EPRI Report TP 001.[18]

The EPRI has studied many potential U.S. tidal energy sites through various resource evaluation and feasibility studies.[19] For those sites examined thus far, EPRI estimates a potential tidal energy resource of 115 TWh/y. These numbers are expected to change as additional analysis is conducted. The EPRI's estimates show that Alaska holds over 90-percent

[18] EPRI TP-001 "Tidal In-Stream Energy Resource Assessment and Power Production Methodology" available at www.epri.com/oceanenergy/

[19] These can be accessed at http://oceanenergy.epri.com/default.asp

of the total U.S. resource at 106 TWh/y. Sites with extremely high power density and large surface area exist in southeast Alaska, Cook Inlet, and the Aleutian Islands. While some of the resource may fall in Federal waters (such as portions of Cook Inlet), analysis is incomplete at this time.

#### (3) Information Gaps in Resource Assessment

***Ocean Current:*** The best sites for ocean current energy development in the United States fall off the southeast coast of Florida within Federal waters, but analysis is incomplete at this time, so there may be other areas that have potentially viable current energy resources. To date there is no comprehensive nationwide estimate on the current energy resource potential. The only published attempts to quantify site-specific potential (see Von Arx et al., 1974; Lissaman and Radkey, 1979) are focused off the coast of Florida. These early estimates have not been validated.

Efforts to characterize the Gulf Stream's current energy potential in the Florida Straits are underway by the Florida Atlantic University's (FAU) Center for Ocean Energy Technology (COET).[20] The FAU plans to deploy a number of Acoustic Doppler Current Profilers (ADCPs) that will help to map the current resources off the coast of Florida, and these efforts will help to fill some of the data gaps that exist today. The FAU also has approached the MMS with plans to establish an offshore testing range where developers can assess different types of technology in a real ocean environment. Although harnessing the energy of the Gulf Stream has been considered for over a century, no system has been installed for more than a few hours at a time (FAU, 2009). Therefore, a limited technical and environmental knowledge-base exists for in-situ operation in the United States. This type of information is needed to help design reliable turbines and to make informed decisions for policy and permitting (ibid).

***Tidal:*** There is incomplete information on the amount of potential tidal energy resource available for development on the OCS. While a small component of the U.S. tidal resource may fall within Federal waters, typically tidal projects occur close to the coast, within State boundaries. Information gaps remain with regards to uncertainties in technology, questions on environmental impacts, and potential for space-use conflicts.

## 2. Geographic Focus and Areas of High Potential

The following section provides a more focused description of ocean renewable energy resources on a regional level.

[20] See the Center's website at http://coet.fau.edu/?p=overview.

### a. Atlantic OCS Region

The Atlantic OCS has significant potential for providing renewable energy. In the next 5-7 years this is most likely to come from offshore wind power, but wave and current power have some potential to contribute in the future as the technology advances.

**<u>Resource Potential in the Atlantic OCS—Wind, Ocean Current, and Wave Energy</u>**

***Wind:*** Not only do vast wind resources exist offshore the north Atlantic coast, these resources are located next to high population centers that have ever-increasing energy demands. Figure I-15 shows that locations of the highest potential wind resources in the Northeast are near the areas of highest population density. The north Atlantic contains the top offshore wind resource in the United States that is technologically and economically feasible to develop on a large commercial scale today. Areas from Maine to North Carolina have consistently strong winds (wind power Class 5 and Class 6) relatively close to shore, while some areas off New England exhibit up to Class 7 winds.

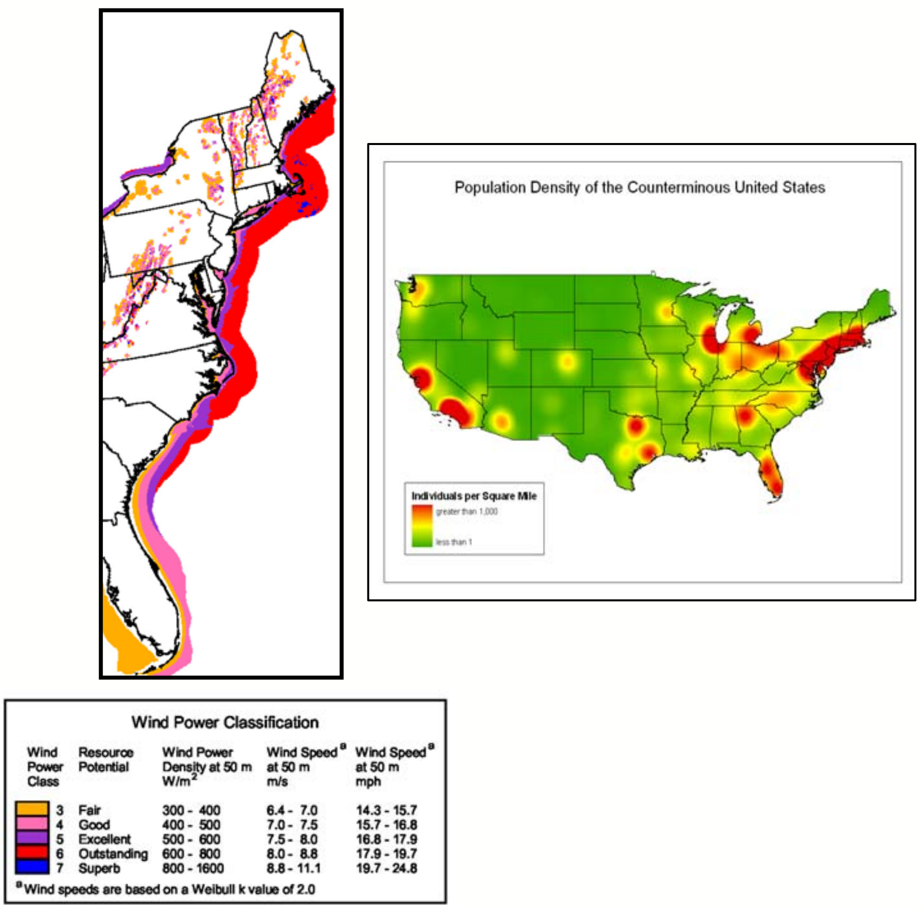
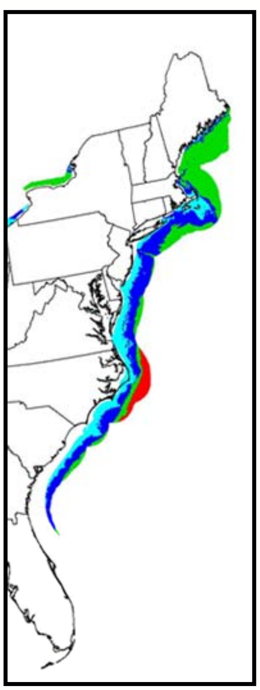



Figure I-15. Atlantic Wind Speed Map and Population Density of United States

Researchers at the University of Delaware recently conducted an empirical analysis of the wind resource over the Mid-Atlantic Bight (the aquatic region from Cape Cod, Massachusetts, to

Cape Hatteras, North Carolina.). Kempton et al. (2007) used anemometer readings from nine regional NOAA weather buoys to extrapolate decades of wind speed data to determine average wind speed at the height of modern offshore turbines (80-100m). In their analysis, they also include realistic “exclusion fractions” to account for areas that are assumed to be undevelopable due to the presence of major bird flyways, shipping lanes, military restricted areas, and major tourist beaches, among others. Kempton et al. (2007) estimate an average annual wind power resource of 330 GW (1,012 TWh/y) for the Mid-Atlantic Bight. This estimate is based on the installation of 166,720 5-MW turbines out to a 100-m water depth, spanning an area of more than 50,000 square miles. Whether or not that degree of offshore wind power development is feasible, the estimate substantially exceeds the region’s combined energy use (~185 GW) from electricity, gasoline, fuel oil, and natural gas sources.

Figure I-16 depicts NREL’s estimate of gross offshore wind power potential along the Atlantic coast. The NREL analysis uses Class 5 winds or greater to a distance extending 50 nm offshore, and it does not consider any exclusion zones. The light blue areas on the map signify a depth of 0 to 30 m, which, because of technology constraints, is close to the maximum water depth that could be utilized today. In the future it is anticipated that advanced technologies, such as floating turbines, will allow access to deeper waters further offshore. The NREL estimates a gross offshore wind resource of 1,024 GW (3,140 TWh/y) for the entire Atlantic . Assuming that only 40 percent is available because of other ocean uses gives an extractable resource of 410 GW (1,257 TWh/y). While the majority of this occurs in waters that are too deep for development today (due to technological constraints), a substantial gross resource of 253 GW (775 TWh/y) does exist in shallow waters (< 30 m). Using the same assumption, that gives an extractable shallow-water wind resource of 101 GW (310 TWh/y) which could be developed now with current technology.



| Region | *GW by depth (m)* | | | | |
|---|---|---|---|---|---|
| | 0-30 | 30-60 | 60-900 | >900 | Grand Total |
| New England | 59.2 | 127.7 | 273.4 | 0.0 | |
| Mid Atlantic | 165.6 | 181.6 | 59.7 | 56.6 | |
| S. Atlantic Bight | 28.4 | 58.2 | 13.7 | 0.0 | |
| Total | 253.2 | 367.5 | 346.8 | 56.6 | 1024.1 |

**Figure I-16.** Atlantic Wind Resource Potential Map in GW by Depth (Source: NREL)

***Ocean Current:*** Florida has the greatest potential for future development of ocean current power in the United States, and perhaps even the entire world. The water within the Gulf Stream moves at a steady pace of about 1.5 meters per second (m/s), with average velocities approaching 2.5 m/s off the coast of Florida. The Gulf Stream never stops, and its flow velocity actually increases in the summer, matching well with base-load summer-peaking energy demands (FAU, 2009). According to Von Arx et al. (1974), the ocean flow of the Gulf Stream has the potential to be more energy-dense than the world's best wind power-generating sites, with a total energy flux of 25 GW. This resource is located close to shore in areas that exhibit high coastal populations and high energy demand. For example, the Florida Straits Current flows only 8 km offshore in the southern part of Florida, close to Miami, and sustains relatively large speeds over significant distances in relatively unchanging patterns.

Early estimates show that the ocean current energy resource in Florida has a potential of 10 GW annual average power, or 50 TWh/y at full build-out, assuming a 57-percent capacity factor (Lissaman and Radkey, 1979). That is approximately one third of Florida's average electricity consumption. Recent estimates by Florida Atlantic University range between 4 and 8 GW annual average power (35 and 70 TWh/y) (FAU, 2009). Better information should become available as additional resource work is conducted and advances in technology can make extraction estimates more predictable.

***Wave:*** The EPRI estimates the gross offshore wave energy resource to be 110 TWh/y for the Atlantic (New England and Mid-Atlantic) (see Figure I-10). Assuming 15 percent could realistically be harnessed results in an energy potential of about 16.5 TWh/y. These estimates are preliminary, and they have yet to be validated, but they are the best estimates that exist to date. To help fill this information gap, EPRI is under contract with the DOE for a comprehensive 2-year study to determine the actual available and extractable wave resource estimates. New numbers are due to be released in 2009 and 2010. In contrast to the west coast, early estimates suggest that wave resources along the eastern coast of the United States likely are not strong enough to be suitable for development as a primary energy source, though there may be areas where it can be locally important.

### b. Gulf of Mexico OCS Region

**Resource Potential in the Gulf of Mexico OCS—Wind Energy**

***Wind:*** Wind speed data from NREL show that the majority of the Gulf's coastline has only Class 3 wind speeds close to shore. Still, there is limited potential for offshore wind development, mostly off the southeast coast of Texas.

Texas—like the west coast of Florida—is unique in that its State waters extend to 9 nm offshore (rather than the typical 3-mile boundary), and it has shown interest in building wind facilities offshore Galveston Island and Padre Island. The Texas General Land Office, which is responsible for leasing the State's land and mineral resources, recently approved lease agreements for two offshore wind farms. In October 2005, Texas became the first state to enter a lease agreement with a private developer for testing and construction of an offshore wind facility.[21] The 2005 agreement leases some 11,355 acres of State waters to Galveston Offshore Wind, LLC, for a planned 150-MW wind facility off Galveston Island. It remains to be seen whether or not this venture will prove economically viable.

Figure I-17 depicts NREL's estimate for offshore wind power along the Gulf coast. The NREL analysis uses Class 5 winds or greater to a distance extending 50 nm offshore, and it does not consider any exclusion zones. The NREL estimates a gross offshore wind resource of 67 GW (205 TWh/y) for the Gulf. Assuming that only 40 percent is available because of other ocean uses gives an extractable resource of 27 GW (82 TWh/y). The Gulf's wind resource occurs in relatively deep water (>30 m), and given technological constraints, is not expected to be developed in the near future. However, initial development in State waters, like Texas, may provide an opportunity for expansion onto the OCS in the future. In the long term it is anticipated that advances in technology, such as floating turbines, will allow access to deeper waters further offshore.

| Region | *GW by depth (m)* | | | | |
|---|---|---|---|---|---|
| | 0-30 | 30-60 | 60-900 | >900 | Grand Total |
| Gulf of Mexico | 0 | 12.3 | 54.7 | 0 | 67 |

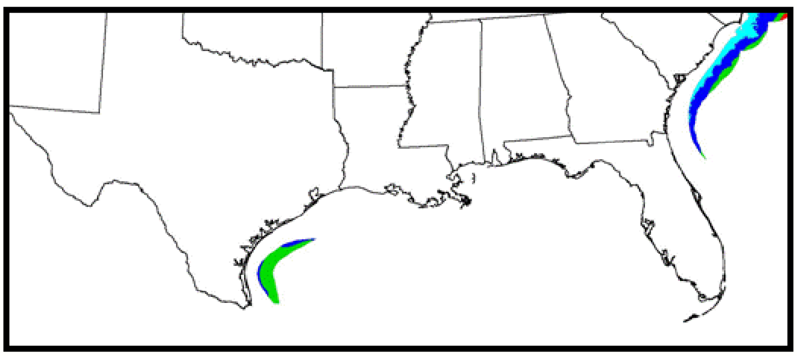


Figure I-17. Gulf Wind Resource Potential Map in GW by Depth (Source: NREL)

### c. Pacific OCS Region and Hawaii

Both the Pacific Northwest and Hawaii show strong potential for offshore renewable energy. For both of these areas, wave power is the most likely resource to be developed on the OCS in the short term. Although strong wind resources exist offshore California, Oregon, Washington, and Hawaii, the majority of this resource lies in deep waters and, thus, is currently challenged by technology constraints.

Wave energy resources are best between 30º and 60º latitude in both hemispheres, and the potential for more intensive wave energy tends to be the greatest on western coasts due to

[21] See press release at http://www.glo.state.tx.us/news/archive/2005/jpgs/Offshore-FINAL-PR-10-24-05.pdf ; accessed November 1, 2006.

prevailing winds and weather patterns. The wave climate along the west coast of North America represents one of the best prospects for development. Deeper waters closer to shore also make wave energy more advantageous there—though the same deep waters will hamper the development of significant offshore wind power resources in the short term. In addition to the relatively consistent and predictable wave energy produced across the long fetch in the North Pacific, this region possesses the coastal infrastructure and the demand for electrical power generation that could make development economically viable.

In the immediate future, wave energy seems most likely to be deployed off the coasts of California, Oregon, and Washington. Developers have shown a high level of interest in this area, and numerous projects have been proposed, licensed, or granted preliminary permits, mostly in state waters through the FERC licensing process. Although no full-scale wave energy projects are operational, several offshore wave energy projects are in the permitting or demonstration phases in Oregon, Washington, and Hawaii. Internationally, wave energy projects are operating on a small scale or are in development in Portugal, Japan, the United Kingdom, and Australia. Offshore wave energy likely would be commercially introduced first in Hawaii and northern California because of the combination of strong wave climate and the relatively high cost of electricity in the regions. Oregon and Washington also have strong wave resources; however, the demand for electricity in those States is lower because they already generate alternative power from hydro resources.

**<u>Resource Potential in the Pacific—Wave and Wind Energy</u>**

***Wave:*** The EPRI estimates the gross offshore wave energy resource to be 440 TWh/y for waters of the Pacific Northwest (northern California, Oregon, and Washington). Assuming 15 percent could realistically be harnessed results in an energy potential of about 66 TWh/y. To put this number into perspective, Oregon's electricity consumption in 2006 was about 53 TWh. The Hawaiian Island chain wave energy potential is estimated at 300 TWh/y, or about 45 TWh/y of electricity generation potential using an extraction rate of 15 percent. Again the above estimates are preliminary and they have yet to be validated, but they are the best estimates that exist to date. To help fill this information gap, EPRI is under contract with the DOE for a comprehensive 2-year study to determine the actual available and extractable wave resource estimate. Revised estimates are due to be released in 2009 and 2010.

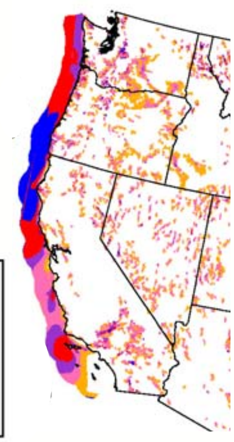
***Wind:*** Site-specific offshore wind resource estimates have been performed for various parts of the United States, including California (see Musial and Butterfield, 2004; Dvorak et al., 2007). Researchers at Stanford University recently conducted an in-depth analysis of California's offshore wind energy potential. Dvorak et al. (2007) focused on three geographic areas of California—Northern California, the San Francisco Bay area, and Southern California. By modeling the offshore resource at high resolution, their analysis found between 78-330 TWh offshore wind energy potential developable annually—a significant available resource—though the vast majority (86-98%) of California's wind resource exists in deep waters and, thus, currently is not viable for development.[22] Interestingly, the study found that Northern California showed the most potential for offshore wind resource, but this region lacks any large population centers and any large transmission lines near the coast, making large-scale development in that area somewhat problematic. As grid connectivity is a key factor for ocean-based renewables, inadequate onshore infrastructure could potentially hamper offshore development.

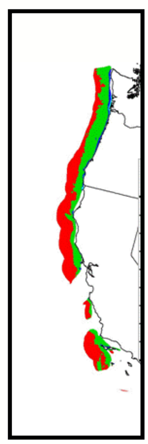
Figure I-18 depicts NREL's estimate for offshore wind speed and gross resource potential along the Pacific coast. Figure I-19 shows the wind speed map for Hawaii. The NREL analysis for resource potential uses Class 5 winds or greater to a distance extending 50 nm offshore, and it does not consider any exclusion zones. The light blue areas on the resource potential maps signify a depth of 0-30 m, which, because of technology constraints, is close to the maximum water depth that could be utilized today. The NREL estimates a gross offshore wind resource potential of 902 GW (2,765 TWh/y) for the Pacific, including Hawaii. Assuming that only 40 percent is available because of other ocean uses gives an extractable resource of 361 GW (1,106 TWh/y). The majority of the resource occurs in deep water, however, and therefore cannot be developed today. Even so, the MMS has received Interim Policy nominations and other inquiries showing interest for offshore wind power development off the coasts of California and Oregon. In the future, it is anticipated that advanced technologies, such as floating turbines, will allow access to deeper waters further offshore.

**Wind Power Classification**

| Wind Power Class | Resource Potential | Wind Power Density at 50 m $W/m^2$ | Wind Speed[a] at 50 m m/s | Wind Speed[a] at 50 m mph |
|---|---|---|---|---|
| 3 | Fair | 300 - 400 | 6.4 - 7.0 | 14.3 - 15.7 |
| 4 | Good | 400 - 500 | 7.0 - 7.5 | 15.7 - 16.8 |
| 5 | Excellent | 500 - 600 | 7.5 - 8.0 | 16.8 - 17.9 |
| 6 | Outstanding | 600 - 800 | 8.0 - 8.8 | 17.9 - 19.7 |
| 7 | Superb | 800 - 1600 | 8.8 - 11.1 | 19.7 - 24.8 |

[a] Wind speeds are based on a Weibull k value of 2.0





| Region | GW by depth (m) | | | | |
|---|---|---|---|---|---|
| | 0-30 | 30-60 | 60-900 | >900 | Grand Total |
| Pacific Northwest | 7.5 | 19.2 | 188.1 | 121.0 | |
| California | 2.3 | 4.8 | 130.5 | 277.9 | |
| Hawaii | 0.8 | 1.4 | 24.9 | 123.6 | |
| Total | 10.6 | 25.4 | 343.5 | 522.5 | 902 |

Figure I-18. Pacific Wind Speed Map (left) and Gross Resource Potential Map (right) in GW by Depth (Source: NREL)

[22] The study assumed the use of a Repower 5M 5.0 MW turbine, each of which requires an area of 0.44 $km^2$. The study also accounted for exclusion zones (shipping lanes, restricted wildlife preservation areas, viewshed considerations, etc.) by including a 33% exclusionary factor for all possible turbine areas.

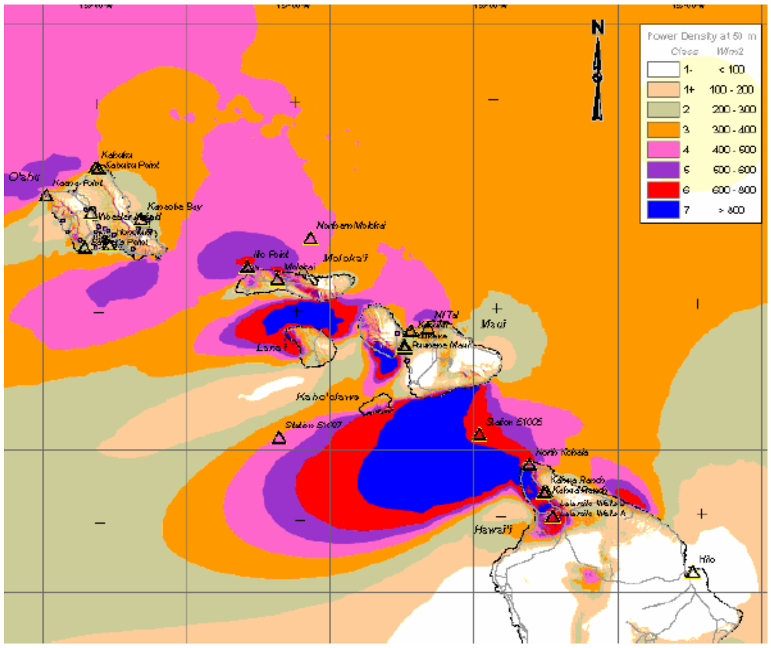



Figure I-19. Hawaii Offshore Wind Speed Map (Source: EPRI)

### d. Alaska OCS Region

Alaska has significant ocean energy resource potential in the form of offshore wind, wave, and tidal power. There are several reasons these resources may not be developed on the OCS in the near-term, however. Harsh weather conditions, untested and unproven technologies, significant distance from high-energy demand centers, and more readily accessible locations in other parts of the country are some of the challenges that developers may face in this area.

**<u>Resource Potential in the Alaska OCS—Wave, Tidal, and Wind Energy</u>**

***Wave:*** The EPRI estimates show that Alaska has the best wave energy resource potential in the U.S., at 1,250 TWh/y, or some 60 percent of the U.S. resource as estimated to date (see Figure I-10). Assuming 15 percent could realistically be harnessed results in an energy potential of about 188 TWh/y. While the resource is vast, it is hard to predict the extent of development that is likely to occur in Alaska either in the short term or the long term. Weather conditions are harsh here; wave power technology is still unproven on a commercial scale, and Alaska's remote location is far from high-energy demand centers in the Pacific Northwest.

***Tidal:*** The EPRI has conducted extensive analysis on the tidal resource in Alaska, including specific site surveys and feasibility studies for building tidal power plants.[23] Similar to wave power, Alaska holds vast tidal resources that could produce enormous amounts of electricity. As highlighted earlier, though, the majority of tidal power potential occurs close to shore,

[23] See the reports at http://oceanenergy.epri.com/default.asp.

typically in state waters. Even if some tidal resources were present in Federal waters, it is much more likely that those resources in State waters will be developed first.

***Wind:*** Validated wind speed maps show that Alaska has wind speeds that could support utility-scale production both onshore and offshore (Figure I-20). Offshore of mainland Alaska and the Alaskan Panhandle, wind speeds of Class 6 and Class 7 are readily available, often close to shore. Although the MMS is not currently aware of any developers that are interested in development at this time, the potential does exist given the abundant wind resources. The estimated wind power potential for this area of the OCS is unknown at this time.

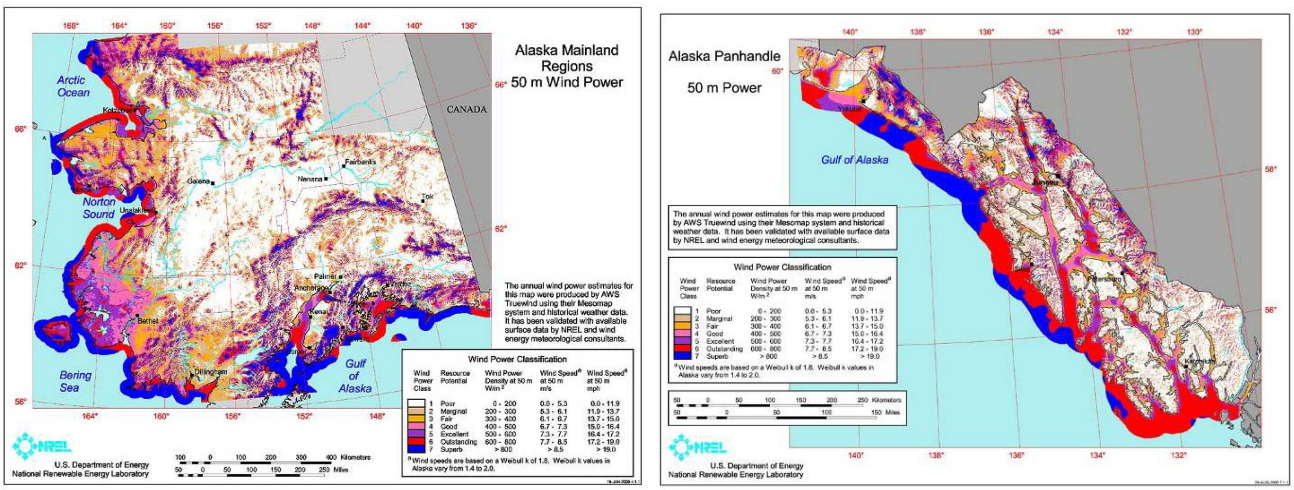



Figure I-20. Alaska Offshore Wind Speed Map (Source: NREL)

## D. Current Developments and Suggestions for Next Steps

### 1. State Initiatives

#### a. Coastal States' Renewable Portfolio Standards

Many coastal States have adopted renewable portfolio standards (RPS) that require electricity providers to obtain a minimum percentage of their power from renewable energy resources by a certain date. Due to constraints on onshore energy development, many States, especially those on the east coast, must look offshore to develop renewable energy in support of their RPS. Figure I-21 shows each coastal state RPS. Three States on the east coast—Delaware, New Jersey, and Rhode Island—have acted formally to encourage the development of offshore wind power in support of their RPS and related energy policy goals.

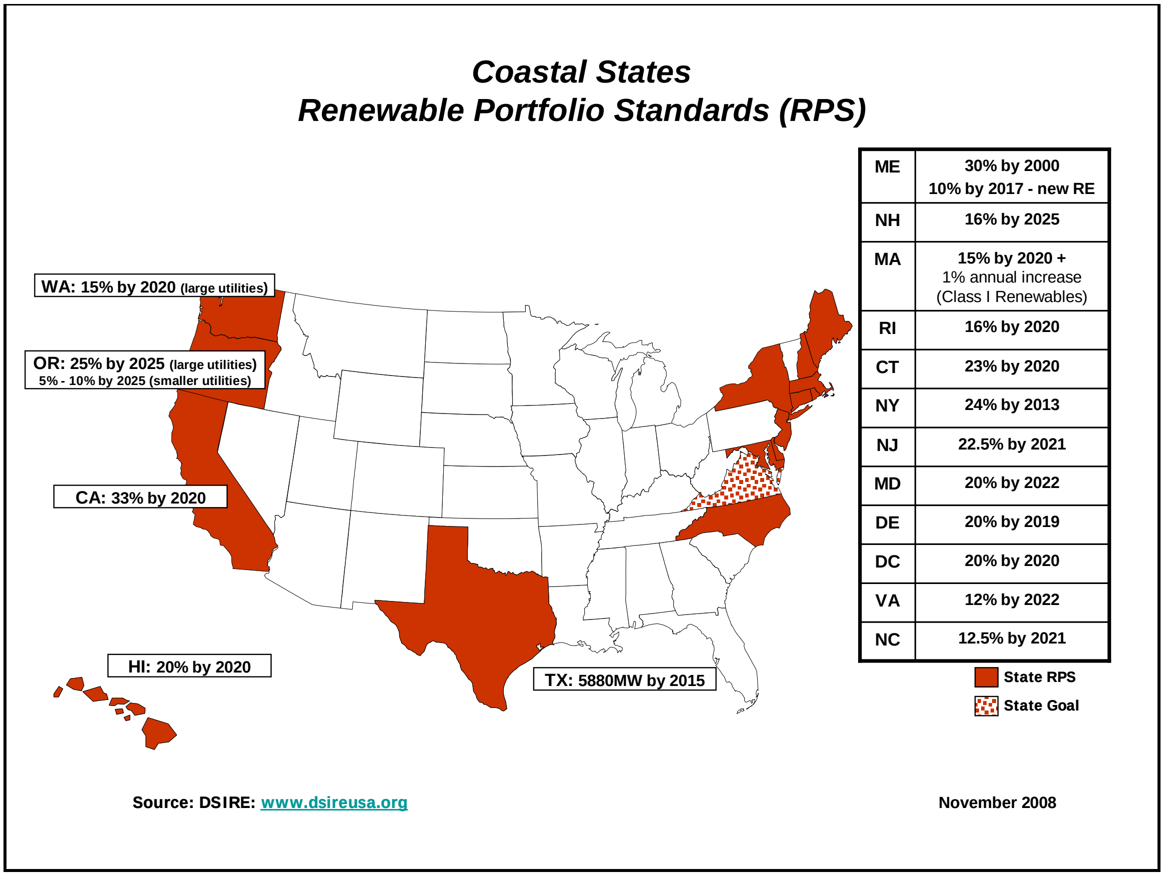



Figure I-21. Renewable Portfolio Standards for Coastal States

#### (1) Delaware

The Delaware General Assembly passed a bill directing the State's largest utility, Delmarva Power, to contract with new power resources that will guarantee stable prices for electricity. The Delaware legislature also passed an RPS requiring that 20 percent of the State's electricity come from renewable sources by the year 2019. In November 2006, Delmarva Power issued a Request for Proposals (RFP) for the construction of a new power plant in Delaware. Bluewater Wind submitted the winning proposal, and in June 2008, Bluewater Wind announced that it signed a 25-year power purchase agreement with Delmarva Power to sell the utility up to 200 MW of power from an offshore wind facility proposed on the OCS. The agreement with Delmarva Power was ratified by the Delaware legislature on July 31, 2008. Under this contract, the developer needs to obtain from MMS the permits for construction and operation of the project by August 2012.

#### (2) New Jersey

The New Jersey Energy Master Plan contains a goal of installing at least 1,000 MW of offshore wind energy by 2012 and at least 3,000 MW by 2020. In April 2006, the New Jersey Blue Ribbon Panel recommended that the New Jersey Board of Public Utilities (NJ PBU) proceed with an offshore wind pilot project to obtain practical knowledge of benefits and impacts resulting from offshore wind turbine facilities. The NJ BPU issued a solicitation for proposals to develop a capacity of 350 MW of wind power on the OCS and offered a grant of $19 million. In October 2008, the State selected Garden State Offshore Energy LLC (GSOE) as the winner of the grant solicitation. New Jersey is currently in negotiations with GSOE for a project to come online in 2013. After being selected as the winning bidder, GSOE decided not to accept the full grant funding, which the State subsequently has decided to use for a meteorological tower rebate program and studies funding. In October 2008, the NJ BPU initiated an application process for the proposed offshore wind rebate program for the construction of meteorological towers, with total funding in the amount of $12 million. The program requires applicants to commit to putting a meteorological tower into operation by the end of 2009 and to diligently pursue the permitting of a 200-MW commercial generating facility to be constructed no later than 2012.

#### (3) Rhode Island

In 2006, the Governor of Rhode Island announced a plan to increase the use of renewable sources of energy to generate 20 percent of the State’s electricity needs. It is expected that approximately 15 percent will be derived from wind energy. In July 2008, the Rhode Island Renewable Energy Fund Board of Trustees approved funding for the development of a Special Ocean Area Management Plan (SAMP) for the Rhode Island coast, which would determine appropriate areas for siting offshore wind facilities in both State and Federal waters. Rhode Island also issued a RFP seeking bids from private companies to construct and operate an offshore wind facility, and Deepwater Wind was chosen the winner in September 2008. The project is planned in two phases, the first entailing completion of construction of a facility in state waters in 2012, and the second entailing the start of construction of a facility in Federal waters in 2015.

### b. Other Coastal State Plans and Initiatives

Several other coastal states are not as far along in offshore renewable energy activity as those discussed above, but have to varying degrees acted to encourage development.

#### (1) Massachusetts

The Commonwealth of Massachusetts has established a RPS and has enacted the Oceans Act of 2008, which requires preparation of a comprehensive plan to manage development, including renewable energy, in State waters. In January 2009, the Governor announced a goal of producing 2,000 MW of wind power by 2020, citing the abundant offshore resource as an important means to achieving this goal.

Massachusetts is also the site of the proposed Cape Wind Energy Project. Cape Wind proposes to construct and operate a commercial-scale wind energy facility offshore Massachusetts, on Federal submerged lands in Nantucket Sound. The proposed project would occupy approximately 24 square miles of the OCS and consist of 130, 3.6 MW wind turbine generators mounted on monopole foundations. Cape Wind was proposed by Cape Wind Associates, LLC in November 2001. Following the passage of EPAct in 2005, the MMS assumed lead federal responsibility and initiated its own independent environmental review pursuant to the NEPA.

Cape Wind must obtain a lease from the MMS prior to commencing construction and operation of the project. The MMS published the Cape Wind draft Environmental Impact Statement (EIS) in January 2008 and the final EIS on January 16, 2009.

**(2) New York**

The State of New York has established an RPS. The Long Island Power Authority (LIPA) proposed a 140-MW wind generating facility off Long Island in 2005, but suspended work in 2007 due to concerns about escalating costs. In recognition of the great demand for electricity in the area of New York City and the State's RPS, LIPA and Consolidated Edison announced in September 2008 their intention to study the potential for wind development 10 miles off Rockaway. Similarly, in November 2008, the New York Power Authority announced preparation of a 10-year plan that includes an offshore wind farm off Long Island with a capacity of up to 500 MW. Consolidated Edison Inc., owner of New York's electric utility, and the State-owned Long Island Power Authority will solicit proposals by year-end for an offshore wind farm capable of powering 25,000 homes. The project would be 13 miles (21 kilometers) off Rockaway Peninsula in the Atlantic Ocean.

**(3) Maryland, Virginia, and North Carolina**

Maryland and North Carolina have established RPS's, and Virginia has set a nonbinding goal for renewable energy generation. All three States have engaged in stakeholder outreach and preliminary research activities to explore the feasibility of offshore renewable energy development.

**(4) South Carolina and Georgia**

Neither State has established an RPS, but both have taken preliminary steps to consider offshore wind development. Following several years of joint research involving Southern Company and the Georgia Institute of Technology, Southern Company has applied for limited leases to construct site assessment facilities on the OCS off Georgia under the MMS Interim Policy, and the MMS lease issuance process is underway. Areas off South Carolina also were nominated but not selected for processing by MMS. Santee Cooper, Coastal Carolina University, and the South Carolina Energy Office plan to launch weather buoys that will measure wind off the coast of Georgetown and Little River in South Carolina.

**(5) Florida**

The State has not established an RPS. Its main interest in offshore renewable energy at this time relates to ocean current resources off its southeastern coast. Efforts to investigate these resources have been led by the FAU COET, which is pursuing partnerships to establish a South Florida Testing Facility range for research, design, and implementation relating to commercial development. Also, MMS is processing limited lease requests under its Interim Policy for four proposed lease areas off the southeastern coast.

#### (6) Texas

Texas has shown interest in building offshore wind facilities in State waters off Galveston and Padre Island. The Texas General Land Office, which is responsible for leasing the State's land and mineral resources, recently approved lease agreements for two offshore wind farms. In October 2005, Texas became the first State to enter a lease agreement with a private developer for testing and construction of an offshore wind facility.[24] The 2005 agreement leased some 11,355 acres of State waters for a planned 150-MW wind facility off of Galveston Island. It remains to be seen whether or not this venture will prove economically viable.

#### (7) California, Oregon, and Washington

The Governors of California, Oregon, and Washington have joined the West Coast Governors' Agreement on Ocean Health, which was announced on September 18, 2006. The Agreement launched a new, proactive regional collaboration to protect and manage the ocean and coastal resources along the entire west coast, as called for in the recommendations of the United States Commission on Ocean Policy and the Pew Oceans Commission. One element of the action plan developed under the Agreement concerns new, environmentally sustainable energy production. While offshore renewable energy could provide new, reliable sources of energy for the west coast, the feasibility and environmental impacts of these technologies are not yet fully understood. The west coast States have agreed to collaborate with the MMS, DOE, FERC, NOAA, and other Agencies, organizations, and industry, to evaluate the potential benefits and impacts of renewable ocean energy projects off the west coast, as well as develop the long term regulatory structure for removal or expansion of activities. The MMS and the State of Oregon are co-leads for the West Coast Governors' Agreement on Ocean Health Renewable Ocean Energy action coordination team.

All of these States have established RPSs, and all have substantial wind and wave resources off their coasts. Currently, there are seven wave projects proposed off California, six wave projects proposed off Oregon, and two wave projects off Washington (one already licensed by FERC and the other proposed). The State of Oregon has entered into a Memorandum of Agreement (MOA) with FERC to coordinate procedures and schedules for review of wave energy projects in State waters, and the State of Washington is in the process of developing a similar MOA with FERC. Off Oregon, there are plans for phased development of a 150-MW floating offshore wind facility on the OCS to provide power to the Tillamook People's Utility District.

## 2. Federal Agency Initiatives

Federal agencies must comply with EPAct mandates for increased reliance on renewable energy sources for their needs. The United States Navy has expressed to MMS an interest in setting aside an area off the coast of Virginia for a potential wind energy facility, and

[24] See press release at http://www.glo.state.tx.us/news/archive/2005/jpgs/Offshore-FINAL-PR-10-24-05.pdf ; accessed November 1, 2006.

Vandenberg Air Force Base has informally discussed plans to receive power from a wave facility associated with an existing OCS oil and gas platform located off southern California. The MMS intends to move forward with its mission regarding development of renewable energy resources in association with various stakeholder groups, new state and federal task forces, and other established working groups, including the U.S. Offshore Wind Collaborative. On March 11, 2009, Interior Secretary Ken Salazar issued an order for the Department to increase its focus on the production, development, and transmission of electricity created from renewable sources. The directive also creates an energy and climate change task force that will identify specific zones on public land where the DOI can facilitate large-scale renewable energy projects quickly.

## E. Filling Information Gaps with Additional Studies and Research

### 1. Efforts to Identify Information Needs

Early steps in developing an environmental studies program to support OCS renewable energy, in 2006 the MMS sponsored a Worldwide Synthesis and Analysis of Existing Information Regarding Environmental Effects of Alternative Energy Uses on the Outer Continental Shelf (Michel et al., 2007) and a Workshop to Identify Alternative Environmental Information Needs (Michel and Burkhard, 2007). The MMS also cosponsored a workshop in Oregon, Ecological Effects of Wave Energy Development in the Pacific Northwest (Oregon State University, 2007),[25] in October 2007, and a workshop at the National Conservation Training Center on Birds and Offshore Wind Development in the Northeast/Mid-Atlantic in 2008.[26]

The objectives of the worldwide synthesis—the first MMS renewable energy study—were to identify, collect, evaluate, and synthesize existing information on offshore renewable energy activities for the following topics:

- Current offshore energy technologies and future trends;
- How public acceptance of existing projects was or was not achieved;
- Potential direct, indirect, and cumulative environmental impacts of offshore energy technologies;
- Previously used mitigation measures that could avoid, minimize, rectify, eliminate, or compensate for environmental impacts;
- Current physical and numerical models designed to determine environmental impacts; and
- Information needs to address gaps in our current understanding of environmental impacts.

[25] See http://hmsc.oregonstate.edu/waveenergy/
[26] See http://www.mms.gov/offshore/AlternativeEnergy/WorkshopBirdsOffshoreWindDevelopment.htm

The identified information needs for each resource (wind, wave, and current power) are comprehensive, and they covered a wide range of types of studies and priorities which can be divided into the following five general categories:

- Detailed data on the distribution and life history for key species in each regional ecosystem; environmental assessments for specific projects need more detailed data on benthic habitats, and multiyear studies of seasonal abundance and distribution of key species.
- Development of uniform field data collection methods for baseline studies and post-construction monitoring surveys to improve the confidence of impact detection; study of highly mobile species in offshore areas is particularly difficult, requiring new approaches and technologies.
- Focused laboratory studies to determine thresholds for potential effects resulting from exposure to the types and levels of sound and electromagnetic fields (EMFs) likely to be generated by different types of renewable energy devices in full-scale installations.
- Development of protocols for field studies on potential effects from exposure to sound, EMFs, and obstructions on the behavior and survival of key species of each resource of concern.
- Development of guidelines to set acceptable limits of direct, indirect, and cumulative impacts resulting from the installation and operation of offshore renewable energy projects; guidelines are needed for all types of potential impacts such as changes to the hydrodynamic climate, erosion of adjacent shorelines, habitat loss and alteration, avoidance and attraction behavior, mortality, aesthetics, and lost use.

As a follow-up to the report, the MMS held a workshop, “Workshop to Identify Alternative Energy Environmental Information Needs,” in June 2007 (see Michel and Burkhard, 2007). The workshop was an important step for the MMS to communicate and develop a collaborative relationship with other Federal Agencies, affected State and local groups, and industry. National and international experts in the field of offshore renewable energy development and marine environmental resources (i.e., academia or representatives from countries or States where development is already occurring) were invited to share their expertise, to identify data needs, and to outline potential studies for the MMS Environmental Studies Program and its partners. The workshop began with ten technical presentations by national and international experts covering the state of wind and wave technologies, future trends, environmental concerns, and lessons learned. Four breakout groups were formed (Aquatic Resources; Flying Animals; Physical Oceanography /Air Quality; Social Sciences and Economics) to develop a list of critical information needs and provide supporting detailed information for the most important research priorities.  To see a complete summary of the synthesis report and workshop, please see http://www.mms.gov/eppd/sciences/mmsaeworkshop.htm.

## 2. Filling Information Gaps

### a. Collaborative Efforts

Recently, the MMS joined efforts with the DOE and the FERC on a 3-year collaborative international study to identify the environmental impacts of marine hydrokinetic devices (ocean wave, ocean current, and tidal). The collaborative effort is part of the International Energy Agency's (IEA) Ocean Energy Systems (OES) Implementing Agreement,[27] which aims to facilitate and coordinate ocean energy research, development and demonstration through international cooperation and information exchange. This effort will culminate in a publicly accessible and searchable database and a comprehensive summary report that will be published by the IEA-OES. The report will provide critical analysis on monitoring efforts and mitigation, and provide guidance to international ocean energy stakeholders including policymakers, developers, regulators, agencies, academic institutions, and research organizations. Greater understanding of the environmental effects and monitoring methods related to ocean energy will enable better decision making and help to advance ocean energy technology.

As the MMS moves forward with commercial leasing for renewable energy projects on the OCS, MMS will continue its outreach efforts and utilize the close partnerships and collaborative opportunities that exist among the Federal, State, and local government entities. These opportunities could include government research programs and initiatives, interagency groups or committees, regional and local task forces, and partnerships with universities or industry. As additional data is collected over the next few years, site-specific surveys and research are completed, and projects are approved, construction and operations will begin to commence. Collaborative efforts with the NOAA, U.S. Fish and Wildlife Service, United States Geological Survey, U.S. National Park Service, DOE, and others offer an opportunity to share critical information, and agency expertise, and to foster better communication between different arms of the Federal Government as these new and exciting opportunities are realized.

### b. MMS Agency Research Programs

The MMS uses two primary mechanisms for filling critical information needs with regard to offshore renewable energy development and its affect on the marine and human environment—the MMS Environmental Studies Program (ESP) and the Technology Assessment and Research Studies (TA&R) Branch. The history and objectives of each are discussed in Section III. Each program's renewable energy initiatives and efforts are highlighted briefly below.

#### (1) Environmental Studies Program

Over the years, the scope of the ESP has broadened to support non-energy mineral development on the OCS, and most recently, renewable energy development on the OCS. To date the ESP has funded over $840 million in research on a variety of topics. With the passage of the Energy Policy Act of 2005, the ESP has begun to initiate studies specifically to help fill information gaps regarding the offshore renewables (Figure I-22).

[27] See http://www.iea-oceans.org/

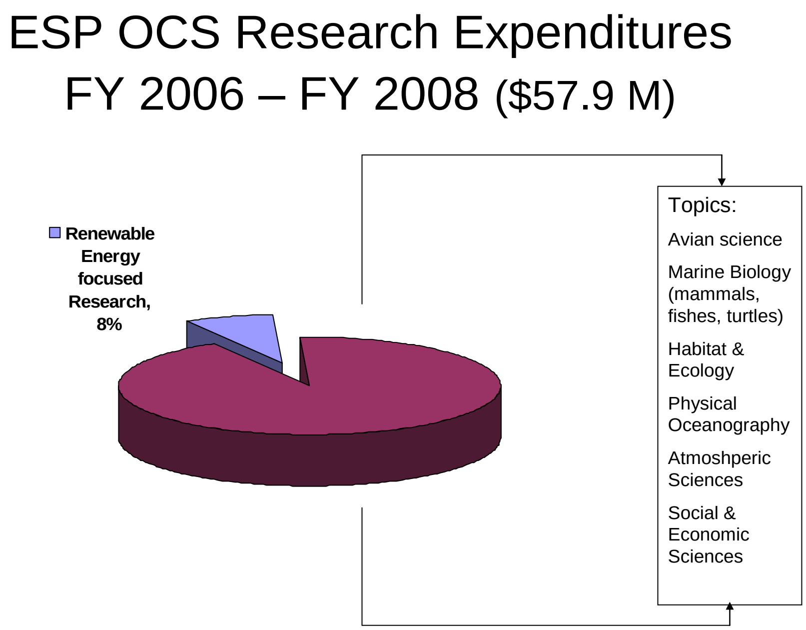



Figure I-22. MMS Environmental Studies Program —Offshore Research Serves Many Customers

In the next few years, the MMS anticipates regulating a number of activities related to offshore renewable energy development, including site characterization, facility construction, operation, monitoring, and decommissioning. Prior to approval of any of these activities, the MMS needs baseline environmental information about the lease areas to evaluate the potential impacts of these activities on the marine and human environment. The timely acquisition of environmental information is crucial to issuing leases on the Atlantic, Pacific and Gulf of Mexico coasts. Given that these areas are considered frontier areas for renewable energy development, numerous baseline and issue-specific studies are required and will take a substantial amount of time (2-3 years) to complete. Without sound science for decision-making, opportunities for renewable energy development could be hindered or delayed.

In support of the MMS Offshore Renewable Energy Program, the ESP prepared a "studies development plan" that identifies environmental information gaps based on projected renewable energy activities on the OCS. This plan builds on information collected through earlier work, including consideration of recommendations from the "Worldwide Synthesis and Analysis of Existing Information Regarding Environmental Effects of Alternative Energy Uses on the Outer Continental Shelf" (Michel et al., 2007) and the "Workshop to Identify Alternative Environmental Information Needs" (Michel and Burkhard, 2007). Importantly, the MMS Environmental Studies Program planning process utilizes an integrated approach for identifying research to address the environmental consequences of the many possible energy and mineral development activities on the OCS. This broad multi-use planning process serves the needs of many while conducting applied research to address specific resource management questions. For a detailed list of anticipated studies through FY2011, please see the Alternative Energy Studies Development Plan, http://www.mms.gov/offshore/AlternativeEnergy/Assets/PDFs/AE_SDP_2009_2011_FINAL.pdf. Currently, funds are being used to undertake research to address diverse environmental issues in the areas where renewable energy activities are initially expected to occur. The following lists MMS ESP ongoing research in support of renewable energy on the OCS:

1. Meteorological and Wave Measurements for Improving Meteorological and Air Quality Modeling
2. Evaluation of Visual Impacts on Historic Properties
3. Energy Market and Infrastructure Information for Evaluating Alternative Energy Projects for OCS Atlantic and Pacific Regions
4. Update of Summary of Knowledge: Selected Areas of the Pacific Coast
5. Compendium of Avian Information and Comprehensive GIS Geodatabase
6. Effects of Pile Driving Sounds on Auditory and Non-auditory Tissues of Fish
7. Potential for Interactions between Endangered and Candidate Bird Species with Wind Facility Operations on the Atlantic OCS
8. North and Central Atlantic Information Resources: Data Search and Literature Synthesis
9. Workshop on the Status of Passive Acoustic Monitoring
10. Effects of EMF From Transmission Lines on Elasmobranchs and other Marine Species
11. Surveying for Marine Birds in the Northwest Atlantic

**(2) Technology Assessment and Research Studies**

In addition to conducting environmental studies, technology-specific research efforts will help to identify the most critical knowledge gaps and help to find ways to overcome existing technical challenges. These are especially needed as the offshore renewable energy industries continue to mature. Funds dedicated to the TA&R Program are used for technological and engineering studies to ensure safety of operations and protection of the environment. Current TA&R Program efforts that focus on renewable energy can be viewed at http://www.mms.gov/tarprojectcategories/AlternativeEnergy.htm. They include:

1. Comparative Study of Offshore Wind Turbine Generators Standards
2. Assess/Develop Inspection Methodologies for Offshore Wind Turbine Facilities
3. Assess the Design/Inspection Criteria/Standards for Wave and/or Current Energy Generating Devices
4. Assess the Design and Inspection Criteria and Standards for Wave and Current Energy Generating Devices
5. Wind Farm/Turbine Accidents and the Applicability to Risks to Personnel and Property on the OCS, and Design Standards to Ensure Structural Safety/Reliability/Survivability of Offshore Wind Farms on the OCS

Recently, the TA&R Program completed an initial review of various structural design standards for offshore wind facilities to determine their applicability to operations on the OCS. The TA&R Program is continuing this effort by studying the adverse operational incidents that have occurred on worldwide wind facilities in an attempt to determine general trends and potential mitigation methods. The TA&R Program also is in the process of awarding a project that will study the potential mitigation of underwater noise during pile-driving activities. This is important because the most common structural support for the wind turbines, a monopile, requires extensive use of pile driving equipment. The TA&R Program is collaborating with research institutions and industry on testing wave and current energy systems as well at the MMS Ohmsett testing facility in New Jersey.[28] Ohmsett is the world's largest tow/wave tank and is designed to evaluate the performance of meso-scale sized equipment under realistic but safe environmental conditions. Results are being utilized to establish basic design standards to ensure the safety of wave, current, and tidal energy conversion devices.

Branching further into renewable energy, the TA&R Program began initial work in determining the state of the art in ocean wave and current energy conversion technology, identifying existing design standards that might be applicable, and determining whether information gaps exist that will require new standards or inspection methodologies to be developed. For example, Free Flow Energy, Inc, under contract to MMS, recently completed a survey of recommended practices and standards for the design and inspection of wave and current energy conversion devices. As part of their research, they reviewed U.S. patents and found that although there has been an attempt to harness marine hydrokinetic power since the mid-1800's, the industry is still "nascent" with uncertainties in technological development and large-scale feasibility. The study also contrasts "site developers" to "technology developers," noting that while technology developers may be pursuing site development as a means of marketing their technology, some site developers with little or no technological know-how often boast unproven technologies as a means of gaining public interest in their site proposals. The study outlines a need for industry-specific standards with an established industry consensus, as significant gaps do exist in the various components, materials, and/or functions of these potential devices.

[28] See http://www.ohmsett.com/

# II. OIL AND GAS RESOURCE EVALUATION

## A. Introduction

This report presents the results of a regional assessment of the entire U.S. Outer Continental Shelf (OCS) completed by the Minerals Management Service (MMS) in 2006. It represents the results of a thorough investigation of the petroleum geology of each province and an identification of appropriate domestic and international analogs, coupled with a probabilistic methodology to estimate the remaining hydrocarbon potential.

### 1. Commodities Assessed

The petroleum commodities assessed in this report are crude oil, natural gas liquids (condensate), and natural gas that exist in conventional reservoirs and are producible with conventional recovery techniques. Crude oil and condensate are reported jointly as oil; associated and nonassociated gas are reported as gas. Oil volumes are reported as stock tank barrels and gas as standard cubic feet. Oil-equivalent gas is a volume of gas (associated and/or nonassociated) expressed in terms of its energy equivalence to oil (i.e., 5,620 cubic feet of gas per barrel of oil and is reported in barrels. The combined volume of oil and oil-equivalent gas resources is referred to as barrels of oil equivalent (BOE) and is reported in barrels.

This assessment does not include potentially large quantities of hydrocarbon resources that could be recovered from known and future fields by enhanced recovery techniques, gas in geopressured brines, gas hydrates, or oil and natural gas that may be present in insufficient quantities or quality (low permeability “tight” reservoirs) to be produced by conventional recovery techniques. These unconventional resources have yet to be produced from the OCS; still, with improved extraction technologies and economic conditions, they may become important future sources of domestic oil and gas production. A discussion of OCS gas hydrates is included in Section II-D of this report.

### 2. Resource Categories

A set of precise, universally accepted definitions regarding resource assessment terminology does not exist, so it is important that the terminology associated with this resource assessment is understood so that the results can be correctly interpreted. The important terms related to this resource assessment are defined below. The definitions presented here should be viewed as general explanations rather than strict technical definitions of the terms.

***Resources***: Concentrations in the earth’s crust of naturally occurring liquid or gaseous hydrocarbons that can conceivably be discovered and recovered. Normal use encompasses both discovered and undiscovered resources.

***Undiscovered Resources:*** Resources postulated, on the basis of geologic knowledge and theory, to exist outside of known fields or accumulations. Also included are resources from undiscovered pools within known fields to the extent that they occur within separate plays.

***Undiscovered Technically Recoverable Resources (UTRR):*** Hydrocarbons that may be produced as a consequence of natural pressure, artificial lift, pressure maintenance (gas or water injection), or other secondary recovery methods, but without any consideration of economic viability. The UTRR do not include quantities of hydrocarbon resources that could be recovered by enhanced recovery techniques, gas in geopressured brines, natural gas hydrates, or oil and gas that may be present in insufficient quantities or quality (low permeability "tight" reservoirs) to be produced via conventional recovery techniques. Also, the UTRR are primarily located outside of known fields.

***Undiscovered Economically Recoverable Resources (UERR):*** The portion of the UTRR that is potentially recoverable at a profit under specified economic and technologic conditions.

***Reserves:*** The quantities of hydrocarbon resources anticipated to be recovered (and therefore economic) from known accumulations from a given date forward. All reserve estimates involve some degree of uncertainty.

***Proved Reserves:*** The quantities of hydrocarbons estimated with reasonable certainty to be commercially recoverable from known accumulations under current economic conditions, operating methods, and government regulations. Current economic conditions include prices and costs prevailing at the time of the estimate. Estimates of proved reserves do not include reserves appreciation.

***Unproved Reserves:*** The quantities of hydrocarbon reserves that are assessed based on geologic and engineering information similar to that used in developing estimates of proved reserves, but technical, contractual, economic, or regulatory uncertainty precludes such reserves being classified as proved.

***Reserves Appreciation:*** The observed incremental increase through time in the estimates of reserves (proved and unproved) of an oil and/or natural gas field. It is that part of the known resources over and above proved and unproved reserves that will be added to existing fields through extension, revision, improved recovery, and the addition of new reservoirs. Also commonly referred to as reserves growth or field growth.

***Cumulative Production:*** The sum of all produced volumes of hydrocarbons prior to a specified point in time.

***Estimated Ultimate Recovery (EUR):*** All hydrocarbon resources within known fields that can be profitably produced using current technology under existing economic conditions. The EUR is the sum of cumulative production plus proved reserves plus unproved reserves plus reserves appreciation.

***Total Endowment:*** All technically recoverable hydrocarbon resources of an area. Estimates of total endowment equal undiscovered technically recoverable resources plus EUR.

Estimates of undiscovered recoverable resources are presented in two categories, undiscovered technically recoverable resources (UTRR) and undiscovered economically recoverable resources (UERR). In addition, the quantities of historical production, reserves, and future reserves appreciation are usually presented to provide a frame of reference for analyzing the estimates of UTRR. The UERR results are presented as price-supply curves which show the relationship of price to economically recoverable resource. Because the assessment discussed in this report excludes oil and natural gas that are producible only through the use of more exotic and expensive "unconventional technologies" significant portions of the resource base are eliminated from consideration, some portion of which may be developable in the future.

## 3. Sources and Types of Data Used

The MMS's assessment of the hydrocarbon potential of the OCS required the compilation and analysis of published information and vast amounts of proprietary geologic, geophysical, and engineering data obtained by industry from operations performed under permits or mineral leases and furnished to the MMS. Prior to the effective date of this assessment, more than 11,500 permits to conduct prelease geologic or geophysical (G&G) exploration had been issued on the OCS and more than 22,000 leases were awarded to industry for the exploration, development, and production of oil and natural gas. As a condition of these permits and leases, the MMS acquired approximately 1.75 million line-miles of two-dimensional (2-D) common depth point (CDP) seismic data and nearly 300,000 square miles of three-dimensional (3-D) CDP seismic data. Moreover, the MMS has accumulated geologic and reservoir engineering information from over 42,400 wells drilled on the U.S. continental margin. These exploration activities have resulted in the discovery of 1,151oil and gas fields.

In addition to these data, MMS had access to significant amounts of seismic and well data acquired from industry exploration activities on the Scotian Shelf released by the Canadian and Nova Scotian Governments. The MMS also acquired and analyzed seismic and well data from offshore in the Canadian Arctic, Bahamas, and Cuba. MMS evaluated and considered publicly available information from the onshore portions of the OCS basins, often working with the United States Geological Survey (USGS) in their complementary role of characterizing and assessing onshore and State waters oil and gas resources, as well as international geologic analogs from the South China Sea, Vietnam, North Sea, North Africa, Angola, Australia, Brazil, Norway, Canada, and Mexico among others. This database, in its entirety, was the information source for the play delineation process, as well as the basis for determining key parameters of geologic variables and pool size distributions for the OCS.

The 2-D and 3-D seismic surveys are the primary method of exploration for oil and gas. They allow geologists and geophysicists to image and map subsurface structures, identifying favorable conditions for the entrapment of hydrocarbons, as well as helping optimally locate exploration and development wells, thereby maximizing production volumes. As 3-D seismic technology has evolved, it enables a more accurate portrayal of subsurface structure and stratigraphy, and it sometimes can reveal information about fluids within the subsurface.

Seismic surveys involve the generation of low frequency sound energy (typically 10 to 125 hertz [Hz]) which penetrates into the earth and is reflected back by layers below the seafloor. The sound source is typically an array of airguns, which are towed behind a survey vessel (see Figure II-1). Airguns are essentially small compressed air chambers that vent their compressed air underwater. When reflected back by subsurface layers, the sounds are received by arrays of hydrophones, which are towed behind the survey vessel in long streamers, up to 12 km long. Sophisticated computer processing is then undertaken to interpret these "echo-returns" and construct an image of the subsurface.

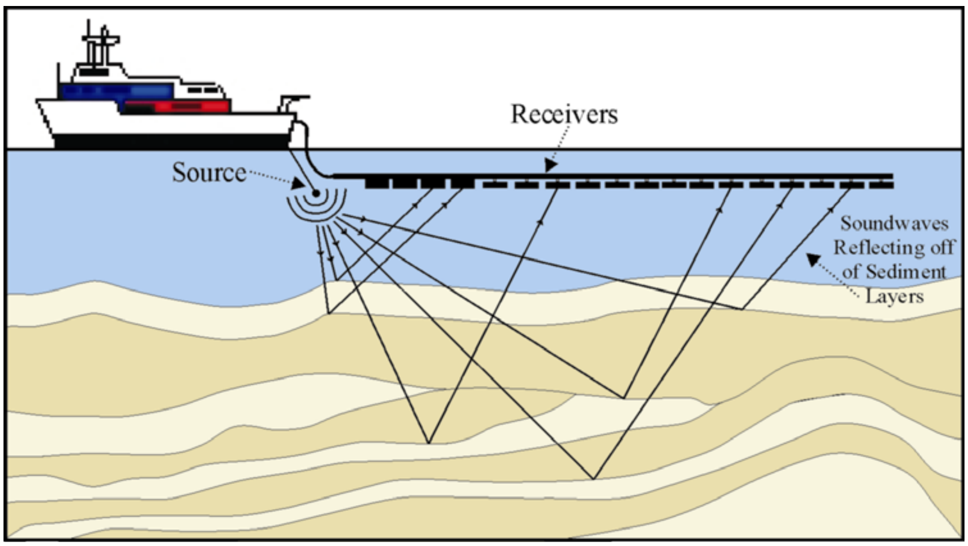



Figure II-1. Schematic View of Seismic Survey Vessel Showing Relation of Sound Source and Receivers.

## 4. Limitations of Resource Assessments

It is important to recognize that estimates of undiscovered oil and natural gas resources are just that: estimates. Resource assessments are an attempt to quantify something that cannot be accurately known until the resource has been developed and essentially depleted. In spite of this inherent uncertainty, resource assessments are valuable inputs to developing energy policy and for corporate planning—e.g., for ranking exploration opportunities, as a basis for economic analyses, and evaluations of technology and capital needs. The resource assessment results do not imply a rate of discovery or a likelihood of discovery and production within a specific timeframe. In other words, resource assessments cannot be used directly to draw conclusions concerning the rate of conversion of these undiscovered resources to reserves and ultimately to production. Due to the inherent uncertainties associated with an assessment of undiscovered resources, probabilistic techniques are used and the results are reported as a range of values corresponding to different probabilities of occurrence.

All resource estimates are subject to continuing revision as undiscovered resources are converted to reserves and reserves to production and as improvements in data and assessment methods occur. Uncertainty surrounding the estimates also decreases as the asset progresses through this cycle.

The estimates presented in this report should be considered general indicators and not predictors of the absolute volumes of petroleum potential of the areas. It is also important to realize that the UTRR volumes estimated may not be found or, in fact, produced. It is, however, implied that these resources have some chance of existing, being discovered, and possibly produced. Finally, serendipitous plays, those found as complete surprises, are not considered in this assessment. These unknown plays do not have a geologic model that can be logically assessed at this time. In sum, resource estimates should be viewed from the perspective of the point in time the assessment was performed—based on the data, information, and methodology available at that time.

## 5. Role of Technology and Economics in Resource Assessment

This assessment estimates technically recoverable hydrocarbon resources, both discovered and undiscovered. In developing these estimates, it is necessary to make fundamental assumptions regarding future technology and economics. The inability to accurately predict the magnitude and effect of these factors introduces additional uncertainty to the resource assessment.

Scientists can estimate the quantity of technically recoverable resources (both discovered and undiscovered) on the basis of the present state of geologic and engineering knowledge, modified by a subjective consideration of future technologic advancement. However, the quantity of resources that may ever actually be produced is dependent in large part upon economics. Actual cost/price relationships are critical determinants.

There is a technologic and economic limit to the amount of in-place oil and natural gas resources that can be physically recovered from a reservoir. Three principal factors affect the amount of oil or gas that can be recovered from a known reservoir— rock properties, technology, and economics. Advanced technology now provides for the exploitation of resources in challenging operating environments such as ultra-deep water or ultra-deep drilling that were not previously economically viable. New technologies such as horizontal wells and multi-lateral completions enable the recovery of a higher percent of the in-place resources from the field. The introduction of new technologies serves to expand the resource base that is identifiable and "technically or economically recoverable."

Scientific advances aided by new technologies have affected the ability to identify previously unknown potential exploration plays. One example is new seismic data acquisition techniques, which when combined with sophisticated computing technology and new data processing algorithms, result in the ability, for the first time, to "see" below massive salt bodies underlying a large portion of the Gulf of Mexico (GOM) OCS.

## B. Overview of Assessment Methodology

The assessment of hydrocarbon resources is a statistical analysis of geologic data. The principal procedural components of the assessment process consist of petroleum geological analysis, play definition and analysis, and resource estimation. Petroleum geological analysis forms the basis of the assessment. Play definition and analysis involves identifying and quantifying the necessary elements for the estimation of resources in a form that can be used for statistical resource estimation. Resource estimation uses a set of computer programs developed for the statistical analysis of play data. The results of that statistical analysis are estimates of the undiscovered technical resources of geologic plays.

These resource estimates were further subjected to a subsequent statistical analysis that incorporated economic and engineering parameters to estimate the undiscovered economically recoverable resources for the assessment areas. For those geographic areas with production, an estimate of the total endowment is obtained by adding cumulative production to estimates of discovered resources and UTRR. For a detailed summary of MMS's resource assessment methodology please refer to Appendix B of this report.

## C. Oil and Gas Resource Estimates

### 1. Introduction

Essential in performing the resource management mission responsibilities of the DOI is developing and maintaining a thorough knowledge of the resource base. This knowledge provides an understanding of the characteristics and distribution of the resource, providing a sound basis for decisions related to resource management issues. With this as the primary objective, the MMS completed an assessment of the technically and economically recoverable oil and natural gas resources of the OCS in 2006 (MMS 2006a, MMS 2006b, MMS 2006c). This assessment was the culmination of a multi-year effort that reflected data and information available on January 1, 2003, incorporated advances in petroleum exploration and development technologies.

This section summarizes the results of the MMS's 2006 assessment of the technically recoverable oil and gas resources for the U.S. OCS. Technically recoverable resources are hydrocarbons potentially amenable to conventional production regardless of the size, accessibility, and economics of the accumulations assessed. The OCS comprises the portion of the submerged seabed whose mineral estate is subject to Federal jurisdiction (see Figure II-2).

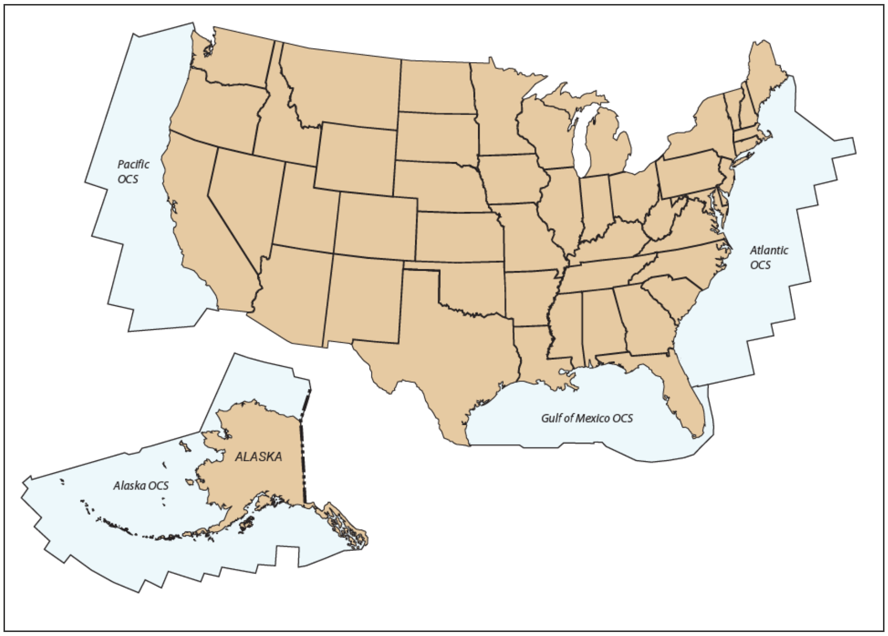



Figure II-2. Map Showing the United States Outer Continental Shelf

In addition to presenting the results of the assessment, this section also contains discussions of the interpretation and utility of resource estimates, and of improvements in estimates by acquiring additional data. Also, a comparison with the previous two MMS assessments is included.

## 2. 2006 National Assessment Results

### a. Undiscovered Technically Recoverable Resources

The 2006 assessment provided estimates of the undiscovered, technically recoverable (UTRR) and undiscovered economically recoverable (UERR) oil and natural gas resources located outside of known oil and gas fields on the OCS. The assessment considered recent geophysical, geological, technological, and economic information and utilized a probabilistic play-based approach to estimate the UTRR of oil and gas for individual plays. This methodology, described in Appendix B is suitable for both conceptual plays where there is little or no specific information available, and for developed plays where there are discovered oil and gas fields and considerable information is available. After estimation, individual play results were aggregated to larger areas such as basins, planning areas, and regions. The UTRR results are presented here on a regional basis, and in Appendix C on a planning area basis. Estimates of the quantities of historical production, reserves, and future reserves appreciation are presented to provide a frame of reference for analyzing the estimates of UTRR.

The UTRR estimates are presented as a range of estimates, and include the mean estimate and the 95th and 5th percentile levels. This range of estimates corresponds to a 95-percent probability (a 19 in 20 chance) and a 5-percent probability (a 1 in 20 chance) of there being more than those amounts of petroleum present, respectively. The 95- and 5-percent probabilities are considered reasonable minimum and maximum values, and the mean is the average or expected value.

Estimates of UTRR for the entire OCS range from 66.6 billion barrels of oil (Bbo) at the F95 fractile to 115.1 Bbo at the F5 fractile with a mean of 85.9 Bbo (Figure II-3 and Table II-1). Similarly, gas estimates range from 326.4 to 565.9 trillion cubic feet of gas (Tcf) with a mean of 419.9 Tcf. On a barrel of oil-equivalence (BOE) basis, 54 percent of the potential is located within the Gulf of Mexico. The Alaska OCS ranks second with 31 percent. The Pacific is third among the Regions in terms of oil potential and fourth with respect to gas. The Atlantic Region, on the other hand, ranks third when considering gas potential and fourth in terms of oil.

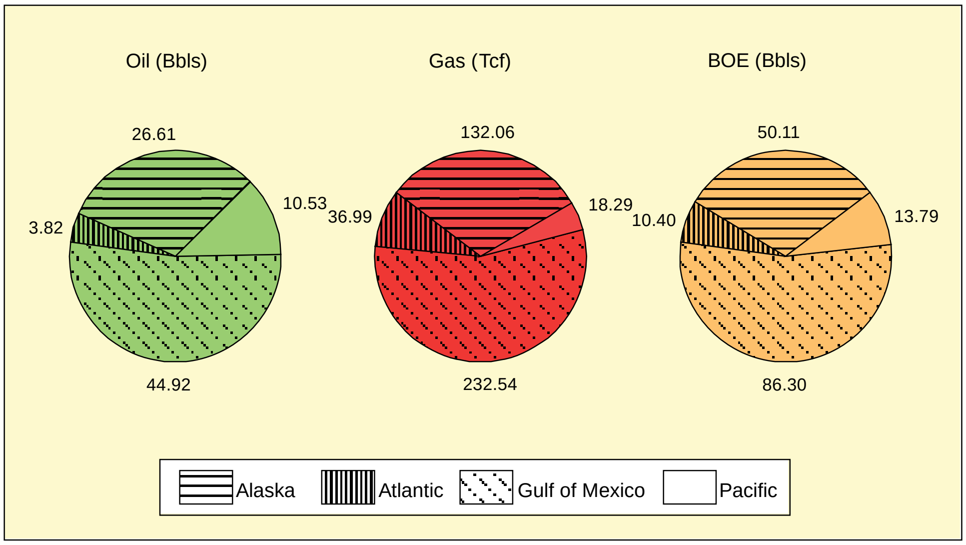



Figure II-3. Mean Undiscovered Technically Recoverable Resources by Type and Region.

Table II-1. Undiscovered Technically Recoverable Resources of the OCS

| Region | Oil (Bbo) | | | Natural Gas (Tcf) | | | BOE (Bbo) | | |
|---|---|---|---|---|---|---|---|---|---|
| | F95 | Mean | F5 | F95 | Mean | F5 | F95 | Mean | F5 |
| Alaska OCS | 8.66 | 26.61 | 55.14 | 48.28 | 132.06 | 279.62 | 17.25 | 50.11 | 104.89 |
| Atlantic OCS | 1.12 | 3.82 | 7.57 | 14.30 | 36.99 | 66.46 | 3.67 | 10.40 | 19.39 |
| Gulf of Mexico OCS | 41.21 | 44.92 | 49.11 | 218.83 | 232.54 | 249.08 | 80.15 | 86.30 | 93.43 |
| Pacific OCS | 7.55 | 10.53 | 13.94 | 13.28 | 18.29 | 24.12 | 9.91 | 13.79 | 18.24 |
| | | | | | | | | | |
| Total U.S. OCS | 66.60 | 85.88 | 115.13 | 326.40 | 419.88 | 565.87 | 124.68 | 160.60 | 215.82 |

(Bbo-billion barrels of oil; Tcf-trillion cubic feet of gas. F95 indicates a 95-percent chance of at least the amount listed; F5 indicates a 5-percent chance of at least the amount listed. Only mean values are additive.)

Technological advances in hydrocarbon exploration and development are sure to occur in the future, yet the nature and timing of advancement is extremely difficult to predict, and its impact difficult to estimate. For the purpose of this assessment, recent technological advances in gathering, processing, and interpreting seismic data contributed to a better characterization of geologic parameters and identification and mapping of the geologic plays than in past assessments. Similarly, recent technological advances in offshore drilling and development operations were incorporated through the assumptions of what is technically recoverable as well as the costs of these activities.

However, no attempt was made to determine an empirical relationship between the future technological advancements and the estimated undiscovered resources.

### b. Total Hydrocarbon Endowment

Estimates of the quantities of historical production, reserves, and future reserves appreciation are presented to provide a frame of reference for analyzing the estimates of UTRR. The total endowment is the sum of historical production, current reserves, future reserves appreciation, and UTRR. Mean estimates of the OCS total hydrocarbon endowment are 115.4 Bbo and 633.6 Tcf (228.2 billion barrel of oil equivalent [BBOE]). The total endowment distribution by resource category can be seen in Table II-2 and Figure II-4.

Table II-2. Distribution of Total Hydrocarbon Endowment by Type, Region, and Resource Category

| Resource Category | | Alaska OCS | Atlantic OCS | Gulf of Mexico OCS | Pacific OCS | Total OCS |
|---|---|---|---|---|---|---|
| Cumulative Production | Oil ( Bbo) | .01 | 0 | 13.05 | 1.06 | 14.12 |
| | Gas (Tcf) | 0 | 0 | 152.25 | 1.32 | 153.57 |
| | BOE (Bbo) | .01 | 0 | 40.14 | 1.29 | 41.45 |
| | | | | | | |
| Reserves | Oil ( Bbo) | .03 | 0 | 7.06 | 1.46 | 8.55 |
| | Gas (Tcf) | 0 | 0 | 27.70 | 1.56 | 29.26 |
| | BOE (Bbo) | .03 | 0 | 11.98 | 1.74 | 13.76 |
| | | | | | | |
| Reserves Appreciation | Oil ( Bbo) | - | - | 6.88 | - | 6.88 |
| | Gas (Tcf) | - | - | 30.91 | - | 30.91 |
| | BOE (Bbo) | - | - | 12.38 | - | 12.38 |
| | | | | | | |
| UTRR (Mean) | Oil ( Bbo) | 26.61 | 3.82 | 44.92 | 10.53 | 85.88 |
| | Gas (Tcf) | 132.06 | 36.99 | 232.54 | 18.29 | 419.88 |
| | BOE (Bbo) | 50.11 | 10.40 | 86.30 | 13.79 | 160.60 |
| | | | | | | |
| Total Endowment | Oil ( Bbo) | 26.65 | 3.82 | 71.91 | 13.05 | 115.43 |
| | Gas (Tcf) | 132.06 | 36.99 | 443.40 | 21.17 | 633.62 |
| | BOE (Bbo) | 50.15 | 10.40 | 150.81 | 16.82 | 228.18 |

(Bbo-billion barrels of oil; Tcf-trillion cubic feet of gas.)
Note: Data and information as of January 1, 2003

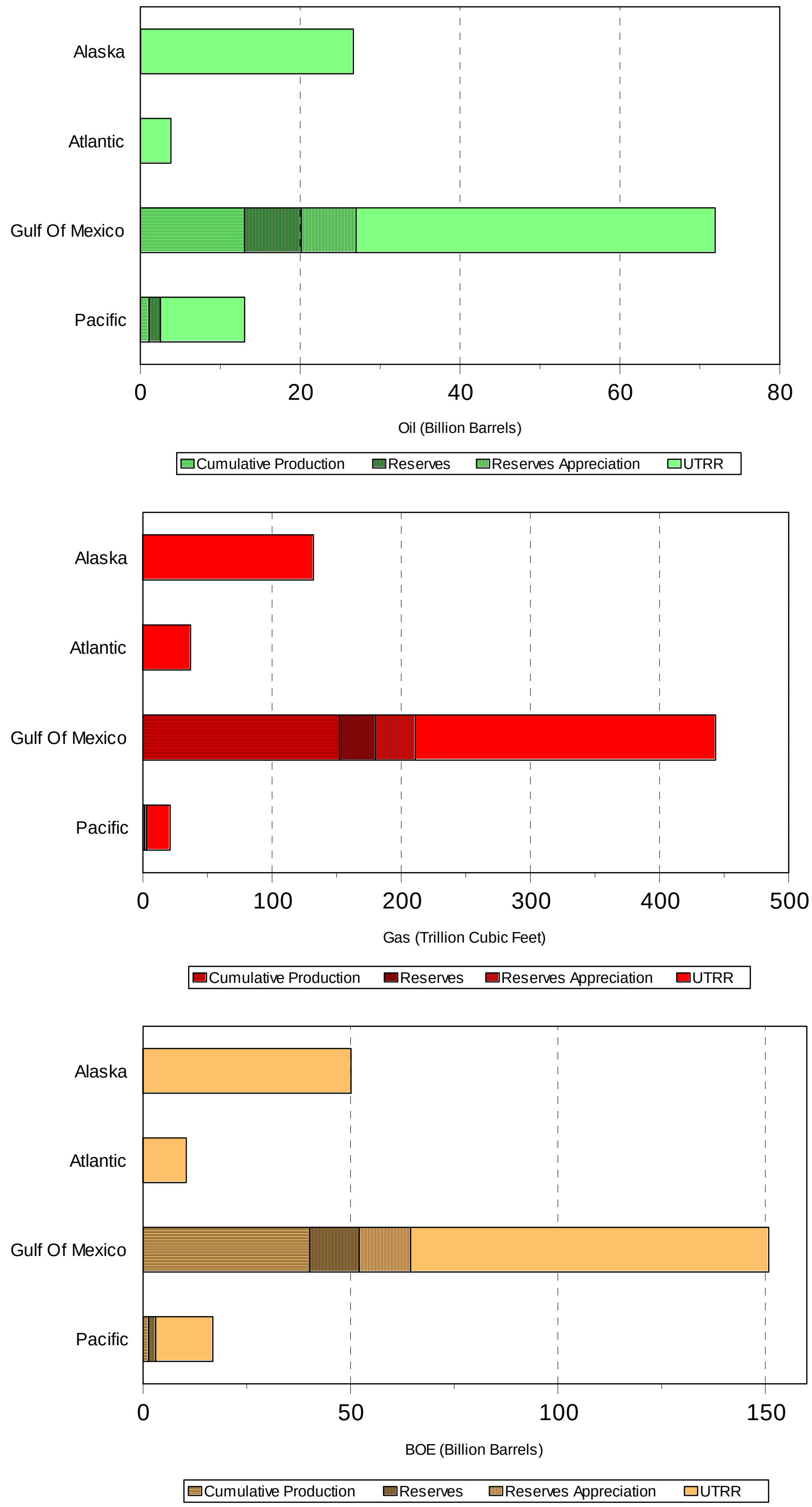



**Figure II-4.** Distribution of Total Hydrocarbon Endowment by Type, Region, and Resource Category (Note: Alaska OCS cumulative production is 0.01 Bbo and reserves are 0.03 Bbo.)

After more than 50 years of exploration and development, 70 percent of the mean BOE total endowment is represented by undiscovered resources. More than half of this potential exists in areas of the OCS outside of the Central and Western GOM. During the 50 year history of OCS production more than 14 Bbo and 153 Tcf have been produced. The majority of the remaining reserves, 7.1 Bbo and 27.7 Tcf, are located within fields in the Central and Western GOM. Equally important as a source of future domestic production is the 6.9 Bbo and 30.9 Tcf projected as future volumes of reserves appreciation within the existing Gulf of Mexico fields.

**Cumulative Production:** Cumulative production is a measured quantity that can be accurately determined. Because cumulative production is a measurable entity, the uncertainty associated with these estimates is considerably less than with comparable estimates of volumes of reserves and considerably less than estimates of undiscovered resources.

Through January 1, 2003, 14.1 Bbo and 153.6 Tcf (41.4 BBOE) were produced from the Federal OCS (see Figure II-5 and Table II-2. Almost 97 percent of this production has occurred within the GOM.

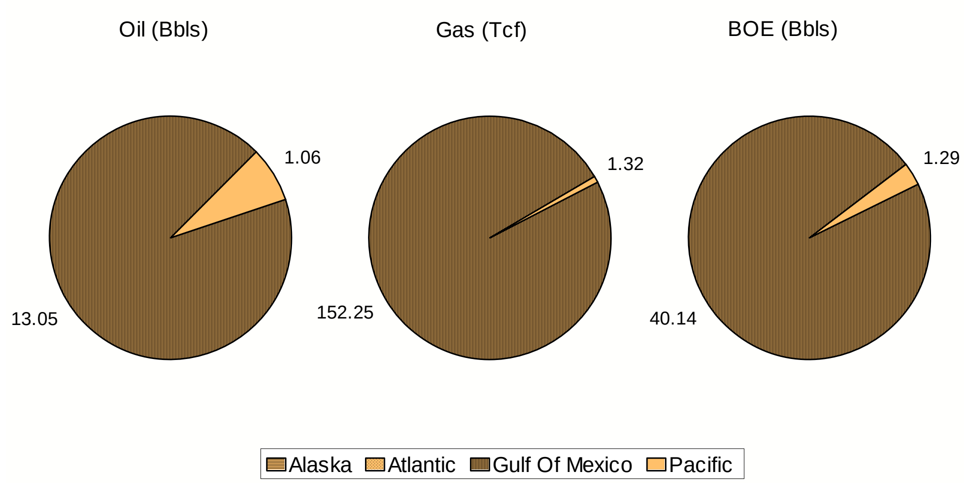



Figure II-5. Distribution of Cumulative Production by Type and Region
(Note: Alaska OCS cumulative production is 0.01 Bbo and reserves are 0.03 Bbo.)

**Reserves:** Reserves are frequently estimated at different stages during the exploration and development cycle of a hydrocarbon accumulation, i.e., after exploration and delineation drilling, during development drilling, after some production and, finally, after production has been well established. Different methods of estimating the volume of reserves are appropriate at each stage. Reserve estimating procedures generally progress from volumetric to performance-based techniques as the field matures. The relative uncertainty associated with these estimates decreases as more subsurface information and production history become available. Table II-2 shows that the total proved and unproved reserves remaining in the 1,151 fields beneath the OCS are estimated to be 8.6 Bbo and 29.3 Tcf (13.8 BBOE). Nearly 94 percent of the reserves are present within the GOM (see Figure II-6). Because there are no current activities or leases in the Atlantic OCS, there are no reserves identified there.

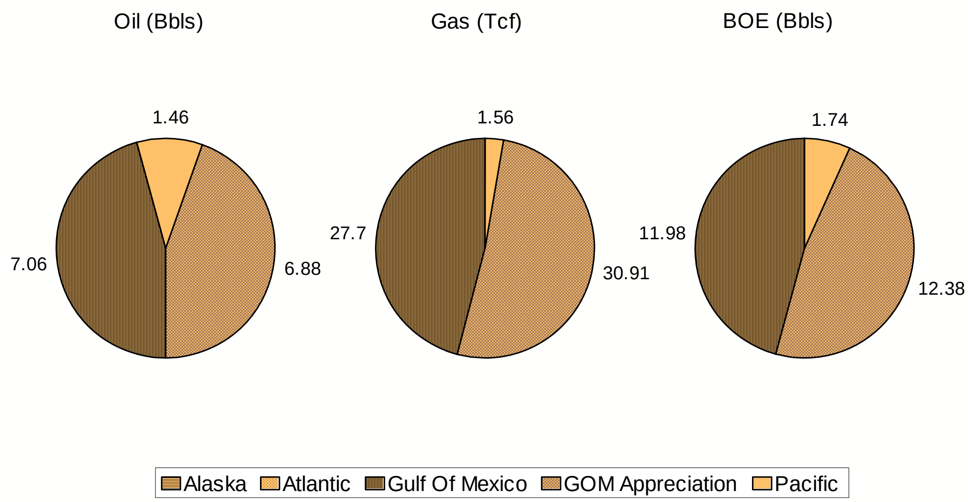



Figure II-6. Distribution of Reserves by Type and Region
(Note: Alaska OCS reserves are 0.030 Bbo.)

**Reserves Appreciation:** Cumulative production plus total estimated future production (from reserves) equals the estimate of the ultimate recovery (EUR) from a field. Predicting a field's true EUR requires an estimate of its future reserves growth or appreciation. The reserves appreciation phenomenon has been observed in onshore and offshore basins for years. During the initial years after discovery, Gulf of Mexico OCS reserve estimates typically increase rapidly. The rate of growth then tends to level off at a much smaller annual rate of increase. Appreciation is the result of numerous factors which occur as a field is developed and produced, most importantly:

- Revisions resulting from recalculations of viable reserves in dynamically changing economic and operating conditions;
- An increased understanding of the petroleum reservoir;
- Physical expansion of the field through the discovery of new reservoirs or the extension of existing reservoirs; and
- Improved recoveries due to experience with actual field performance, the implementation of new technology, and/or changes in the cost-price relationships.

Growth functions are modeled from empirical historical trends derived from the set of existing OCS fields having proved reserves as of January 1, 2003. These trends were used to develop an estimate of an existing field's size at a future date. Growth factors represent the ratio of the size of a field several years after discovery to the initial estimate of its size in the year of discovery. The assumptions central to this analysis are that:

- The amount of growth in any year is proportional to the size of the field;
- This proportionality varies inversely with the age of the field;
- The age of the field is a reasonable proxy for the degree to which the factors causing appreciation have operated; and
- The factors causing future appreciation will result in patterns and magnitudes of growth similar to that observed in the past.

The appreciation model used in this assessment projects no growth for fields more than 53 years of age. This appears to be a reasonable assumption for the OCS since it fits well with the observed data and does not entail extending projections considerably beyond the timeframe of the observations. On balance, however, the model used in this assessment of reserves appreciation is apt to be conservative. The oldest fields are generally the largest, contribute the bulk of the original proved reserves, and also are most likely to experience growth beyond 53 years of age.

Reserves appreciation in the GOM routinely exceeds new field discoveries and contributes the bulk of annual additions to proved reserves. It is an important consideration in any analysis of future oil and natural gas supplies. Future reserves appreciation within the existing active fields in the GOM OCS is estimated at 6.9 Bbo and 30.9 Tcf (12.3 BBOE) (see Figure II-6 and Table II-2). This anticipated volume of growth approaches the yearend 2002 estimate of proved and unproved reserves in the GOM.

Reserves appreciation has not been estimated for the existing fields on the California and Alaska OCS. The fields off California have not exhibited any meaningful pattern in the growth of the EUR that could be used to project future appreciation. The single producing field on the Alaska OCS is primarily in state waters and does not have a significant production history.

### c. Undiscovered Economically Recoverable Resources

The economic analysis is the second phase in the assessment of each petroleum province, following the assessment of the geologic characteristics and UTRR. The geologic model generates an inventory of pools in each play, which is sampled repeatedly to select pools for the simulations in the economic model. After the modeling run is completed, statistics are aggregated for successful (profitable pools) and unsuccessful (not discovered or negative Net Present Value simulations). Economic volumes of oil and gas, including associated substances (solution gas in oil, condensate liquids in gas) are compiled, and probability levels are calculated. The reported volumes are considered as “risked” because unsuccessful trials are included in the statistics. These results are known as the Undiscovered Economically Recovered Resources.

The UERR's for the 2006 assessment were generated using an oil price range of $8/barrel (bbl) to $80/bbl and can be found in MMS (2006b). This analysis was updated for the Draft Proposed OCS Oil and Gas Leasing Program 2010-2015 in January 2009 (MMS 2009). For the updated analysis, an oil price range of $60/bbl to $160/bbl was used to account for then record high commodity prices. In addition, MMS's economic model was updated to incorporate a relationship between oil price and development costs. Capturing observed variations in oil and gas exploration and development costs across a wide range of oil prices improved the MMS confidence in estimating UERR's.

Results are shown in Table II-3 and indicate that approximately 53 percent of the total UTRR is economically recoverable on a BOE basis, with an oil price of $60/bbl and gas price of $6.41/Mcf. This increases to about 78 percent with an oil price of $160/bbl and gas price of $17.08/Mcf.

Table II-3. Mean Undiscovered Economically Recoverable Resources of the OCS

| Region | $60/bbl and $6.41/Mcf | | | $110/bbl and $11.74/Mcf | | | $160/bbl and $17.08/Mcf | | |
|---|---|---|---|---|---|---|---|---|---|
| | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) |
| Alaska OCS | 4.45 | 7.20 | 5.73 | 11.45 | 30.01 | 16.79 | 15.46 | 50.78 | 24.50 |
| Atlantic OCS | 2.58 | 14.55 | 5.17 | 3.07 | 21.85 | 6.96 | 3.28 | 25.79 | 7.87 |
| Gulf of Mexico OCS | 36.75 | 165.94 | 66.28 | 41.04 | 203.43 | 77.24 | 42.56 | 214.87 | 80.79 |
| Pacific OCS | 8.38 | 13.16 | 10.72 | 9.29 | 15.14 | 11.98 | 9.49 | 15.60 | 12.27 |
| | | | | | | | | | |
| Total U.S. OCS | 52.16 | 200.85 | 87.90 | 64.85 | 270.43 | 112.97 | 70.79 | 307.04 | 125.42 |

(Bbo-billion barrels of oil; Tcf-trillion cubic feet of gas.)

### d. Comparison with Previous Assessments

A general comparison of UTRR results from 1996, 2001, and 2006 MMS assessments is shown in Figure II-7. At the mean level, the estimates of UTRR for the entire OCS represent an increase compared to the previous (2001) assessment of 10.9 Bbo and 57.7 Tcf or about 15 percent for oil and gas. The vast majority of this increase occurred in the GOM, where estimates of UTRR range from 41.2 to 49.1 Bbo and 218.8 to 249.1 Tcf, with a mean of 44.9 Bbo and 232.5 Tcf, respectively. Significant increases in the estimates for the deepwater areas were the major contributor to the overall growth in the estimates of UTRR for oil. The majority of the increase in the estimate of UTRR from gas was related to deep gas plays located beneath the shallow water shelf of the GOM. This increase in UTRR was also accompanied by approximately 4.5 Bbo and 14 Tcf that were discovered in fields such as Thunder Horse and Holstein, whose resources were moved to the reserve category during this time period.

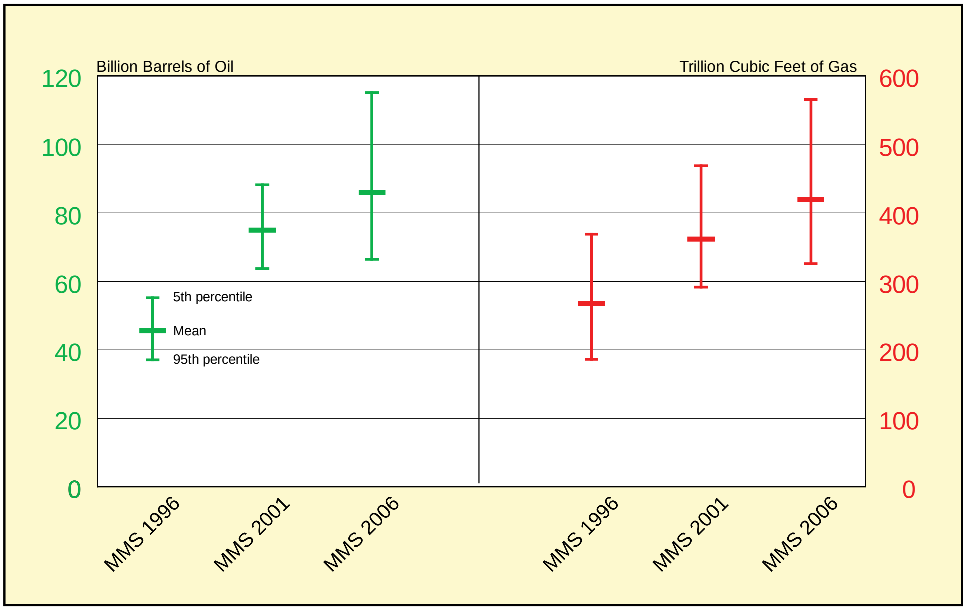



Figure II-7. Comparison of UTRR from MMS 1996, 2001, and 2006 Assessments

In the Pacific OCS Region, the mean estimate for UTRR of 10.5 Bbo and 18.3 Tcf represented a slight decrease for both oil and natural gas. This decrease was due to the inclusion of updated analog information from producing fields. The Atlantic OCS estimate of UTRR ranges from 1.1 to 7.6 Bbo and 14.3 to 66.5 Tcf, with a mean of 3.8 Bbo and 37.0 Tcf. The estimates represent a 66-percent increase in oil resources and a 33-percent increase in gas resources in the Atlantic OCS, when compared with the MMS 2001 assessment. The last remaining leases in the Atlantic OCS, on the Manteo Prospect, expired in 2002 without a well being drilled. However, significant new analog information was available as the result of recent exploration in the Scotian Shelf offshore Canada and the West African Continental Slope offshore Mauritania. Applying these new exploration ideas to the older Atlantic play models led to adjustments to risks in previously defined plays and the identification of additional new plays.

Estimates of UTRR on the Alaska OCS changed only slightly compared to the previous assessment. The mean oil estimate increased by 1.7 Bbo, while the mean natural gas estimate declined by 6.7 Tcf. The first Alaskan OCS production occurred in 2001 from the joint State/Federal Northstar Unit in the Beaufort Sea.

## 3. Interpreting Resource Estimates

The main objective of the government's assessment of undiscovered resources is to develop a set of scientifically-based hypotheses concerning the potential quantities of oil and natural gas that may exist on the OCS. The estimates are used primarily for internal planning and policy purposes. The MMS's assessments represent the government scientists' best estimate of what quantities of oil and natural gas remain undiscovered given the current state of geologic knowledge and reasonably foreseeable technology. Both the MMS and the EIA use these assessments for planning, forecasting, and policy analyses. The oil and gas companies and private investors will use this information generally to guide investment decisions and their search for new resources.

Each assessment reflects a snapshot in time. True knowledge of the extent of oil and natural gas resources can only come through the actual drilling of wells. Estimating undiscovered resources, no matter how sophisticated the models and statistical techniques employed, is an inherently uncertain exercise that is based on hypotheses and assumptions, with the results limited by the quality of the underlying geologic data and current understanding of the origin and entrapment of petroleum. Results incorporate perceived levels of risk and are expressed in ranges of estimates to reflect uncertainty. Nevertheless, resource assessments are a critical component of energy policy analysis, and provide important information about the relative potential of U.S. offshore areas as sources of oil and natural gas to supply the Nation's future energy needs.

The Government's resource assessments typically focus on large areas to estimate the potential size distributions of undiscovered accumulations of oil and gas. These assessments do not attempt to locate, identify, or delineate specific potential fields or prospects.

## 4. Data Gaps

There is much uncertainty in the resource estimates due to a lack of adequate data, especially in those OCS areas which have been unavailable for exploration and development for many years. For example, outside of the active OCS producing areas, significant quantities of oil and gas resources are known to exist in part of the Eastern GOM and the California OCS, but in other areas, less is known about resource potential due to scarce or older data. In Alaska, there has not been any commercial exploration activity in many of the areas outside the Beaufort and Chukchi Seas for the past two decades.

There have been significant advances in exploration, formation evaluation and exploitation technologies that potentially could be utilized in these frontier areas today. Significant advancements in the technology of seismic data acquisition and processing allow for use of these data to create high resolution images of the subsurface to great depths.

To support policy decisions that rely on the best possible resource estimates, it is important to obtain sufficient G&G data for all areas in order to make appropriate comparisons and to reduce uncertainty about resource potential, especially in frontier areas. Specific discussions of information gaps and data adequacy are included in Sections II-C.5.a through II-C.5.d of this report. To target limited areas in frontier planning areas and better define the resource potential of specific sites, seismic surveys could be acquired. See Appendix D for a brief discussion of the efforts and costs involved.

## 5. New Program Areas

New areas in the Atlantic, Eastern Gulf of Mexico, Pacific, and Alaska OCS have been identified for potential inclusion in the 2010-2015 Draft Proposed Program. Although leasing has not occurred in these areas for upward of 20 years, all have undergone previous exploration, and several of the areas contain active leases with producing oil and gas fields. This section summarizes the geology, previous leasing, exploration, development history, oil and gas resources, and current G&G data needs of these new areas.

### a. Atlantic OCS Region

#### (1) Geographic and Geologic Setting

The Atlantic OCS Region encompasses an area of 269.13 million acres and includes the Atlantic offshore area from Canada to the offshore territorial waters of the Bahamas and Cuba (Figure II-8). The area begins 3-miles off the coastal States where water depths range from approximately 80 to more than 10,000 feet. The Atlantic OCS area is divided into four planning areas: the North Atlantic, Mid-Atlantic, South Atlantic, and the Straits of Florida. Due to its location and geology, the MMS includes the Straits of Florida Planning Area with the Gulf of Mexico for resource assessment purposes. The Straits of Florida Planning Area resources are not included in this report.

The Atlantic OCS is a passive continental margin, underlain by Mesozoic and Cenozoic sediments. In the northern and central area, sediments underlying the shelf are siliciclastic, derived from the erosion of the Appalachian Mountains, with platform and possibly reefal carbonates lying seaward of the siliciclastics. Carbonate rocks predominate in the southern portion of the Atlantic OCS. The sedimentary section of the Atlantic OCS attains thicknesses exceeding 40,000 feet.

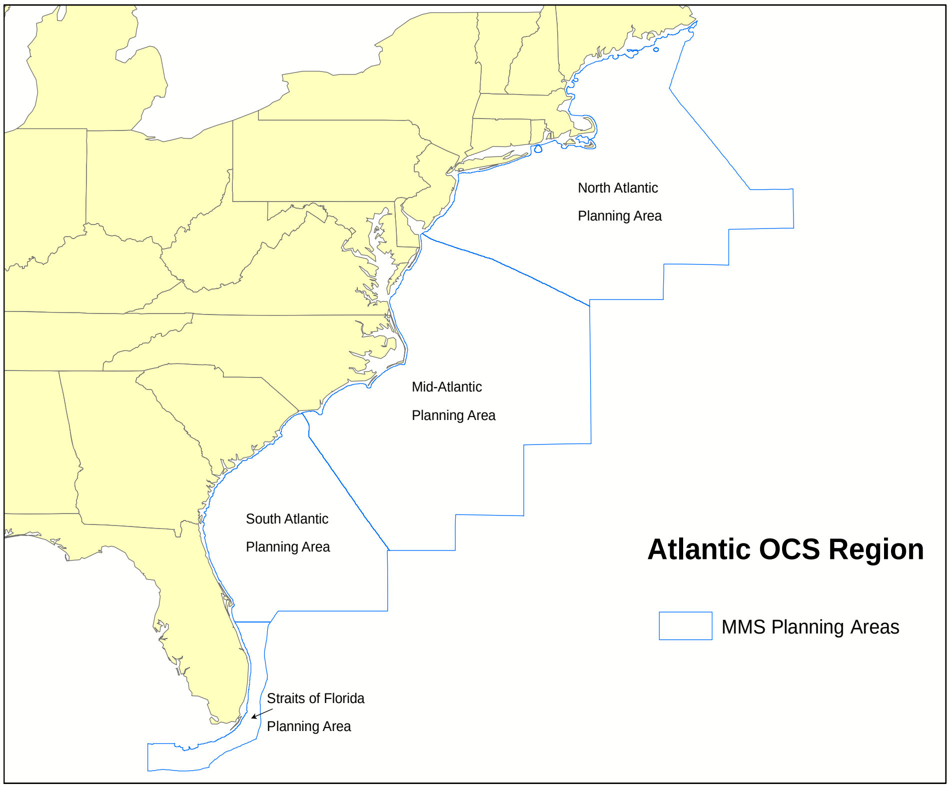



Figure II-8. Map of the Atlantic OCS Region

During the Jurassic and Cretaceous, siliciclastic sediments were eroded from the Appalachian Mountains and were deposited on the Atlantic Margin shelf. Delta complexes prograded across the shelf and submarine fans were deposited on the slope where siliciclastic sediment influx was sufficient. Potential reservoirs were deposited in delta complexes, barrier bars, and channel systems on the shelf, and in fan complexes on the slope. Trapping structures include mainly anticlines, growth faults, and normal faults. Potential source rocks may include shelf and slope shales, and lagoonal coals. However, only platform carbonates have been geochemically identified as being source rocks, based on analysis of the condensates recovered in well tests. Seals are provided by Mesozoic limestones, or by overlying shales.

In addition, shelf-edge carbonate margin complexes with associated platforms, “reefs”, and talus were deposited contemporaneously. These carbonate depositional environments developed where deltaic siliciclastic influx was minimal. Potential reservoirs may be located in the reef itself, in the fore-reef talus, and in the back-reef as oolitic, pelletal, or reef detritus grainstones. Creation of secondary porosity is critical to forming reservoirs in these rocks. Although subaerial exposure is often assumed to facilitate the creation of porosity, existing drilling indicates that it also creates a significant risk by destroying top seals for reservoirs. In the only commercial discovery, Deep Panuke (offshore Nova Scotia, Canada) porosity is created by hydrothermal dolomitization of the reservoir, and the top seal consists of additional carbonate margin facies. Traps are expected to be mainly stratigraphic on the carbonate platform. Combination stratigraphic and fault traps may occur within the reef complex on the shelf edge and in reef talus on the slope. Potential source rocks include shelf and slope shales, and possibly lagoonal and platform carbonates. Source rocks have been geochemically identified as being deeper, more mature carbonate facies.

The primary geologic plays assessed are regional in scope spanning the Atlantic OCS margin (Figure II-9). They include Cretaceous and Jurassic siliciclastic plays and Jurassic carbonate margin plays that are based on analog fields from offshore Nova Scotia and the Gulf Coast, both onshore and offshore. The MMS is currently in the process of reassessing the oil and gas resources of the Atlantic OCS Region. This reassessment is focusing on specific basins along the Atlantic margin and incorporating analog field information from discoveries elsewhere along the Atlantic margin including Eastern Canada and West Africa.

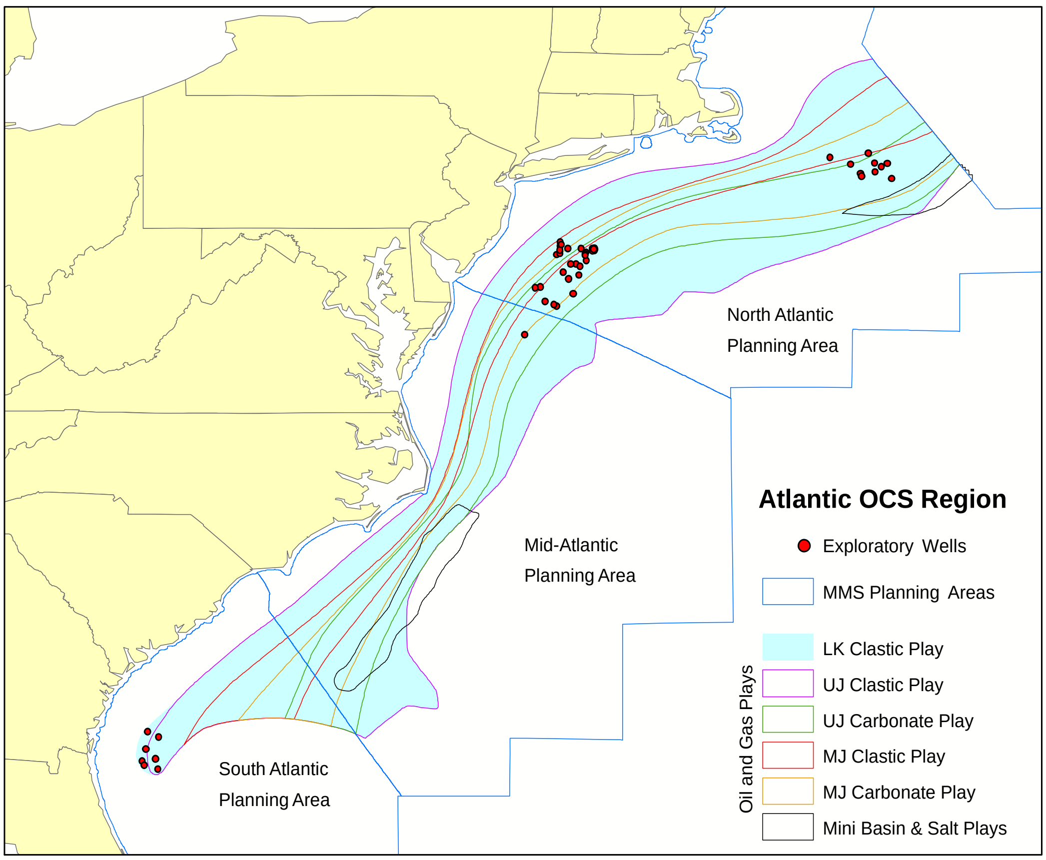



Figure II-9. Map of Atlantic OCS Region Showing the Extent of Oil and Gas Plays and Exploratory Well Locations

### (2) Exploration and Discovery History

Between 1959 and 1983, 9,240 tracts were offered for lease, and 433 blocks were leased in the 10 lease sales that occurred in the Atlantic OCS Region. This leasing program resulted in 49 exploratory wells and five Continental Offshore Strategic Test (COST) wells drilled. At present, there are no remaining active oil and gas leases in the Atlantic OCS Region. On November 17, 2000, the interests in the last remaining eight natural gas and oil leases active in the Federal waters offshore North Carolina were relinquished by Conoco, Shell Offshore, and OYX USA.

The North Atlantic Planning Area lies offshore Maine to New Jersey. The area encompasses approximately 92.32 million acres of seafloor on the Federal OCS. Thirty-nine exploratory wells and four COST wells have been drilled in the North Atlantic Planning Area. The Mid-Atlantic Planning Area lies offshore Delaware to North Carolina and encompasses about 112.83 million acres on the Federal OCS. Only one well was drilled in the Mid-Atlantic Planning Area.

In the Mid- and North Atlantic area, industry's primary interest was focused on the Baltimore Canyon Trough offshore New Jersey, where two deep stratigraphic tests (one with a hydrocarbon show) and 32 exploratory wells were drilled. Tests on the "Great Stone Dome" structure, the largest in this area, were dry. The only drilling successes achieved on the Atlantic OCS were in the area offshore New Jersey. Eight wells were drilled, in a four block area referred to as the Hudson Canyon Block 598 Area. All eight wells encountered natural gas and/or condensate, and five had successful drillstem tests. These leases were later abandoned as sub-commercial.

Analysis of the Baltimore Canyon Trough wells suggests that deeper, more thermally mature source rocks not encountered in the wells generated the hydrocarbons encountered. A lack of hydrocarbon shows on drilled structures other than those similar to the Hudson Canyon 598 may imply that the source rocks are locally, not regionally, present. Siliciclastic reservoir qualities are poor to fair with relatively low permeability in the most likely perspective reservoirs. Reservoir porosity and permeability both deteriorate with depth and southward in the Baltimore Canyon Trough.

In the Georges Bank Basin offshore New England, eight exploratory and two COST wells were drilled. Exploration targets were Jurassic oolite banks, reefal buildups, and carbonate drape structures over basement highs. The drilling results in this basin were disappointing. Analysis of the drilling results suggests that there is considerable risk as to the presence of both source rocks and reservoir rocks. Total organic carbon (TOC) analyses available in seven of 10 wells drilled in this area show a low value of less than 1 percent, with only one TOC value greater than three percent. Both potential carbonate and siliciclastic reservoir rocks encountered were of low quality with permeabilities generally less than 1 millidarcy.

The last wells drilled on the Atlantic OCS were operated by Shell Oil, which undertook an ambitious, four well, deepwater drilling program in the Baltimore Canyon Trough. This program set what at the time were several world records for deep water drilling operations. Three of these wells were in the North Atlantic Planning Area, and one was the only well in the Mid-Atlantic Planning Area. The targets were the Mesozoic shelf-edge carbonate margin complex and an associated shelf-margin delta complex in an anticlinal closure. All of these wells were dry holes. Limestone reservoirs targeted by Shell had adequate reservoir porosity and permeability, but were never deeply buried. It is very probable that when more deeply buried, reservoir conditions would deteriorate unless reservoirs have been dolomitized. Lack of timely deposition and lithification of top sealing units were a probable cause of failure for several of the Shell wells.

The South Atlantic Planning Area lies offshore South Carolina to Florida. The area encompasses approximately 54.34 million acres. There were 109 blocks leased as a result of several OCS sales. Six exploratory wells and one COST well were drilled in this planning area. Companies targeted Cretaceous and Jurassic siliciclastic rocks on several basement-cored structures, and one tilted fault block trap. Analyses of the wells indicated that source rocks, reservoir rocks and seal rocks are lacking. Consequently, industry has subsequently expressed no further interest in this area.

The Straits of Florida Planning Area lies offshore South Florida and encompasses approximately 9.64 million acres. The only lease sale held in this area, Sale #5, was held in 1959. Of the 80 tracts offered, 23 were leased, each receiving a single bid. In 1960, three exploratory wells were drilled in the vicinity of the Dry Tortugas. These wells were considered dry holes although one encountered hydrocarbon shows.

### (3) Resource Estimates

The 2006 MMS assessment indicates that the Atlantic OCS Region could contain sufficient overall gas and oil accumulations large enough to support economic development. The total volume of mean UTRR is estimated to be 3.82 Bbo and 36.99 Tcf of gas. At the high case (F5), the estimated UTRR is 7.57 Bbo and 66.46 Tcf of gas, and at the low case (F95), the estimated UTRR is 1.12 Bbo and 14.30 Tcf of gas (Table II-4).

Table II-4. Undiscovered Technically Recoverable Resources in the Atlantic OCS Region

| Atlantic OCS Region | Oil (Bbo) | | | Natural Gas (Tcf) | | | BOE (Bbo) | | |
|---|---|---|---|---|---|---|---|---|---|
| | F95 | Mean | F5 | F95 | Mean | F5 | F95 | Mean | F5 |
| North Atlantic PA | 0.57 | 1.91 | 3.80 | 7.18 | 17.99 | 32.17 | 1.85 | 5.12 | 9.52 |
| Mid-Atlantic PA | 0.43 | 1.50 | 2.96 | 5.44 | 15.13 | 27.53 | 1.39 | 4.19 | 7.85 |
| South Atlantic PA | 0.13 | 0.41 | 0.81 | 1.67 | 3.86 | 6.76 | 0.43 | 1.10 | 2.01 |
| | | | | | | | | | |
| Total Atlantic OCS | 1.12 | 3.82 | 7.57 | 14.30 | 36.99 | 66.46 | 3.67 | 10.40 | 19.39 |

(PA-Planning Area; Bbo-billion barrels of oil; Tcf-trillion cubic feet of gas. F95 indicates a 95-percent chance of at least the amount listed; F5 indicates a 5-percent chance of at least the amount listed. Only mean values are additive.)

Table II-5 shows the results of MMS's economic analysis of the Atlantic OCS Planning Area. At the mean, about 50 percent of the UTRR resources are economically recoverable at an oil price of $60/bbl, and a gas price of $6.41/thousand cubic feet (Mcf). This increases to about 76 percent of the UTRR being economically recoverable at an oil price of $160/bbl and a gas price of $17.08/Mcf.

Table II-5. Mean Undiscovered Economically Recoverable Resources of the Atlantic OCS Region

| Atlantic OCS Region | $60/bbl and $6.41/Mcf | | | $110/bbl and $11.74/Mcf | | | $160/bbl and $17.08/Mcf | | |
|---|---|---|---|---|---|---|---|---|---|
| | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) |
| North Atlantic PA | 1.33 | 7.32 | 2.63 | 1.57 | 10.85 | 3.50 | 1.67 | 12.77 | 3.94 |
| Mid-Atlantic PA | 0.94 | 5.54 | 1.93 | 1.15 | 8.56 | 2.67 | 1.24 | 10.17 | 3.05 |
| South Atlantic PA | 0.31 | 1.69 | 0.61 | 0.35 | 2.44 | 0.78 | 0.37 | 2.85 | 0.88 |
| | | | | | | | | | |
| Total Atlantic OCS | 2.58 | 14.55 | 5.17 | 3.07 | 21.85 | 6.95 | 3.28 | 25.79 | 7.87 |

(PA-Planning Area; Bb- billion barrels of oil; Tcf-trillion cubic feet of gas.)

### (4) Data Coverage and Information Gaps

Most of the seismic data acquired in the Atlantic OCS are more than 25 years old. The MMS considers this data adequate for resource assessment purposes, except in the deeper water areas of the eastern most Atlantic OCS where near surface gas hydrate indicators have been recognized, but data coverage is sparse to non-existent. On the Atlantic OCS, between 1968 and 1988, the oil and gas industry acquired approximately 239,000 line miles of two-dimensional (2-D) seismic data. The seismic line spacing is variable, but generally more closely-gridded (1- to 2-mile spacing) in the areas that are considered to contain the most attractive petroleum prospects. The map shown in Figure II-10 illustrates 2-D seismic coverage and OCS well locations. The MMS has scanned most of these data for public release and has vectorized and migrated as needed about 60 percent of these data which are being used to reassess oil and gas resources on the Atlantic OCS.

This older data may not be adequate for detailed prospect mapping and for lease sale bid formulation, especially for geologically complex areas such as the carbonate shelf margin, where prospect analogs similar to the Deep Panuke Field offshore Nova Scotia (Canada) are anticipated. Canadian experience has shown that it can be difficult locating carbonate shelf type reservoirs even with modern three dimensional (3-D) seismic data. Newer seismic acquisition techniques, such as 3-D wide azimuth or 3-D rich azimuth, allow for better imaging quality of geologically complex areas. Controlled source electromagnetic (CSEM) data, used in conjunction with newer seismic data could also further define areas of potential hydrocarbon resources. These technologies were not available when the existing Atlantic OCS data were acquired 25 or more years ago.

The oil and gas industry usually acquires 2-D and 3-D seismic data both preceding and sometimes following a lease sale. This is done to better identify prospects, formulate bids, and determine the best locations for drilling exploration wells. Following a discovery, the lease operator typically acquires additional data (usually 3-D seismic) to assist in efficiently producing the reservoir(s) associated with the discovery.

Oil and gas companies are currently interested in acquiring new data in the Atlantic OCS Region. There are five geophysical companies that have submitted permit applications to

MMS to acquire seismic data. These permit applications total about 158,000 line miles of 2-D data and cover parts of all three Atlantic Planning Areas. In addition, MMS has received a permit application to acquire about 125,000 miles of aeromagnetic data in the Atlantic OCS. The MMS has stated its intention to prepare a Programmatic Environmental Impact Statement (EIS) to evaluate the environmental impacts of multiple geological and geophysical activities in this area.

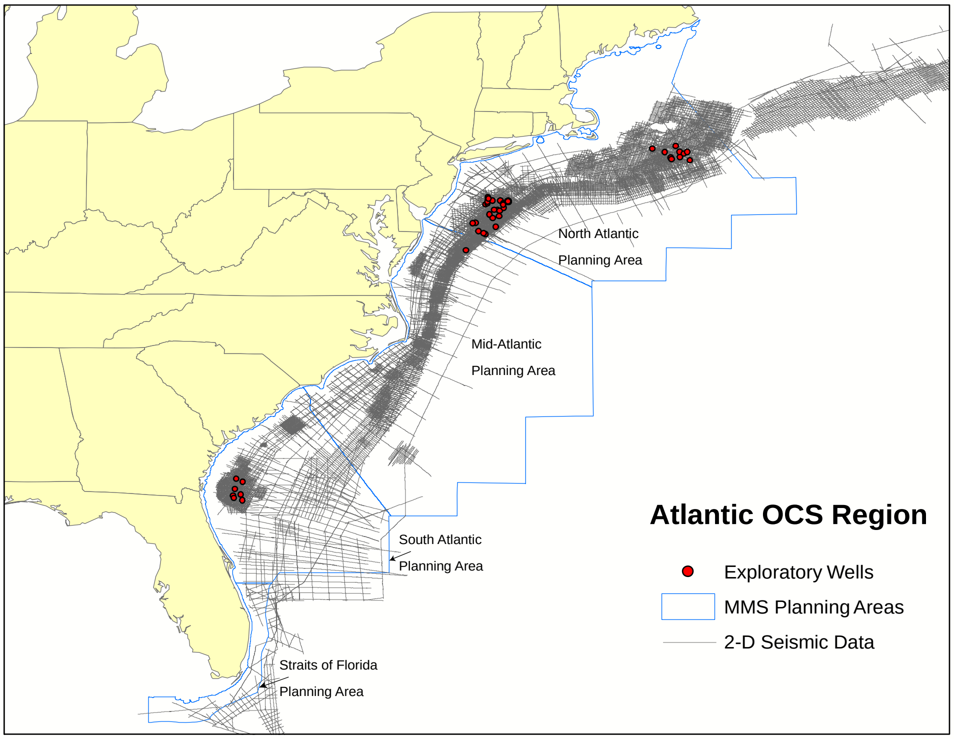



Figure II-10. Map of Atlantic OCS Region Showing 2-D Seismic Data and Exploratory Well Locations

## b. Gulf of Mexico OCS Region – East Gulf of Mexico Planning Area

### (1) Geographic and Geologic Setting

The Eastern Gulf of Mexico Planning Area encompasses an area of 64.56 million acres. The planning area begins 3 leagues (9 nautical miles) off Florida and extends to the south to the EEZ and the international borders with Cuba and Mexico and west to the Central Gulf of Mexico Planning Area (Figure II-11). Water depths range from approximately 50 to more than 10,000 feet.

The Eastern GOM is a part of a passive continental margin, underlain by Mesozoic and Cenozoic sediments. In the northern part of the area, sediments underlying the shelf are interbedded siliciclastics derived primarily from the erosion of the Appalachian Mountains, and platform and reefal carbonates. Carbonate rocks interbedded with massive evaporites predominate in the southern portion of the Eastern GOM. The sedimentary section of the Eastern GOM attains thicknesses exceeding 40,000 feet.


Figure II-11. Map of the Eastern Gulf of Mexico Planning Area Showing Active Leases

The primary geologic plays in the Eastern GOM are extensions of those identified in the Central GOM and include a series of submarine fan plays, a salt roller play, and a basement high play. All three of these plays are physiographically confined to the deeper water portion of the Eastern GOM (> 600-ft water depth). In shallower water depths, the prolific Norphlet gas play extends near shore off the panhandle of Florida. Other plays of lesser potential are recognized off the southwest Florida peninsula in relatively shallow water depths (Figure II-12). No geologic plays are identified in an area of the east central Eastern GOM, where unsuccessful exploratory wells indicated that source rocks of sufficient richness and maturity appear to be generally lacking and top seals for possible accumulations are questionable.

The deepwater fan plays include five relatively young chronostratigraphic units ranging from Miocene through Pleistocene in age, that are encountered at depths of up to 8,000 ft below the seafloor. Deepwater fan reservoirs are often aerially extensive, individually thick, and vertically stacked, thus providing opportunities for large field discoveries. While these plays are both oil- and gas-bearing in the Western and Central GOM, geochemical data from recently discovered fields in the eastern most part of the Central GOM suggest that accumulations in the Eastern GOM are likely to be highly gas-prone. Source rock studies suggest that the methane is biogenic, resulting from bacterial breakdown of organic matter.

The exploration targets for the salt roller and basement high plays include the oldest stratigraphic units in the deepwater GOM. For these plays, the source rock, reservoir, and topseal are all expected to be Jurassic to Cretaceous in age. While the reservoirs are similar in age, a variety of depositional facies and reservoir lithologies are present over and proximal to a high-relief structural feature. For the salt roller play, these structural features include salt-cored anticlines and low amplitude asymmetric salt structures. For the basement high plays, a series of structural highs that formed during the earliest GOM basin evolution were later onlapped and buried by various reservoir facies.

The Norphlet play area of the Eastern GOM consists of Norphlet Formation siliciclastic reservoirs that are sourced from the overlying Lower Smackover Formation, which also functions as a reservoir top seal. Norphlet reservoirs contain oil or gas depending upon the maturity of the Lower Smackover source rocks and the timing of the expulsion of hydrocarbons. Norphlet Formation siliciclastic reservoirs were deposited in a variety of arid conditions with aeolian dunes forming the best reservoirs. Recent drilling has extended the aeolian Norphlet play area into the deep water (greater than 7,500 feet) part of the Eastern GOM (Figure II-12).

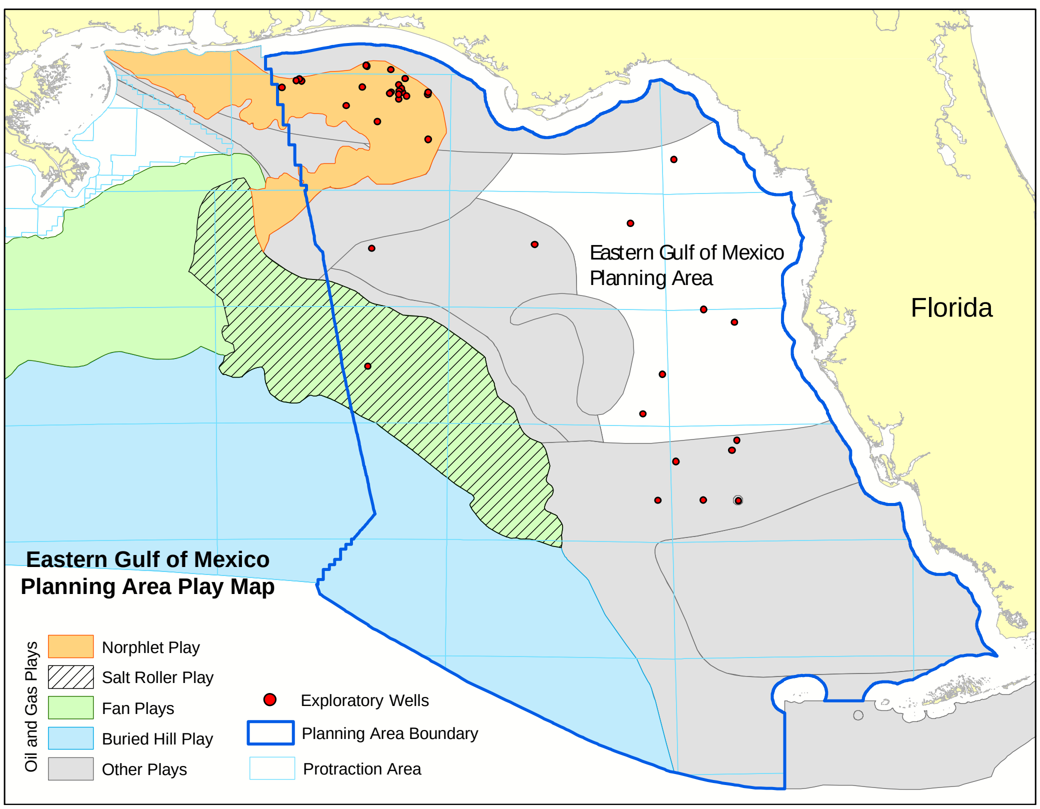



Figure II-12. Map of Eastern Gulf of Mexico Planning Area Showing Petroleum Geologic Plays and Exploratory Well Locations

Farther south, in the offshore extension of the South Florida Basin, the primary exploration targets are similar to the successful Sunniland Trend of onshore Florida. Reservoirs consists of subtle carbonate debris mounds, with hydrocarbons derived from immediately vertically adjacent algal carbonate source rocks, and sealed with evaporites. Onshore, the Sunniland Trend source rocks have attained only a low degree of thermal maturity which adversely affects the quality of the oil.

#### (2) Exploration and Discovery History

The current configuration of the Eastern GOM Planning Area was established in 2006 with the Draft Proposed Program for 2007 to 2012. Historically, the Eastern GOM included areas from offshore Mississippi, Alabama, and Florida as well as the area south of the Florida Keys (now in the Straits of Florida Planning Area). There have been 14 lease sales between 1959 (Sale 5) and 2008 (Sale 224) in areas considered as the Eastern GOM at the time of the sale. In each of the early sales, industry focused on extending known onshore production into Federal waters. In 1960, following Sale 5, three wells were drilled in Federal waters, and numerous wells were drilled on leases in state waters in an attempt to extend the Cretaceous Sunniland production of southern Florida into the offshore. Although hydrocarbon shows were encountered, none of the wells were producible.

No additional activities occurred in the Eastern GOM until December 1973. At that time 89 of the 147 tracts offered in Sale 32 received high bids totaling $1.49 billion, including a single bid from Exxon and Mobil for $211,997,600. This is still the highest bid ever received for a tract in the Gulf of Mexico. Following the sale, Exxon and partners drilled six dry wells trying to extend the producing Cretaceous plays found onshore in Alabama. Their seventh well, also dry, tested the prolific Jurassic Smackover and Norphlet Formations. These formations were the producing intervals in a series of “giant” oil and gas fields discovered in the Florida Panhandle and adjacent Alabama in the early 1970’s. Although this well was dry, it encountered a significant thickness of reservoir-quality sand in the Norphlet Formation. Over the next ten years five additional lease sales were held in the Eastern GOM. Drilling that resulted from the acquisition of these leases resulted in an additional nine dry wells being drilled as industry continued to search for giant hydrocarbon fields in the Norphlet and Smackover formations.

OCS Lease Sale 79 (held January 1984) became the first area-wide sale held in the Eastern GOM. In this sale, 156 tracts were purchased with high bids totaling $310,580,000. The drilling that followed this sale resulted in three discoveries, two of which were considered sub-commercial. Shell's Destin Dome Block 160 Well No. 1, drilled into the Norphlet Formation on the crest of the Destin Dome Anticline, was the first hydrocarbon discovery (oil) made in the Eastern GOM offshore of Florida. Shell relinquished the lease in 1990. Subsequently, Amoco’s Destin Dome 111 Well No. 1 discovered condensate on the flank of the Destin Anticline. This lease was relinquished in 1994. In 1987, 1989, and 1995, Chevron U.S.A. drilled three exploratory wells on the Destin Dome Block 56 structure, located approximately 25 miles south of Pensacola. All three wells found significant quantities of natural gas. Chevron and its partners announced the test results from one of its wells. That well flowed at a rate of 41 million standard cubic feet of gas per day from the Norphlet Formation below 22,000 feet, with no liquid hydrocarbons. The Norphlet Formation is a prolific natural gas producer in the

Florida Panhandle adjacent to Alabama, in Alabama State waters, and in the Mobile protraction area of the adjacent Central GOM.

Although plans were submitted to develop these leases, the State of Florida objected for reasons related to their coastal zone consistency. In 2002, the Department of Interior agreed to settle litigation with the lease-owning companies in the Destin Dome 56 Unit. However, two leases, Destin Dome Blocks 56 and 57, currently remain active. Both leases are held by Murphy Oil Corporation and are suspended until at least 2012, as specified in the terms of the agreement. Murphy has agreed not to submit a development plan on these leases before 2012, the year when the Presidential withdrawal was originally set to expire. Under the terms of the agreement, the leases can not be developed unless approved by both the Federal Government and the State of Florida.

In October 1995, an earlier litigation impacted exploration activity in the planning area. All 73 oil and gas leases acquired in Sales 79 and 94, and located south of 26° N. latitude, were relinquished back to the Federal Government as part the settlement. Consequently, no active Federal natural gas and oil leases exist off southwest Florida.

On December 20, 2006, the Gulf of Mexico Energy Security Act of 2006 became law. The Act requires leasing of 0.5 million acres in the Eastern GOM. The MMS offered this area in Sale 224 held in March 2008, where industry placed high bids of $64.7 million on 36 of the 118 tracts offered.

In summary, 37 wells have been drilled in the area currently referred to as the Eastern GOM, and there are about 117 active leases wholly within the Eastern GOM Planning Area and 8 leases split between the Eastern and Central GOM Planning Areas. This includes 36 leases issued in 2008. There are currently about 682,000 acres leased in the Eastern GOM Planning Area. The earlier leases are held under various terms of suspension where development and production activities are not currently allowed.

### (3) Resource Estimates

The 2006 MMS assessment indicates that the Eastern GOM Planning Area could contain sufficient overall gas and oil accumulations large enough to support economic development. The total volume of mean UTRR is estimated to be 3.88 Bbo and 21.51 Tcf of gas. At the high case (F5) the estimated UTRR is 5.51 Bbo and 25.98 Tcf of gas, and at the low case (F95), the estimated UTRR is 2.76 Bbo and 18.06 Tcf of gas (Table II-6).

Table II-7 shows the results of MMS's economic analysis of the Eastern GOM Area. At the mean case, about 65 percent of the UTRR resources are economically recoverable at an oil price of $60/bbl, and gas price of $6.41/Mcf. This increases to almost 90 percent of the UTRR being economically recoverable at an oil price of $160/bbl and a gas price of $17.08/Mcf.

Table II-6. Undiscovered Technically Recoverable Resources in the Eastern GOM Planning Area

| Gulf of Mexico OCS Region | Oil (Bbo) | | | Natural Gas (Tcf) | | | BOE (Bbo) | | |
|---|---|---|---|---|---|---|---|---|---|
| | F95 | Mean | F5 | F95 | Mean | F5 | F95 | Mean | F5 |
| Eastern GOM PA | 2.76 | 3.88 | 5.51 | 18.06 | 21.51 | 25.98 | 5.97 | 7.71 | 10.13 |

(PA-planning area; Bbo-billion barrels of oil; Tcf-trillion cubic feet of gas. F95 indicates a 95-percent chance of at least the amount listed; F5 indicates a 5-percent chance of at least the amount listed. Only mean values are additive.)

Table II-7. Mean Undiscovered Economically Recoverable Resources in the Eastern GOM Planning Area

| Gulf of Mexico OCS Region | $60/bbl and $6.41/Mcf | | | $110/bbl and $11.74/Mcf | | | $160/bbl and $17.08/Mcf | | |
|---|---|---|---|---|---|---|---|---|---|
| | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) |
| Eastern GOM PA | 3.06 | 11.09 | 5.03 | 3.50 | 16.56 | 6.45 | 3.65 | 18.38 | 6.92 |

(PA-planning area; Bbo-billion barrels of oil; Tcf-trillion cubic feet of gas.)

#### (4) Data Coverage and Information Gaps

Seismic data coverage, in general, is adequate for resource assessment of the Eastern GOM Outer Continental Shelf, with the exception of the abyssal water depths of the southwest portion of the planning area where data are sparse to nonexistent. About 160,000 line miles of 2-D seismic data were acquired by MMS between 1968 and 2008. The seismic line spacing is variable but generally more closely-gridded (1- to 2-mile spacing) in the areas that are considered to be most attractive for oil and gas potential. Many of the data sets are more than 25 years old, but recent 2-D acquisition has provided valuable insight into the geologic trends of the Eastern GOM and has helped extend and document our resource plays eastward. Figure II-13 shows the distribution of 2-D seismic surveys, and the location of exploratory wells.

Modern 3-D surveys would serve to further define the prospects and aid in resource assessment of the Eastern GOM. Preceding and following a lease sale, the geophysical industry may acquire speculative regional 3-D seismic data to better identify prospects, and reducing the risk of drilling unsuccessful exploratory wells. The oil and gas operators will acquire and reprocess much of these data to determine the best locations to set their exploration wells. Following a discovery, the data may be reprocessed again, and additional data may be sought to more efficiently produce the reservoirs associated with the discovery.

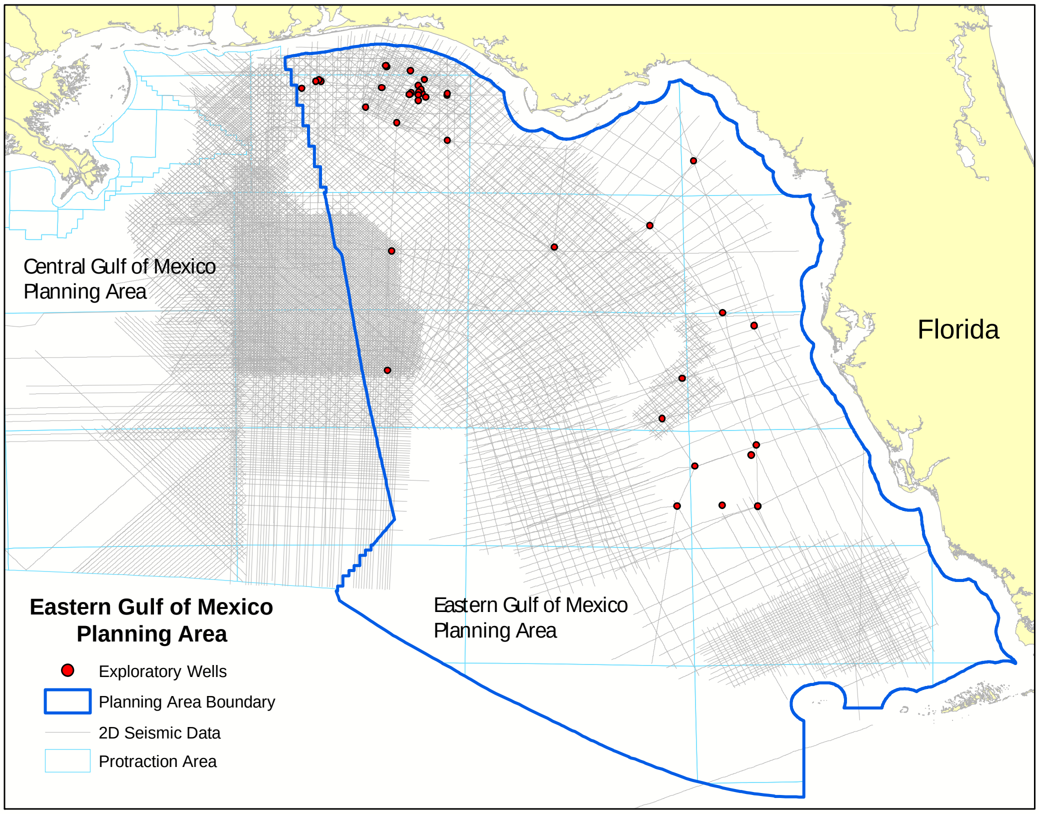



Figure II-13. Map of Eastern Gulf of Mexico Planning Area Showing 2-D Seismic Data and Exploratory Well Locations

## c. Pacific OCS Region

The 2010-2015 Draft Proposed Program includes three potential areas in the Pacific OCS Region. The first is in the Southern California Planning area and includes Santa Maria Basin and Santa Barbara-Ventura Basin. The next is in the Northern California Planning Area and includes Point Arena Basin, and the third is in the Southern California Planning Area and includes Oceanside-Capistrano Basin. In the Pacific OCS Region, there is probably sufficient knowledge of hydrocarbon potential to identify the most promising subareas rather than the entire planning area. The planning areas and the outlines of the prospective basins that are associated with the program are shown in Figure II-14. Brief descriptions of the four basins in the program, including leasing and exploration history, resource estimates, and data adequacy are presented in this document. For more complete descriptive information and references, see OCS Report MMS 97-0019, *1995 National Assessment of United States Oil and Gas Resources – Assessment of the Pacific Outer Continental Shelf Region* (Dunkel and Piper, 1997).

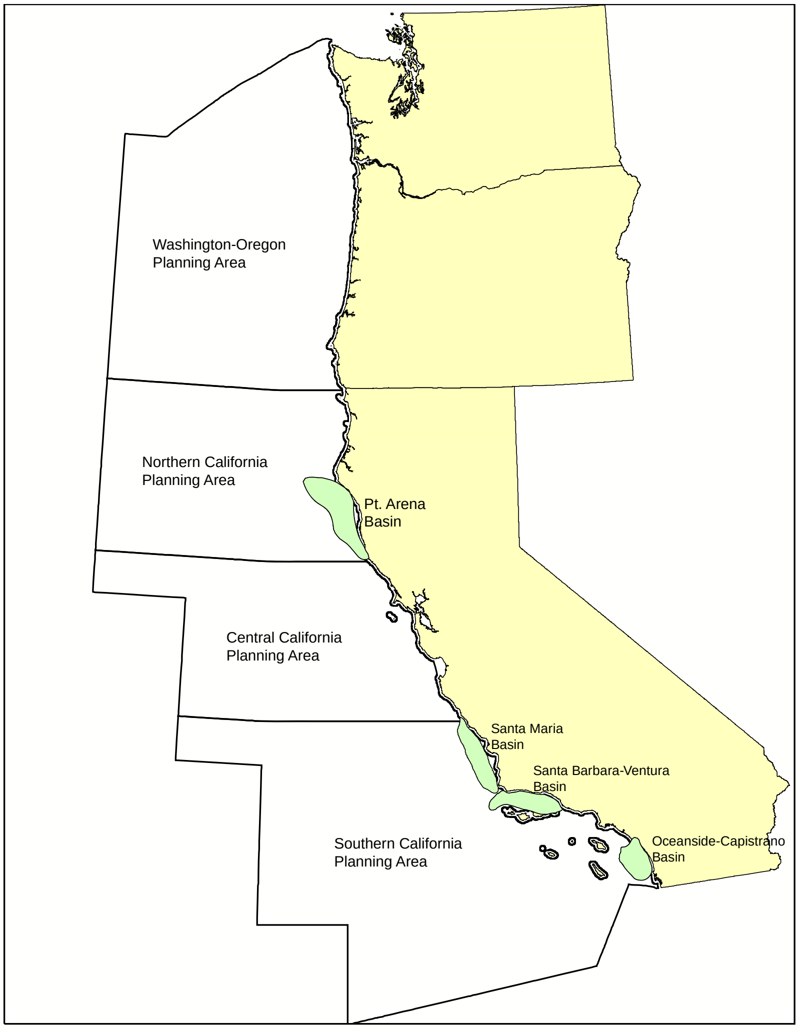



Figure II-14. Map of Pacific OCS Region Showing Areas in 2010-2015 Draft Proposed Program

### (1) Point Arena Basin (Northern California Planning Area)

#### (a) Geographic and Geologic Setting

The Point Arena Basin is the southernmost basin in the Northern California Planning Area (Figure II-14). It encompasses an area of about 3,000 square miles. Water depth in the assessment area ranges from about 200 feet to about 5,000 feet along the western margin.

The Point Arena Basin is on a steeply dipping part of the continental shelf and slope; it does not have a well-defined and structurally high uplift along the western margin and is, therefore, different from the Central California basins. In the late Mesozoic and early Cenozoic, the area was a part of a forearc basin in a convergent margin. Since the late Cenozoic development of the San Andreas transform margin, the San Andreas fault zone defines the northeast and east margins of the present basin, and the Mendocino fracture zone forms the basin's north flank (Figure II-15). Late Cenozoic tectonics have been dominated by strike-slip and reverse faulting associated with these two major right-lateral translational plate boundaries. Major faults and elongate folds generally parallel the northwest-trending San Andreas fault zone, and deformation decreases away from it. The overall folding and faulting patterns suggest that the basin is undergoing transpression.

The most important sedimentary unit from a resource standpoint is the Miocene Point Arena Formation and similar rocks in the overlying Santa Cruz Mudstone. These siliceous clastic rocks occur onshore and offshore and are similar to the prolific Monterey Formation of the Santa Maria and Santa Barbara Basins to the south. Major petroleum prospects are northwest-trending anticlinal structures that occur throughout the basin.

The Point Arena Formation is expected to form both hydrocarbon source rocks and fractured reservoirs, similar to the Monterey Formation. Small amounts of 29$^{o}$ API oil were recovered from an offshore formation test in one of the Point Arena basin OCS exploratory wells. Total organic carbon in this well was measured as high as 5.5 percent with a median value of two percent. Reservoir quality is also expected to be good in interbedded sandstones.

For assessment purposes, three petroleum geologic plays were defined (Figure II-15). The major play (Monterey Fractured) is comprised of Monterey-type shales of the Point Arena Formation and is estimated to contain about 90 percent of the basin resources.

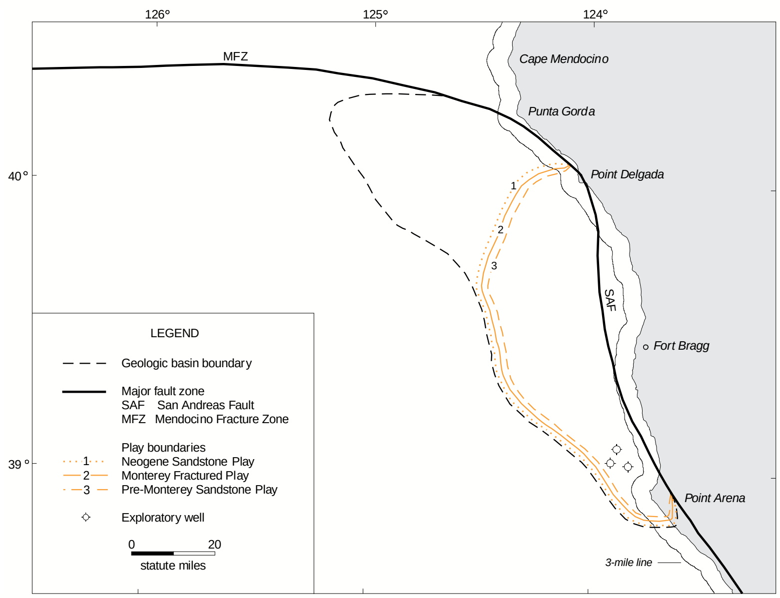



Figure II-15. Map of the Point Arena Basin Assessment Area Showing Petroleum Geologic Plays and Exploratory Wells

### (b) Leasing Activity, Exploration, and Discovery History

The first Pacific OCS Lease Sale, in 1963, offered 19 blocks in southernmost Point Arena Basin, and 5 leases were issued. Three offshore exploratory wells were subsequently drilled in 1965 and 1966. Oil shows were encountered in all three of these wells and in two nearby onshore wells. However, at the time, Monterey type reservoirs were not considered an offshore exploration target, and no well tests were run. In addition a Deep-Sea Drilling Project corehole was drilled in the north part of the basin near the Mendocino Fracture Zone in 1971. Since 1963, no leasing has occurred in northern California, although seismic data were acquired and the area was studied in preparation for Lease Sale 91 in the late 1980's. That lease sale was delayed and then cancelled by the issuance of the Presidential withdrawal in 1990.

### (c) Resource Estimates

The total volume of mean UTRR in the Point Arena Basin assessment area is expected to be 2.01 Bbo and 2.10 Tcf of associated gas. At the high case (F5), the estimated UTRR is 3.46 Bbo and 3.85 Tcf of gas, and at the low case (F95), the estimated UTRR is 1.00 Bbo and 1.00 Tcf of gas (Table II-8).

Table II-9 shows the results of MMS's economic analysis of the Point Arena Basin. At the mean case, about 79 percent of the UTRR resources are economically recoverable at an oil price of $60/bbl, and a gas price of $6.41/Mcf. This increases to almost 90 percent of the UTRR being economically recoverable at an oil price of $160/bbl and a gas price of $17.08/Mcf.

Table II-8. Undiscovered Technically Recoverable Resources in the Point Arena Basin

| Pacific OCS Region | Oil (Bbo) | | | Natural Gas (Tcf) | | | BOE (Bbo) | | |
|---|---|---|---|---|---|---|---|---|---|
| | F95 | Mean | F5 | F95 | Mean | F5 | F95 | Mean | F5 |
| Point Arena Basin | 1.00 | 2.01 | 3.46 | 1.00 | 2.10 | 3.85 | 1.18 | 2.38 | 4.14 |

(Bbo-billion barrels of oil; Tcf-trillion cubic feet of gas. F95 indicates a 95-percent chance of at least the amount listed; F5 indicates a 5-percent chance of at least the amount listed. Only mean values are additive.)

Table II-9. Mean Undiscovered Economically Recoverable Resources in the Point Arena Basin

| Pacific OCS Region | $60/bbl and $6.41/Mcf | | | $110/bbl and $11.74/Mcf | | | $160/bbl and $17.08/Mcf | | |
|---|---|---|---|---|---|---|---|---|---|
| | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) |
| Point Arena Basin | 1.58 | 1.64 | 1.87 | 1.76 | 1.83 | 2.09 | 1.80 | 1.87 | 2.13 |

(Bbo-billion barrels of oil; Tcf-trillion cubic feet of gas.)

### (d) Data Coverage and Information Gaps

The offshore area has been studied using a moderately dense to dense grid of 2-D seismic-reflection profiles that were acquired from 1976 through 1982 (Figure II-16). The MMS purchased most of these data from industry during the 1970's and 1980's. All the seismic data are good quality, and much of it is available in digital form (e.g. http://walrus.wr.usgs.gov/NAMSS/). The data are adequate for resource assessment and possibly for mapping of prospects for a lease sale. In the event that a lease is scheduled, industry may acquire additional seismic data prior to the sale. Following a lease sale, companies may acquire 3-D seismic data over leases that they hold in order to determine the best locations for exploration and development wells.

The 1963 leases were only offered in the southernmost part of the basin, so the well information is limited to that area.

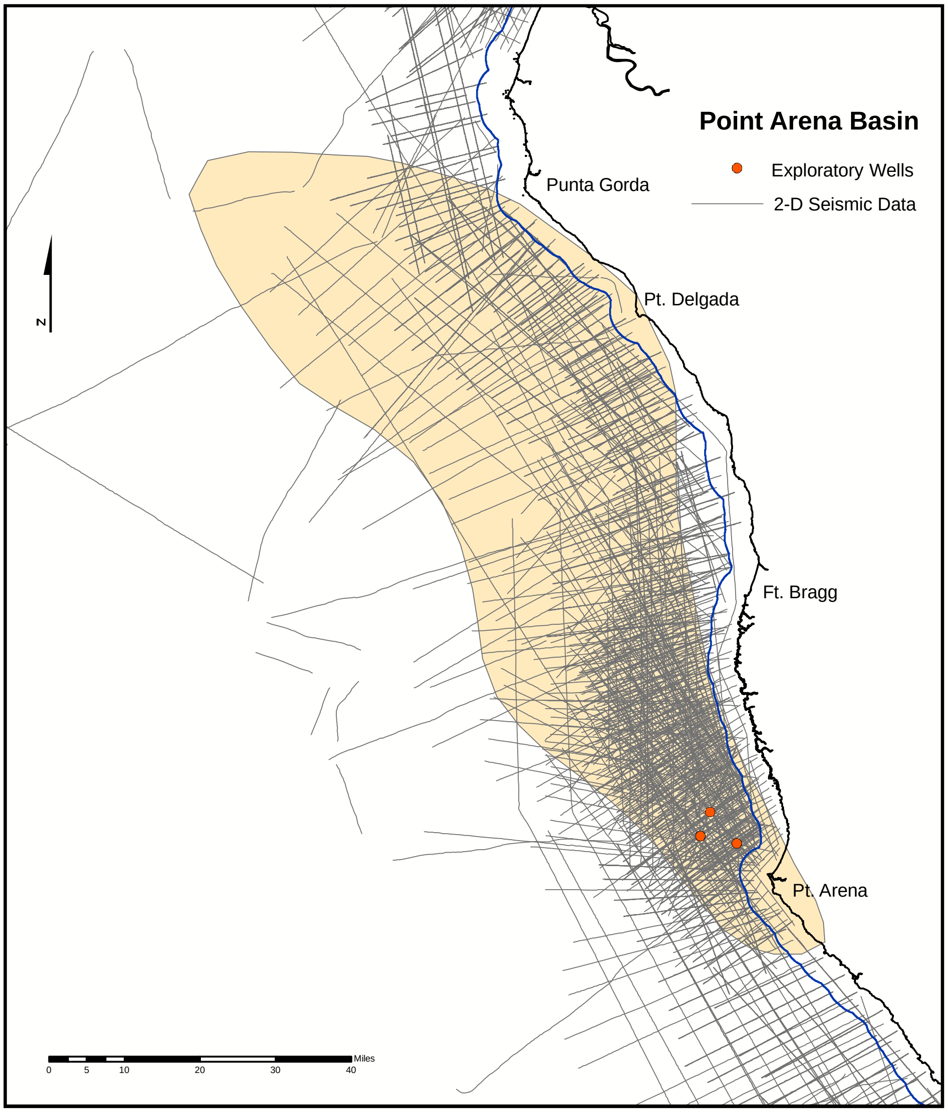



Figure II-16. Map of the Point Arena Basin Assessment Area Showing 2-D Seismic Data and Exploratory Well Locations

### (2) Santa Maria-Santa Barbara (Southern California Planning Area)

The Santa Maria-Santa Barbara program area includes the Federal offshore part of the Santa Maria Basin that is within the Southern California Planning Area and the Federal offshore part of the Santa Barbara-Ventura Basin. For descriptive purposes, the two are treated separately in the sections that follow.

**(a) Geographic and Geologic Setting**

The Santa Maria Basin is the northernmost basin in the Southern California Planning Area (Figure II-14). Part of the basin is onshore, in the westernmost Transverse Ranges geomorphic province (Figure II-17), so named because its east-west orientation runs counter to the predominant north-northwest grain of the region's major structural trends. The offshore basin occupies an area of approximately 2,500 square miles. Water depths range from 300 feet near the state/federal boundary to 3,500 feet in the southwest part of the basin. The northernmost part of the Santa Maria Basin lies within the Monterey Bay Marine Sanctuary.

The Santa Maria Basin is the offshore extension of a prolific, oil-producing, onshore basin. In the late Mesozoic and early Cenozoic, the Santa Maria Basin was a part of the accretionary wedge of a convergent plate margin. Starting in mid Cenozoic, with the cessation of subduction, the oceanic lithosphere became sutured to the continental lithosphere, and the primary tectonic regime became northwest-trending, right-lateral, strike-slip faulting with a component of convergence.

The most important sedimentary section from a resource perspective is the Miocene Monterey Formation. The Monterey is both a prolific source rock and reservoir rock for oil. Source rock studies in the basin found average total organic carbon content of approximately 5 percent, but can range as high as 17 percent in the Monterey Formation. Oil gravities from offshore production and drillstem tests range from $5^{o}$ API to $35^{o}$ API. Where buried sufficiently deep for silica diagenesis (change in mineralogy), fracturing of the rock enhances its permeability, and production rates typically exceed comparable sandstone reservoirs. Traps in the explored areas of the Santa Maria Basin are primarily structural and generally occur in northwest-trending faulted and/or fault-bounded anticlines. In the undrilled parts of the basin, traps have been identified along the northern extension of the Hosgri fault zone, as well as along uplifts and faulted uplifts in the middle and western parts of the southern and central offshore Santa Maria Basin. Hydrocarbon seals are generally provided by mudstones of the Sisquoc Formation or by faults, fractures, and unconformities. Diagenetic seals may also trap petroleum on the flanks of anticlines and homoclines.

Four hydrocarbon plays, defined on the basis of reservoir rock stratigraphy, have been assessed in the Santa Maria Basin. These include two plays from which petroleum production has been established. The Monterey Formation Fractured play is established both onshore and offshore; the Basal Sisquoc Sandstone play is established only in the onshore part of the basin. The primary petroleum source rocks are organic-rich shales and phosphatic rocks of the Monterey Formation (Monterey Fractured play; Figure II-17). This play is estimated to contain more than 90 percent of the undiscovered resources of the basin.

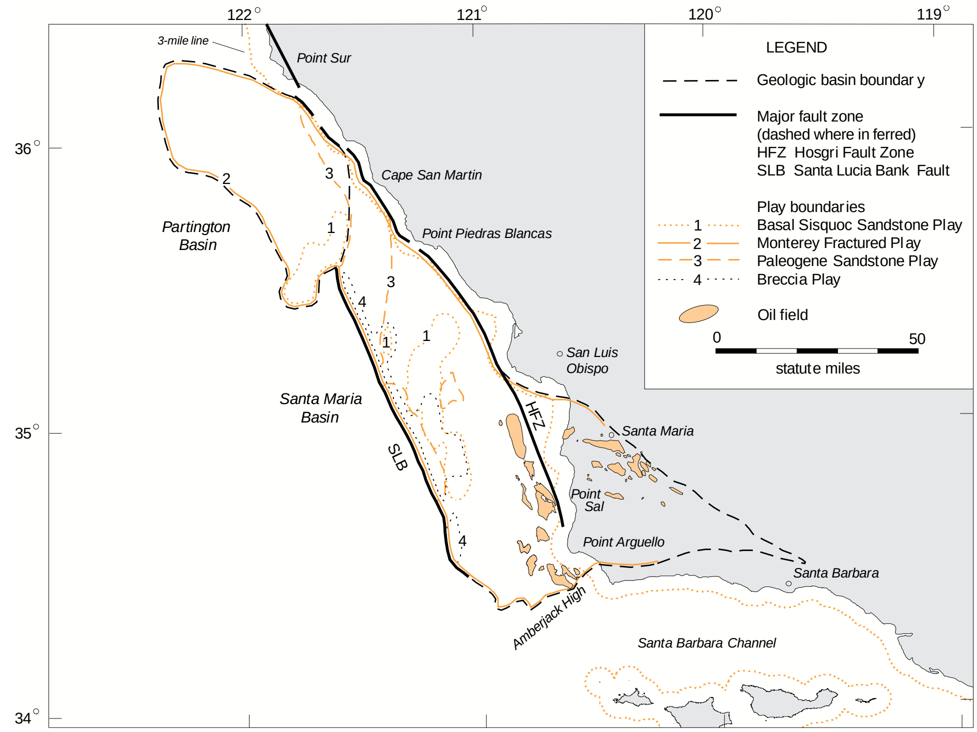



Figure II-17. Map of the Santa Maria-Partington Basin Assessment Area Showing Petroleum Geologic Plays and Oil Fields

### (b) Exploration and Discovery History

In the first Pacific OCS lease sale (P1) in 1963, six leases were issued in the central part of the basin. One exploration well was drilled and had good shows throughout the Monterey section. As was the case in the first Point Arena Basin exploration wells, no well tests were run because at that time, the Monterey was not considered a viable exploration target (Webster and Yenne, 1987). All the Sale P1 leases were subsequently relinquished. Following the recognition of the importance of the Monterey Formation, more than 60 leases were issued (60 from Lease Sale 53 in 1981, and several more at the southernmost part of the basin from Lease Sale 48 in 1979; Figure II-18). Of those, 37 leases are still active (2 from Sale 48, 35 from Sale 53), but only nine leases (44,760 acres) are considered developed. Development of the other 28 leases (153,202 acres) has not progressed. Significant amounts of producible oil and gas have been discovered on these undeveloped leases, but they are currently subject to ongoing litigation. Lease Sale 95 was proposed for the Santa Maria and Santa Barbara Basin areas in the late 1980's. That sale was delayed and ultimately cancelled as a result of the Presidential withdrawal of 1990. Since then no new leases have been offered in the Region.

More than 50 exploratory wells have been drilled in the southern and central portions of the offshore Santa Maria Basin and have resulted in the discovery of 14 fields estimated to contain originally recoverable resources of approximately 1.4 Bbo and 700 billion cubic feet (Bcf) of natural gas. The northern portion of the basin remains undrilled. Of the 14 discovered fields, only four are currently under development, having produced about 260 million barrels of oil (MMbo) and 170 Bcf of gas as of December 2007. As of that date, remaining proved reserves for these four fields are about 150.8 MMbo and 101.3 Bcf. Nine fields are on active leases that remain undeveloped; they are estimated to contain about 1 billion barrels of producible oil and 400 Bcf of producible gas, but as stated above are currently the subject of ongoing buy-back litigation (Amber Resources et al. v. United States).

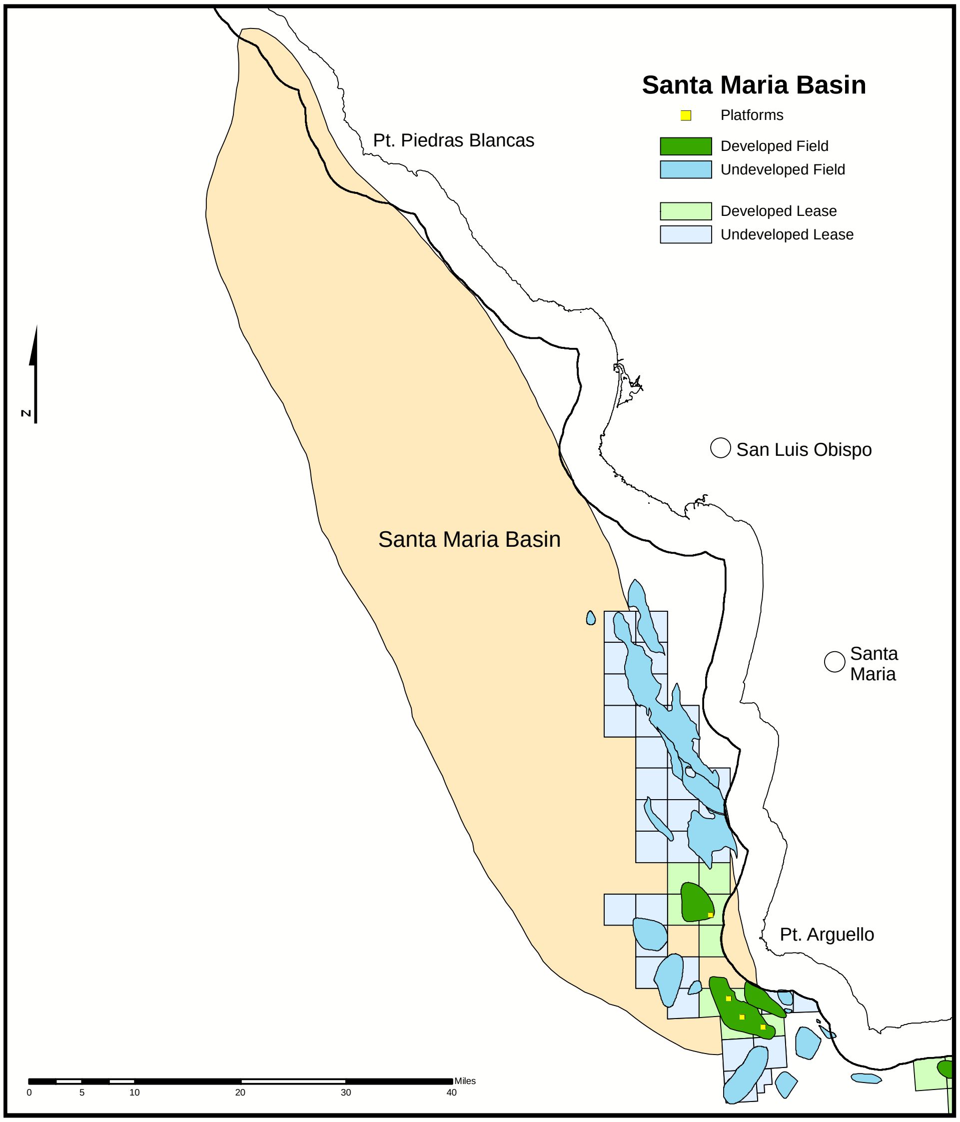



Figure II-18. Map of the Santa Maria Basin Assessment Area Showing Active Developed and Undeveloped Leases, Platforms, And Oil Fields

### (c) Resource Estimates

The total volume of mean UTRR in the Santa Maria Basin assessment area is estimated to be 0.57 Bbo and 0.40 Tcf of associated gas. At the high case (F5), the estimated UTRR is 0.70 Bbo and 0.56 Tcf of associated gas, and at the low case (F95), the estimated UTRR is 0.51 Bbo and 0.33 Tcf of associated gas (Table II-10). The majority of these resources are estimated to exist in the rocks of the Monterey Formation.

Table II-11 shows the results of MMS's economic analysis of the Santa Maria Basin assessment area. At the mean case, about 69 percent of the UTRR resources are economically recoverable at an oil price of $60/bbl, and gas price of $6.41/Mcf. This increases to about 88 percent of the UTRR being economically recoverable at an oil price of $160/bbl and a gas price of $17.08/Mcf.

Table II-10. Undiscovered Technically Recoverable Resources in the Santa Maria Basin

| Pacific OCS Region | Oil (Bbo) | | | Natural Gas (Tcf) | | | BOE (Bbo) | | |
|---|---|---|---|---|---|---|---|---|---|
| | F95 | Mean | F5 | F95 | Mean | F5 | F95 | Mean | F5 |
| Santa Maria Basin | 0.51 | 0.57 | 0.70 | 0.33 | 0.40 | 0.56 | 0.57 | 0.64 | 0.80 |

(Bbo-billion barrels of oil; Tcf-trillion cubic feet of gas. F95 indicates a 95-percent chance of at least the amount listed; F5 indicates a 5-percent chance of at least the amount listed. Only mean values are additive.)

Table II-11. Mean Undiscovered Economically Recoverable Resources in the Santa Maria Basin

| Pacific OCS Region | $60/bbl and $6.41/Mcf | | | $110/bbl and $11.74/Mcf | | | $160/bbl and $17.08/Mcf | | |
|---|---|---|---|---|---|---|---|---|---|
| | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) |
| Santa Maria Basin | 0.34 | 0.23 | 0.38 | 0.44 | 0.30 | 0.49 | 0.46 | 0.31 | 0.52 |

(Bbo-billion barrels of oil; Tcf-trillion cubic feet of gas.)

### (d) Data Coverage and Information Gaps

Seismic-reflection data coverage in the offshore Santa Maria Basin is dense; the average 2-D grid spacing in most of the basin is less than one-half mile (Figure II-19). The MMS purchased most of these data from industry during the 1970's, 1980's, and 1990's. Data quality is very good to excellent and much of it is available in digital form (e.g. http://walrus.wr.usgs.gov/NAMSS/). The data are adequate for prelease evaluation, including resource assessment, and the mapping of prospects for a lease sale. In the event that a lease is scheduled, industry usually acquires additional seismic data prior to the sale. Following a lease sale, companies may acquire 3-D seismic data over leases that they hold in order to determine the best locations for exploration and development wells.

Over 50 exploratory wells have been drilled, and four fields are under development. No additional information is needed for prelease evaluation.

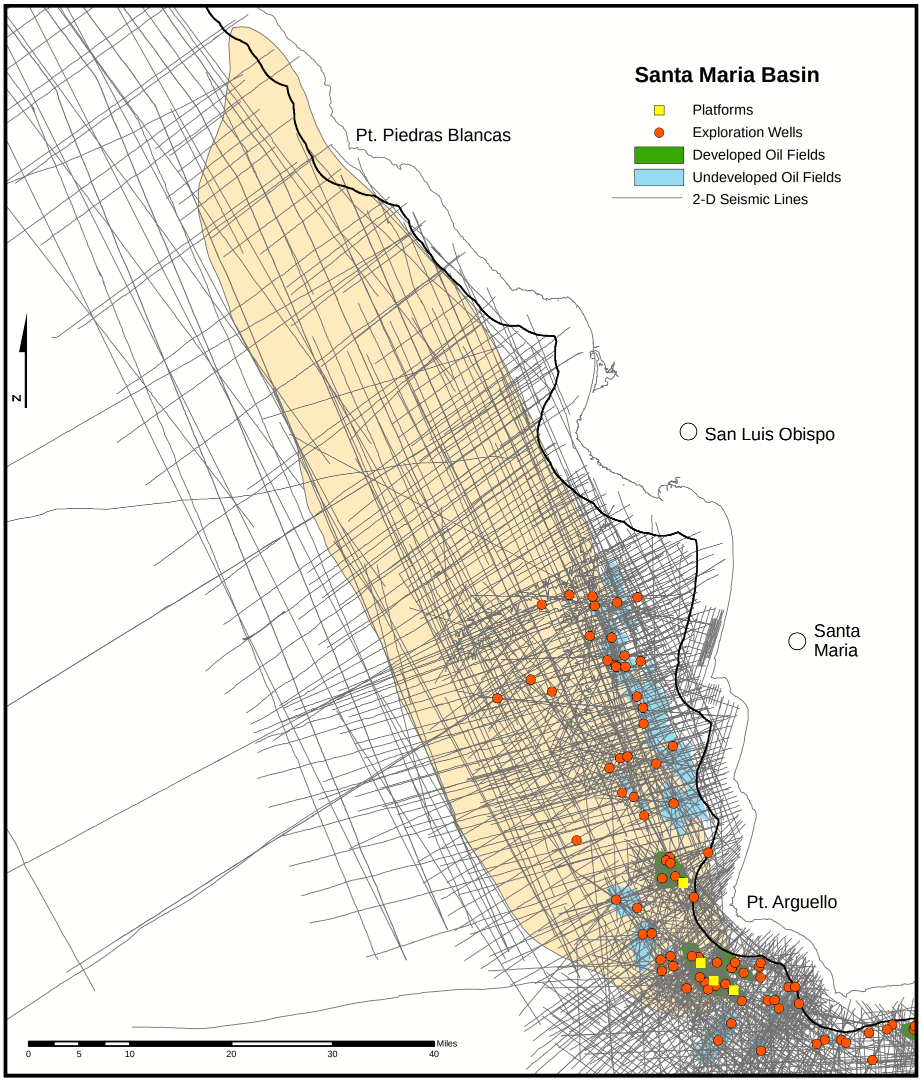



Figure II-19. Map of the Santa Maria Basin Assessment Area Showing 2-D Seismic Data, OCS Platforms, Oil Fields, and Exploratory Well Locations

### (3) Santa Barbara-Ventura Basin (Southern California Planning Area)

#### (a) Geographic and Geologic Setting

The Santa Barbara-Ventura Basin (commonly called the Santa Barbara Channel) comprises the western offshore portion of the Santa Barbara-Ventura Basin, within the western portion of the Transverse Ranges geomorphic province of southern California (Figure II-14). The offshore basin comprises an area of about 1,800 square miles. The southeastern part of this area lies within the Channel Islands National Marine Sanctuary.

The oldest known sedimentary rocks in the basin are late Mesozoic in age, and were deposited in a forearc setting of a convergent plate margin along the north-northwest trending coast of southern California and Baja California. Starting in the early Cenozoic, the western Transverse

Ranges (including the Santa Barbara-Ventura Basin) were rotated clockwise and translated northward to an east-west orientation. In its present orientation it obstructs the relative plate motions of the Pacific and North American plates. Because of this, the current tectonics is characterized by north-south crustal shortening, accompanied by rapid basin subsidence, large scale reverse faulting and mountain building.

The Miocene Monterey Formation in the Santa Barbara-Ventura basin includes a lower member not found in the Santa Maria basin and has a greater stratigraphic thickness. In the western part of the basin major oil reservoirs are primarily within the Monterey Formation which ranges from 2,000 to over 3,500 feet thick (Figure II-20). Rocks of the Monterey Formation also are the principal petroleum source in the basin, with a total organic carbon content ranges from a few percent to as high as 30 percent. Monterey oil gravities range from $9^o$ API to about $22^o$ API. Structurally, at least three trap forming events are evident within the basin: two early extensional events producing faults oriented northeast-southwest and east-west, overprinted by a later compressional event that produced northwest-southeast and east-west folds and faults (Dunkel and Piper, 1997).

Sandstone reservoirs of the Pliocene Pico Formation form major oil and gas reservoirs in the eastern part of the basin, both onshore and offshore. Rock units equivalent to the Monterey have a greater detrital content in the eastern part of the basin and form less productive reservoirs. Oil gravities are generally higher in the eastern part of the basin, usually greater than $22^o$ API. Structural trends in the eastern part of the basin generally run east-west with traps formed by broad anticlinal folds with bounding faults.

Based on reservoir rock stratigraphy and the exploration and production history of the basin, six hydrocarbon plays were defined for analysis, and five of these plays were assessed. The major play is fractured siliceous rocks of the Monterey Formation (Monterey Fractured play). Several sandstone plays are also important in the eastern part of the basin as discussed above.

### (b) Leasing Activity, Exploration, and Discovery History

Natural petroleum seeps have been exploited in the Santa Barbara-Ventura Basin since prehistoric times. Native Americans used the tar from the seeps to caulk their canoes and baskets. Distilleries and refineries were built in the 1850's and 1860's to process and refine seepage oil and tar. As early as 1861, “oil tunnels” tapped the reservoir strata that fed mountainside seeps. Some of the earliest-discovered fields are still in production today, some for over 100 years. Since 1861, at least 155 oil and gas fields have been discovered in the greater Santa Barbara-Ventura Basin. The first offshore oil wells in North America were drilled at the Summerland Field, in 1894, just southeast of the city of Santa Barbara.

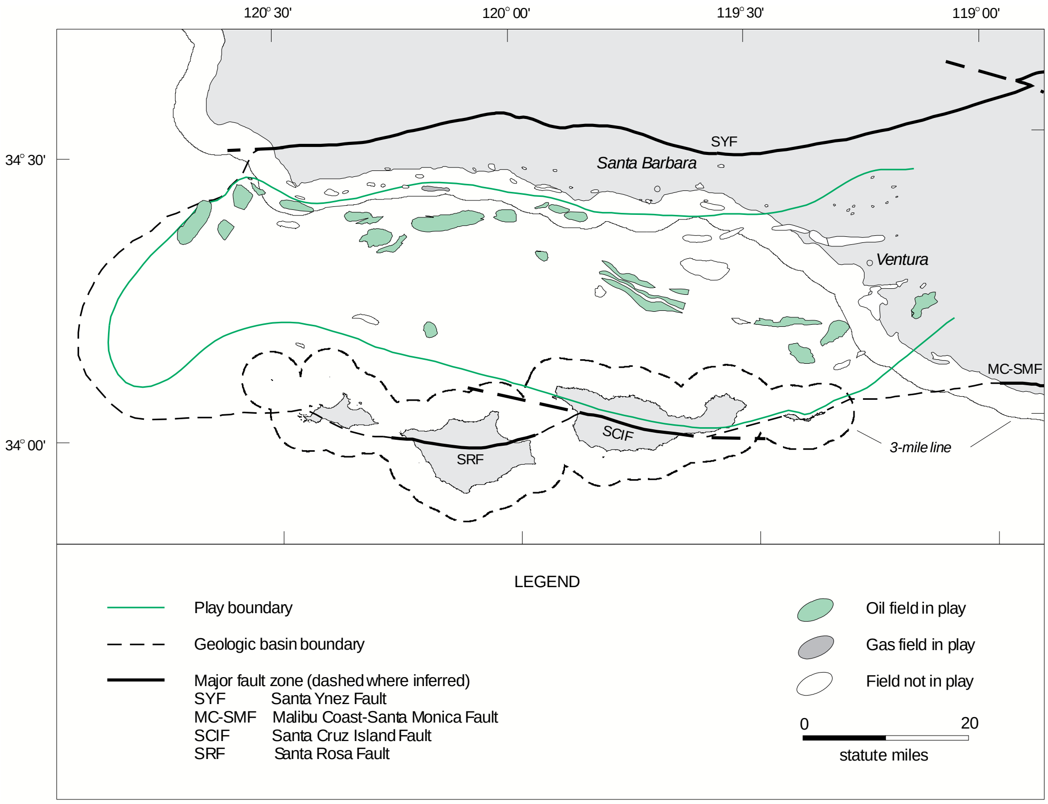



Figure II-20. Map of the Monterey Fractured Play, Santa Barbara-Ventura Basin Showing Selected Oil and Gas Fields

However, it was not until the post-World War II advent of modern offshore exploration technology that the Federal offshore area was explored in earnest. Extensive bottom sampling, coring, and seismic programs have been conducted in the area since then. The first Federal lease in the Santa Barbara Channel (drainage lease P3 for one block on the western end of the Carpinteria Offshore Field State lease) was not issued until 1966, more than 100 years after petroleum development began in the basin. As a result of advances in exploration and development technology, at least 12 fields have been discovered that will each ultimately produce in excess of 100 million barrels of combined oil-equivalent resources (BOE); this estimate includes the supergiant (>1 billion barrels BOE) Ventura Avenue-San Miguelito-Rincon Field.

The first full OCS lease sale in the Santa Barbara Channel (Sale P4, 1968) resulted in the issuance of 71 leases. The 26 remaining active leases from that sale include the major part of all the important producing OCS fields in the Santa Barbara Channel. In total there are currently 38 active leases of which 30 (149,869 acres) are developed and eight (29,636 acres) are undeveloped. As with the undeveloped leases in the Santa Maria basin, the undeveloped leases of the Santa Barbara-Ventura Basin are subject to buy-back litigation in the Amber Resources et al. v. United States lawsuit.

There are nine developed fields and two undeveloped fields in the basin (Figure II-21). As of December, 2007, approximately 844 MMbbl of oil and 1.39 Tcf of gas have been produced from OCS fields, and remaining proved reserves are 284 MMbbl of oil and 763 Bcf of gas. The two fields on undeveloped leases contain about 76 MMbbl of producible oil and 54 Bcf of producible gas. In addition, there are 12 discoveries on expired leases in the Federal offshore part of the basin that were never developed as they were considered sub-commercial at the time. However, since the cancellation of proposed Lease Sale 95 resulting from the Presidential withdrawal of 1990, no leases have been offered in the Region.

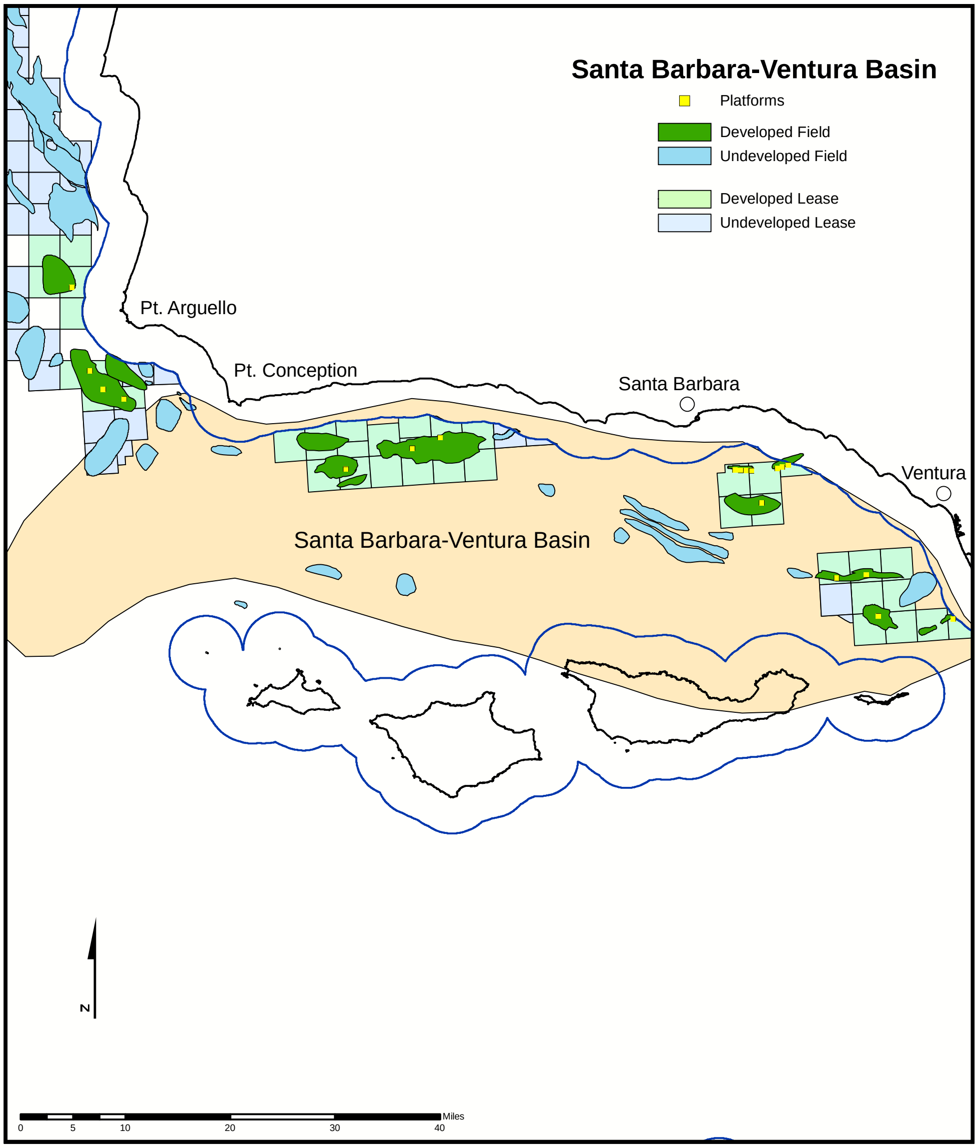



Figure II-21. Map of the Santa Barbara-Ventura Basin Assessment Area Showing Active Developed and Undeveloped Leases, Platforms, and Oil and Gas Fields

### (c) Resource Estimates

The total volume of mean UTRR in the federal portion of the Santa Barbara-Ventura Basin assessment area is estimated to be 1.79 Bbo and 4.75 Tcf of gas. At the high case (F5) the estimated UTRR is 1.97 Bbo and 5.58 Tcf of associated and nonassociated gas, and the low case (F95) estimated UTRR is 1.71 Bbo and 4.30 Tcf of associated and nonassociated gas (Table II-12). Nearly half of these resources are estimated to exist in the Monterey Fractured play.

Table II-13 shows the results of MMS's economic analysis of the Santa Barbara-Ventura Basin assessment area. At the mean case, about 88 percent of the UTRR resources are economically recoverable at an oil price of $60/bbl, and gas price of $6.41/Mcf. This increases to almost 96 percent of the UTRR being economically recoverable at an oil price of $160/bbl and a gas price of $17.08/Mcf.

Table II-12. Undiscovered Technically Recoverable Resources in the Santa Barbara-Ventura Basin Assessment Area

| Pacific OCS Region | Oil (Bbo) | | | Natural Gas (Tcf) | | | BOE (Bbo) | | |
|---|---|---|---|---|---|---|---|---|---|
| | F95 | Mean | F5 | F95 | Mean | F5 | F95 | Mean | F5 |
| Santa Barbara-Ventura Basin | 1.71 | 1.79 | 1.97 | 4.30 | 4.75 | 5.58 | 2.47 | 2.64 | 2.96 |

(Bbo-billion barrels of oil; Tcf- trillion cubic feet of gas. F95 indicates a 95-percent chance of at least the amount listed; F5 indicates a 5-percent chance of at least the amount listed. Only mean values are additive.)

Table II-13. Mean Undiscovered Economically Recoverable Resources in the Santa Barbara-Ventura Basin Assessment Area

| Pacific OCS Region | $60/bbl and $6.41/Mcf | | | $110/bbl and $11.74/Mcf | | | $160/bbl and $17.08/Mcf | | |
|---|---|---|---|---|---|---|---|---|---|
| | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) |
| Santa Barbara-Ventura Basin | 1.60 | 3.84 | 2.28 | 1.71 | 4.32 | 2.48 | 1.73 | 4.41 | 2.51 |

(Bbo-billion barrels of oil; Tcf-trillion cubic feet of gas.)

### (d) Data Coverage and Information Gaps

The Santa Barbara-Ventura Basin is the most heavily explored offshore basin outside of the Gulf of Mexico. About 200 exploratory wells and coreholes have been drilled throughout the basin. Seismic coverage is dense in most areas of the basin (Figure II-22). Although all of the regional 2-D seismic data is over 20 years old, most is of good to excellent quality, and much of it is publicly available in digital form (e.g. http://walrus.wr.usgs.gov/NAMSS/). In most areas, these data are adequate for prelease evaluation, including resource assessment and mapping of prospects.

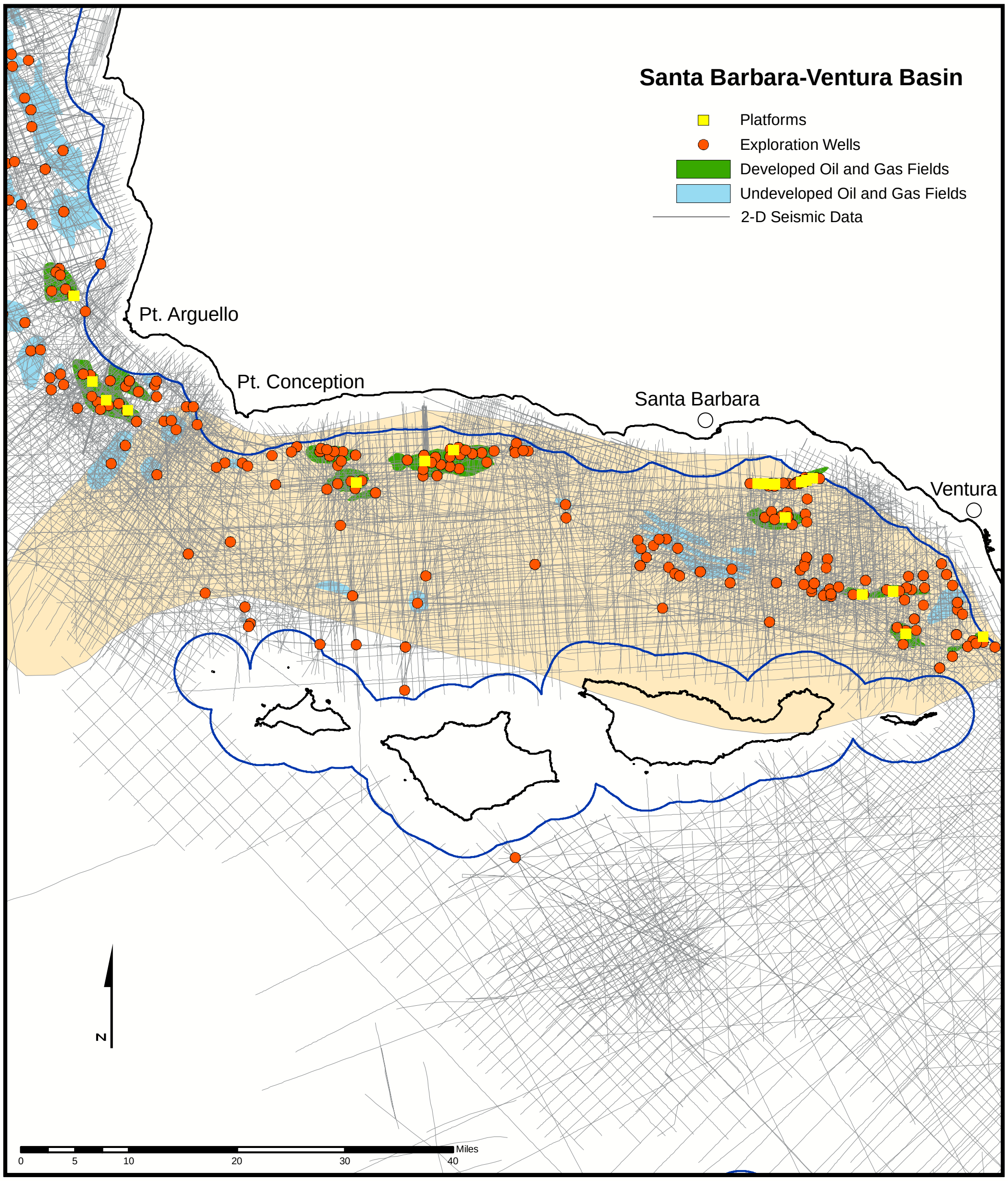



Figure II-22. Map of the Santa Barbara-Ventura Basin Assessment Area Showing 2-D Seismic Data, OCS Platforms, Oil and Gas Fields, and Exploratory Well Locations

### (4) Oceanside-Capistrano Basin (Southern California Planning Area)

#### (a) Geographic and Geologic Setting

The Oceanside-Capistrano Basin is located at the southern end of the Southern California Planning Area (Figure II-14). It occupies an area of about 1,500 square miles. Water depth in the OCS part of the basin ranges from about 300 to 3,000 feet.

The general structure of the region is the result of early Miocene extension, due to rifting and clockwise rotation of the western Transverse Ranges crustal block, followed by late Pliocene to present right-lateral faulting and compression. The Newport-Inglewood fault zone is the dominant structural element of the eastern part of the basin (Figure II-23). To the northwest, in the Los Angeles Basin, several giant and supergiant oil fields are associated with this fault zone.

The Oceanside-Capistrano Basin is filled with up to 11,000 feet of late Mesozoic and Cenozoic marine and nonmarine clastic rocks. Several thousand feet of Miocene and Pliocene marine rocks were penetrated by two exploratory coreholes, but there were no indications of petroleum detected. Since these coreholes were drilled east of the Newport-Inglewood fault, they may not reflect the petroleum potential of the basin, most of which lies west of the fault (Figure II-23). Seismic data indicated that the basin may contain up to 1,500 feet of Monterey Formation equivalent rocks which are highly productive in the Santa Barbara-Ventura and Santa Maria Basins. Large, compressional fault-bound anticlines, faulted homoclines, and stratigraphic pinchouts west of the Newport-Inglewood fault zone are evident on seismic-reflection profiles. These structures are numerous and large enough to contain significant quantities of oil and gas.

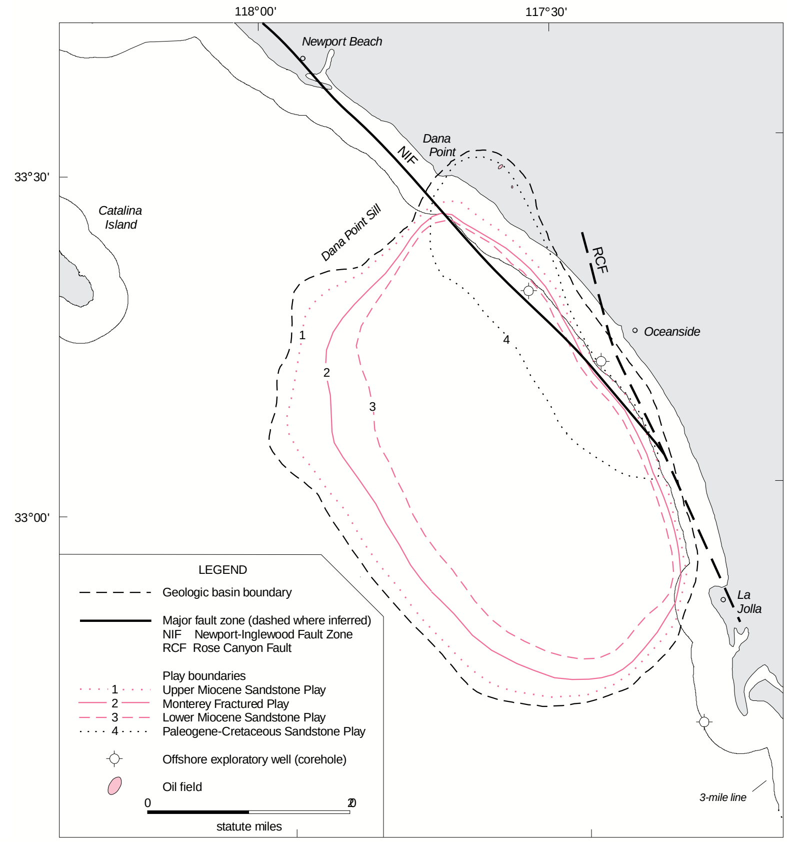



Figure II-23. Map of the Oceanside-Capistrano Basin Assessment Area Showing Petroleum Geologic Plays, Oil Fields, and Exploratory Wells

For assessment purposes, four petroleum geologic plays were defined within the basin. These include sandstone plays and a Monterey-type play which, based on tectonic setting, is expected to be analogous to the eastern Santa Barbara Channel Modelo Formation.

### (b) Leasing Activity, Exploration, and Discovery Data

In the 1960’s, under a State leasing program, two coreholes were drilled offshore; both were nearshore, east of the Newport-Inglewood fault trend and outside of the basin proper (Figure II-23). The Oceanside-Capistrano Basin has been unavailable for leasing since the mid 1970’s because of military restrictions, and later due to Congressional moratoria and Presidential withdrawal. Therefore, no further exploratory wells were drilled. Onshore, more than 60 exploratory wells were drilled from the early 1950's to 1980’s and resulted in the discovery of two small oil fields.

The nearest OCS production to the Oceanside-Capistrano Basin is the Beta Field, located about 25 miles to the north, in the Los Angeles Basin. The exploratory wells and platforms of the Beta Field are shown on the northwest part of Figure II-24. The geologic settings in these two areas are expected to be similar, and the Beta Field was used as an analog in the resource assessment of the Oceanside-Capistrano Basin. Cumulative production from the Beta Field was 88.16 MMbo, and 28.91 Bcf of gas as of December 31, 2007. Remaining proved reserves as of that date were 19.54 MMbo, and 5.89 Bcf.

### (c) Resource Estimates

The total volume of mean UTRR in the Federal part of the Oceanside-Capistrano Basin assessment area is estimated to be 1.10 Bbo and 1.20 Tcf of gas. At the high case (F5), the estimated UTRR is 3.08 Bbo and 3.77 Tcf of associated and nonassociated gas (Table II-14). Nearly half of these resources are estimated to exist in the Monterey Fractured play. At the low case (F95), the resource potential of this area is negligible (less than 5 MMbo).

Table II-15 shows the results of MMS’s economic analysis of the Federal part of the Oceanside-Capistrano assessment area. At the mean case, about 89 percent of the UTRR resources are economically recoverable at an oil price of $60/bbl, and a gas price of $6.41/Mcf. This increases to almost 95 percent of the UTRR being economically recoverable at an oil price of $160/bbl and a gas price of $17.08/Mcf.

Table II-14. Undiscovered Technically Recoverable Resources in the Oceanside-Capistrano Basin

| Pacific OCS Region | Oil (Bbo) | | | Natural Gas (Tcf) | | | BOE (Bbo) | | |
|---|---|---|---|---|---|---|---|---|---|
| | F95 | Mean | F5 | F95 | Mean | F5 | F95 | Mean | F5 |
| Oceanside-Capistrano Basin | 0.00 | 1.10 | 3.08 | 0.00 | 1.20 | 3.77 | 0.00 | 1.31 | 3.75 |

(Bb- billion barrels of oil; Tcf- trillion cubic feet of gas. F95 indicates a 95-percent chance of at least the amount listed; F5 indicates a 5-percent chance of at least the amount listed. Only mean values are additive.)

Table II-15. Mean Undiscovered Economically Recoverable Resources in the Oceanside-Capistrano Basin

| Pacific OCS Region | $60/bbl and $6.41/Mcf | | | $110/bbl and $11.74/Mcf | | | $160/bbl and $17.08/Mcf | | |
|---|---|---|---|---|---|---|---|---|---|
| | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) |
| Oceanside-Capistrano Basin | 0.97 | 1.07 | 1.16 | 1.03 | 1.13 | 1.23 | 1.04 | 1.15 | 1.25 |

(Bbo-billion barrels of oil; Tcf-trillion cubic feet of gas.)

### (d) Data Coverage and Information Gaps

A number of high-quality seismic-reflection surveys were acquired in the 1970's and 1980's. These have resulted in a moderately dense grid of good- to excellent-quality data, much of which is publicly available in digital form (Figure II-24; http://walrus.wr.usgs.gov/NAMSS/). The data are likely adequate for pre-lease evaluation, including resource assessment and mapping of prospects.

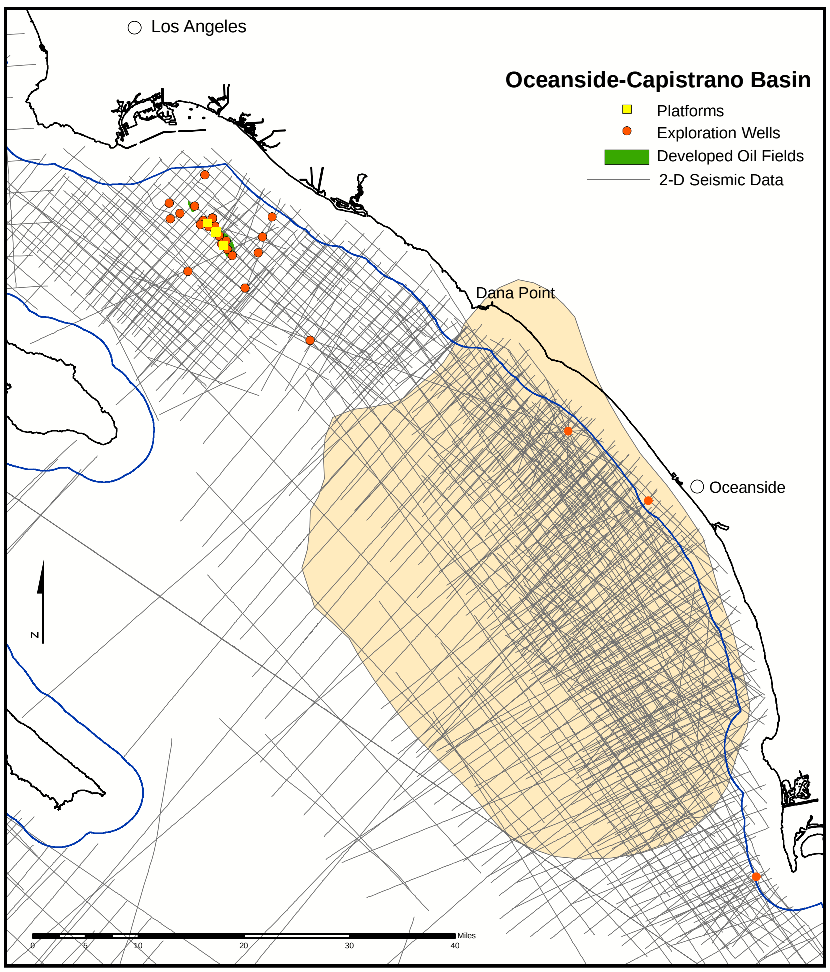



Figure II-24. Map of the Oceanside-Capistrano Basin Assessment Area Showing 2-D Seismic Data, OCS Platforms, Oil Fields, and Exploratory Well Locations

The only well information in the area is from the two basin-margin coreholes described above. The greatest uncertainty is the extent and quality of source and reservoir rocks in the basin.

## d. Alaska OCS Region – North Aleutian Basin Planning Area

### (1) Geographic and Geologic Setting

The North Aleutian Basin OCS Planning Area encompasses an area of 32.45 million acres and includes most of the southeastern part of the Bering Sea continental shelf. The 2007-2012 Federal offshore oil and gas leasing program, as well as the 2010-2015 Draft Proposed Program identify a "Sale 214 Program Area" within the southwest part of the North Aleutian Basin Planning Area (MMS, 2007c, map 5, p. 40, and MMS, 2009). The program area is 5.6 million acres and contains 990 whole and partial OCS blocks (Figure II-25).

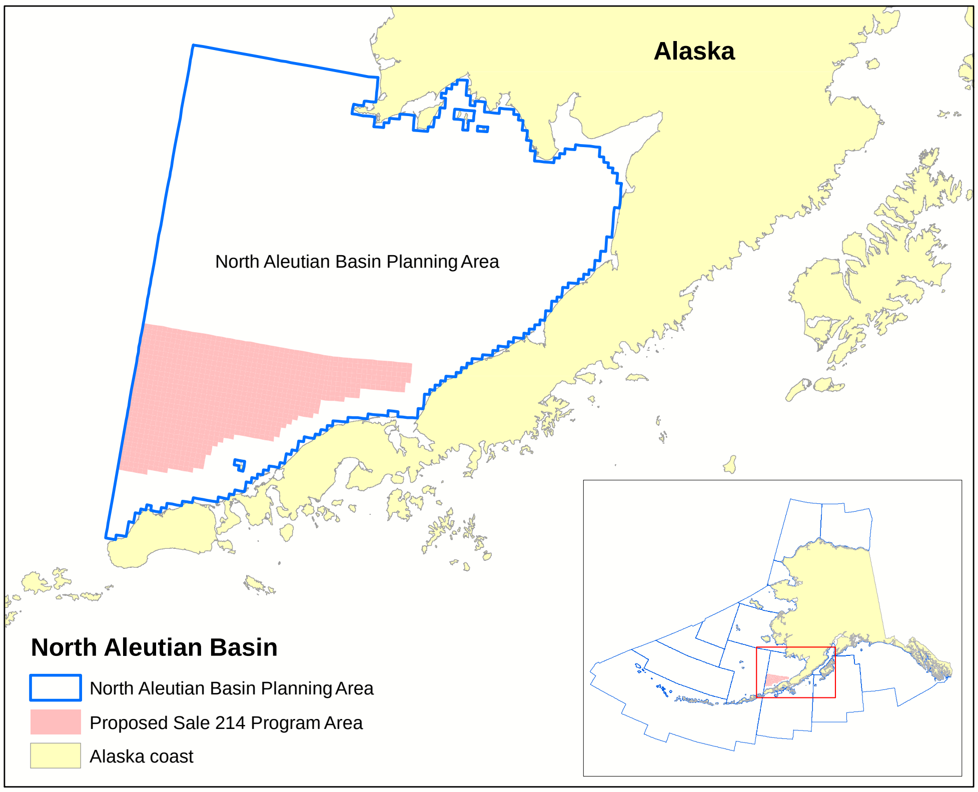



Figure II-25. Map of the North Aleutian Basin Planning Area

A geologic feature known as the North Aleutian geologic basin underlies Bristol Bay in the southern part of the planning area (Figure II-26) and passes south beneath the northern coastal plain of the Alaska Peninsula, where it has been penetrated by several wells. Water depths in the offshore parts of the basin range from 15 to 600 ft. The basin is roughly 100 miles wide and 400 miles in length and reaches depths of 20,000 feet in its deepest parts. The structure of the interior of the North Aleutian Basin is dominated by uplifted basement fault-blocks that have arched the overlying Tertiary-age strata and provide the largest and most prospective traps. North of the basin and throughout most of the planning area, stratified rocks are less than 3,000 feet thick, unstructured, and offer little potential for hydrocarbons.

Most mapped prospects in the central part of the North Aleutian Basin are simple "domes" draped over the crests of fault-bounded basement uplifts and that range up to 93,000 acres in closure area. These domes form the prospects that were targeted by leasing in the only prior sale (Sale 92 in 1988) in the North Aleutian Basin Planning Area. The general locations of some of the targeted prospects are indicated by Sale 92 lease blocks as mapped in Figure II-26.

In the central part of the North Aleutian Basin, the basement uplifts and prospects are surrounded by basin deeps ("area of best prospects" in Figure II-26) where, beginning in late Oligocene or early Miocene time, the basin floor strata reached temperatures sufficient for conversion of organic matter to gas (Sherwood et al., 2006, fig. 30). Any gas or oil generated in these basin deeps could have migrated upward along faults into traps within the porous strata arched over the basement uplifts.

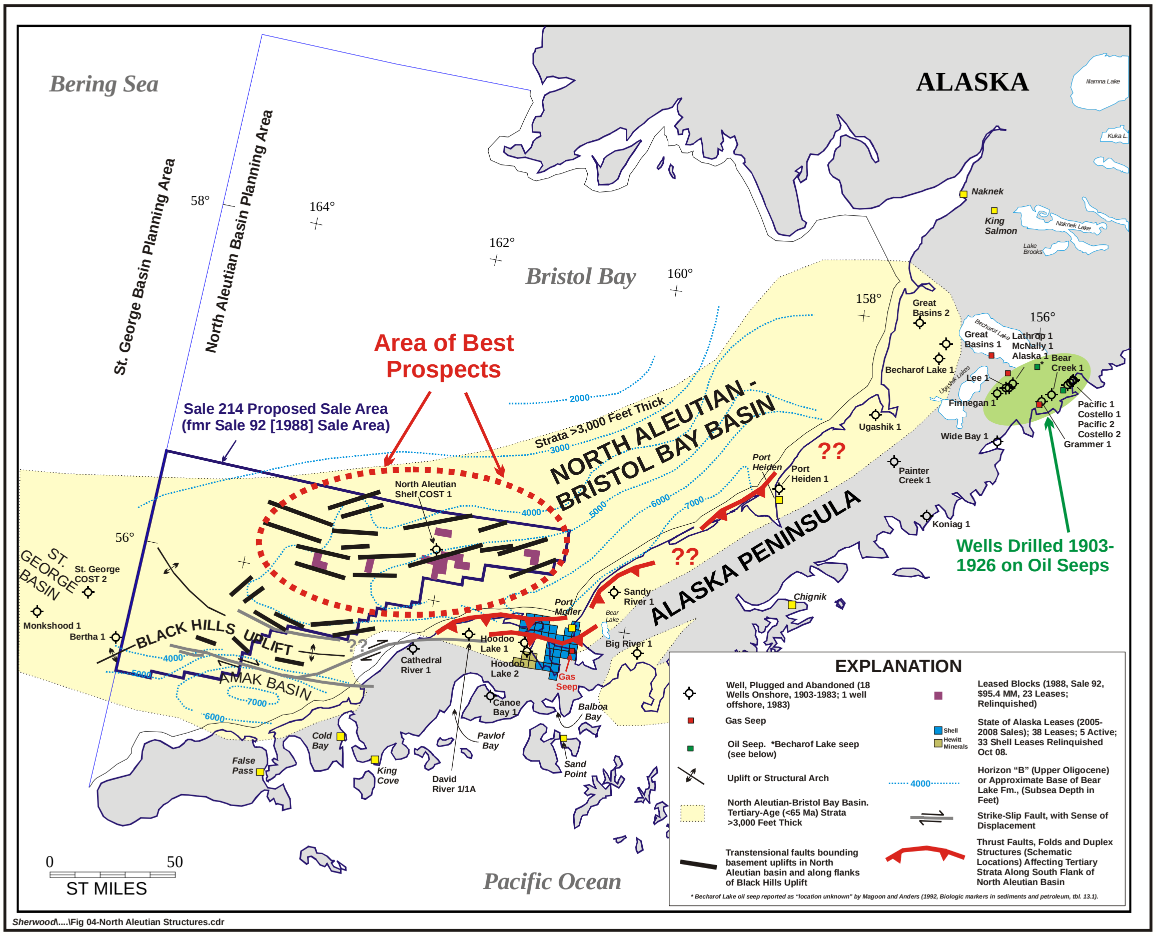



Figure II-26. Map of Principal Geologic Structures of the North Aleutian Basin And Contiguous Areas (including: 1) area of best prospects among transtensional faults and basement uplifts in western part of basin; 2) wrench-fault structures along the Black Hills uplift; and 3) fold/thrust structures along the north coast of the Alaska Peninsula).

The best prospects in the North Aleutian basin are viewed as gas-prone for primarily 3 reasons:

(1) The organic chemistry and organic petrography (classification of organic particle types) of the strata that floor the North Aleutian Basin indicates dominantly coaly material (deposited as cellulose or wood) that lacks the lipidic (fatty) substances that thermally convert to oil (Sherwood et al., 2006, p. 22-26). Coal and cellulose are both primarily sources for gas;

(2) The shallow strata that are thermally immature are coal bearing and are subject to bacterial degradation of organic matter, leading to creation of biogenic methane; and

(3) Unlike the Cook Inlet Basin, where a sub-stratum of Mesozoic sedimentary rocks created the oil that rose into shallow fold structures bearing Tertiary-age reservoir sandstones (Magoon, 1994), the best prospects in the North Aleutian Basin are underlain by a sub-stratum of Mesozoic granites and related rocks that offer no potential as hydrocarbon sources (Sherwood et al., 2006, p. 13-15). Mesozoic sedimentary rocks that might generate oil do extend beneath the southwestern part of the program area and correspond to a lease-sale deferral option in that area.

### (2) Exploration and Discovery History

No oil or gas production has taken place in either the North Aleutian Basin Planning Area, the adjoining (on the west) offshore St. George Planning Area, or on the Alaska Peninsula (onshore to the south). The nearest commercial production is 350 miles northeast of the planning area. The only offshore well drilled in the North Aleutian Basin is the North Aleutian Shelf COST 1 well (Figure II-26). The "COST" (Continental Offshore Stratigraphic Test) well was drilled in 1983 amid the best prospects by an industry consortium led by ARCO Exploration Company for the express purpose of gathering G&G information (the well was specifically drilled in a non-prospective location). The COST well did encounter minor shows of gas and oil below 15,000 feet but nothing capable of inflow to the wellbore (Turner et al., 1988).

Although prospective structures are found throughout the North Aleutian Basin, those in the central part of the Basin have long been the focus of exploration interest. Twenty-three blocks in five groups were leased for total high bids of $95.4 million in OCS Lease Sale 92 in 1988 (lease blocks located in Figure II-26). None of the leases were drilled and all were returned to the U.S. Government under a buy-back agreement in 1995. These blocks remain the most prospective targets in the sale area.

In 2005, the State of Alaska opened a large area of the Alaska Peninsula to competitive oil and gas leasing and has since held three lease sales. The State of Alaska issued a total of 38 leases to Shell Oil and Hewitt Minerals for total high bids of $1,307,116.80 in the Port Moller area (leases located in Figure II-26). In October 2008, all 33 Shell leases were relinquished back to the State of Alaska. The five Hewitt Minerals leases remain active at present. The State of Alaska has issued a call for information (Alaska Division of Oil and Gas [AKDOG], 2008) and proposes a fourth lease sale for May 2009.

In October 1989, the North Aleutian Basin Planning Area was placed under a Congressional moratorium in reaction to reqiests for fisheries protection in Bristol Bay by Native organizations, Native villages, local fishing interests, and the State of Alaska following the March 1989 Exxon Valdez grounding and oil spill in Prince William Sound, Alaska. In the FY 2004 Congressional budget bill for the DOI, the Congressional moratorium for the North Aleutian basin was discontinued. The Presidential Withdrawal was amended in January 2007 to delete references to the North Aleutian Basin, thereby opening the potential for consideration of a leasing program.

**(3) Resource Estimates**

The 2006 MMS assessment (MMS, 2006d) indicates that the North Aleutian Basin could contain sufficient overall gas resources in accumulations large enough to support economic development under realistic gas price scenarios. As shown in Table II-16, mean risked UTRR for associated and nonassociated gas is 8.62 Tcf but could range up to a maximum (F5) potential of 23.28 Tcf. Mean risked UTRR for oil is estimated to be 0.75 Bbo but could range up to a maximum (F5) potential of 2.50 Bbo. At the low case (F95), the estimated UTRR is 0.40 Tcf of gas and 0.02 Bbo.

The North Aleutian Basin is gas-prone, with 67 percent of the undiscovered hydrocarbon energy endowment consisting of natural gas (on an energy equivalent or BOE basis). Because natural gas is the dominant resource, any offshore development will likely be driven by the discovery of large nonassociated gas reserves in the Sale 214 program area. The program area for lease sale 214 comprises only 17 percent of the total area of the North Aleutian Basin Planning Area, but contains 89 percent of the undiscovered gas and oil resources. The largest and most attractive prospects in the planning area are also located within the Sale 214 program area. The mean conditional (“unrisked” resources, or the quantities actually available in the event of a discovery) oil-equivalent size of the largest hypothetical pool in the North Aleutian Basin is 0.83 Bbo on a BOE basis. In an all-gas case, this is equivalent to 4.65 Tcf and is nearly twice the size of the largest gas field in Cook Inlet (Kenai gas field, 2.46 Tcf estimated ultimate original reserves; AKDOG, 2007). At maximum (F5) size, the same hypothetical pool could contain 14.02 Tcf of natural gas. Table II-17 shows the estimated ranges of conditional oil-equivalent and gas-equivalent sizes of the 10 largest hypothetical undiscovered pools in the North Aleutian Basin. The top five hypothetical pools all exceed 1 Tcf gas at the mean and as a group could probably support commercialization through an LNG (liquefied natural gas) export infrastructure.

Table II-18 shows the results of MMS’s economic analysis of the North Aleutian Basin Planning Area. In the mean resource case, about 25 percent of the UTRR resources are economically recoverable at an oil price of $60/bbl, and a gas price of $6.41/Mcf. This increases to about 74 percent of the UTRR being economically recoverable at an oil price of $160/barrel and a gas price of $17.08/Mcf.

Table II-16. Undiscovered Technically Recoverable Resources in the North Aleutian Basin Planning Area

| Alaska OCS Region | Oil (Bbo) | | | Natural Gas (Tcf) | | | BOE (Bbo) | | |
|---|---|---|---|---|---|---|---|---|---|
| | F95 | Mean | F5 | F95 | Mean | F5 | F95 | Mean | F5 |
| North Aleutian PA | 0.02 | 0.75 | 2.50 | 0.40 | 8.62 | 23.28 | 0.09 | 2.29 | 6.65 |

(PA-Planning area; Bbo-billion barrels of oil; Tcf-trillion cubic feet of gas. F95 indicates a 95-percent chance of at least the amount listed; F5 indicates a 5-percent chance of at least the amount listed. Only mean values are additive.)

Table II-17. Sizes of Top 10 Hypothetical Undiscovered Pools in the North Aleutian Basin Planning Area

| Pool Rank | Oil Equivalent Resources* BOE (MMbo) | | | Gas Equivalent Resources** TCFE (Tcf) | | |
|---|---|---|---|---|---|---|
| | F95 | Mean | F5 | F95 | Mean | F5 |
| 1 | 187 | 827 | 2495 | 1.05 | 4.65 | 14.02 |
| 2 | 20 | 378 | 1302 | 0.11 | 2.13 | 7.32 |
| 3 | 106 | 378 | 816 | 0.60 | 2.12 | 4.58 |
| 4 | 65 | 245 | 542 | 0.37 | 1.38 | 3.04 |
| 5 | 61 | 208 | 467 | 0.34 | 1.17 | 2.62 |
| 6 | 41 | 174 | 382 | 0.23 | 0.98 | 2.15 |
| 7 | 9 | 148 | 469 | 0.05 | 0.83 | 2.63 |
| 8 | 26 | 130 | 290 | 0.14 | 0.73 | 1.63 |
| 9 | 34 | 124 | 248 | 0.19 | 0.70 | 1.40 |
| 10 | 6 | 110 | 365 | 0.03 | 0.62 | 2.05 |

MMbo, millions of barrels of oil, Tcf, trillion cubic feet of gas.
* Conditional, Undiscovered Technically Recoverable Oil Resources in millions of barrels of oil equivalent
** Conditional, Undiscovered Technically Recoverable Gas Resources in trillions of cubic feet of gas equivalent

Table II-18. Mean Undiscovered Economically Recoverable Resources in the North Aleutian Basin Planning Area

| Alaska OCS Region | $60/bbl and $6.41/Mcf | | | $110/bbl and $11.74/Mcf | | | $160/bbl and $17.08/Mcf | | |
|---|---|---|---|---|---|---|---|---|---|
| | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) | Oil (Bbo) | Gas (Tcf) | BOE (Bbo) |
| North Aleutian PA | 0.43 | 0.79 | 0.57 | 0.59 | 4.62 | 1.41 | 0.64 | 5.92 | 1.69 |

(PA-Planning area; Bbo-billion barrels of oil; bbl-barrels of oil, Tcf-trillion cubic feet of gas; Mcf-thousands cubic feet of gas; BOE-barrels of oil equivalent.)

### (4) Data Coverage and Information Gaps

The North Aleutian Basin is covered by two dimensional (2-D) seismic data with a 1- to 5-mile grid spacing in prospective areas, mostly acquired 1975 to 1988. These seismic data consist of 61,438 line miles of 2-D data and 3,234 line miles of shallow-penetrating, high-resolution data. Airborne magnetic data cover 9,596 line miles and airborne gravity data cover 6,400 line miles. This extensive grid of 2-D seismic data is shown in Figure II-27. The seismic data are particularly closely-gridded in the areas of the most attractive prospects.

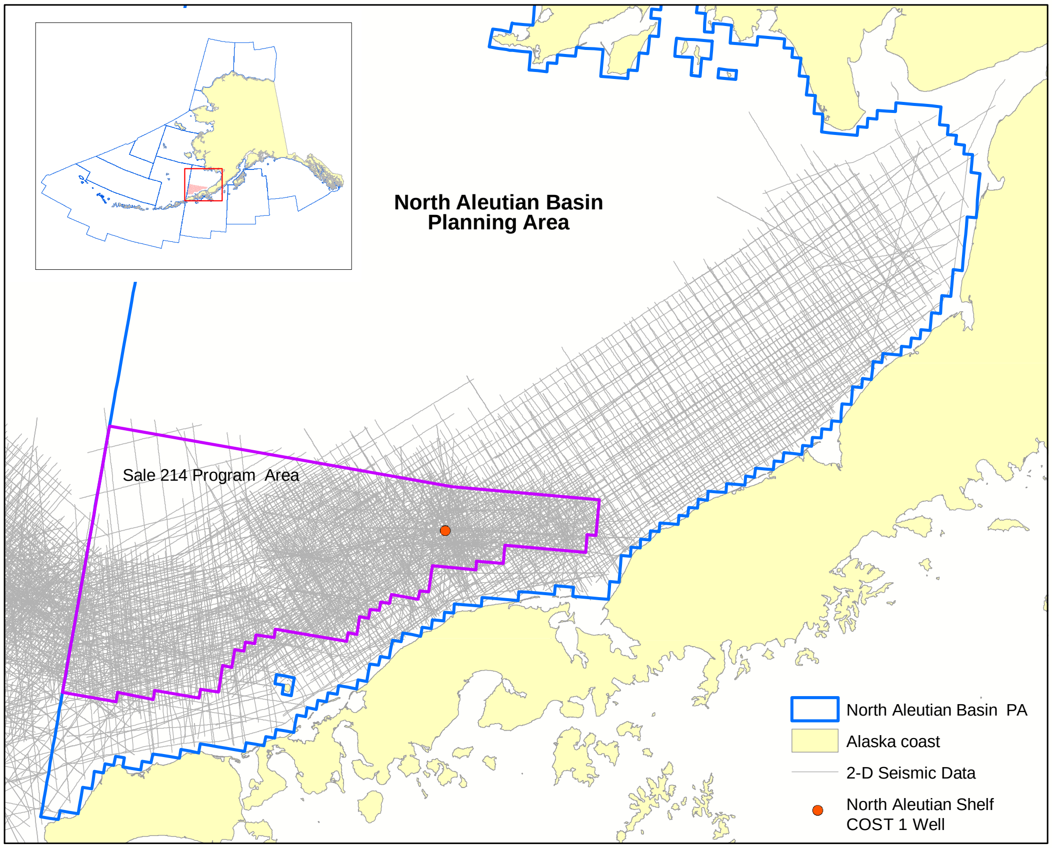



Figure II-27. Map of 2-D Speculative Seismic Data Grid for the North Aleutian Basin and Outline of Sale 214 Program Area

The MMS has acquired the 2-D seismic data shown in Figure II-27. These data are available for purchase to other parties from seismic contractors and are currently being reprocessed for internal conformity and to update and optimize their quality. The existing 2-D seismic data set is likely sufficient for resource assessment, for mapping of prospects, and for bid formulation in the event of a lease sale.

The North Aleutian Shelf COST 1 well, a 1983 industry-sponsored geologic information test, drilled through most of the basin fill and provides an outstanding source for lithologic, biostratigraphic, petrophysical, and geochemical data. However, the only publicly available biostratigraphic study of the COST well is 25 years old and does not consider recent discoveries of past oceanic circulation patterns, their control of biomass productivity, the composition of sedimentary organic materials, and the likelihood of a basin containing gas fields or oil fields.

Numerous onshore seeps have been documented along the Alaskan coastline, but in the Alaska OCS Region, there are no publically documented offshore seeps. Seep studies based on satellite radar imagery have demonstrated the ability to detect offshore seeps and could provide important data for the Arctic offshore areas.

## D. Unconventional Resources -- Gas Hydrates

Gas hydrates are ice-like crystalline substances occurring in nature where a solid water lattice accommodates gas molecules (primarily methane, the major component of natural gas) in a cage-like structure, also known as clathrate. Gas hydrates form under conditions of relatively high pressure and low temperatures, such as those found in the shallow subsurface under many of the world's oceans, including much of the deepwater OCS. Gas hydrates are also found under arctic permafrost conditions that exist onshore in northern Alaska, and in the relatively shallow water areas of the Beaufort Sea. One cubic foot (cf) of gas hydrate at reservoir temperature and pressure yields approximately 160 cf of gas at atmospheric temperature and pressure. The amount of natural gas in methane hydrate worldwide is estimated to be far greater than the entire world's conventional natural gas resources.

The Methane Hydrate Research and Development Act of 2000, later amended in Section 968 of Public Law 109-58, (30 U.S.C. 1902-The Energy Policy Act of 2005), directs several Federal agencies (including MMS, USGS, and Bureau of Land Management [BLM] from the DOI) to cooperatively engage in gas hydrate research and development efforts. The USGS has studied gas hydrates since the 1970’s and remains a world leader in gas hydrate research. The MMS has responsibility for characterizing and managing the Nation’s resources in the U.S. OCS, including gas hydrates. The unique role of DOI, as the Nation’s land and resource manager, is important to note, as 99 percent of the natural gas hydrate resources of the United States are federally managed, the majority in the Federal OCS.

In October of 2008, the USGS published the first-ever assessment of technically recoverable gas hydrate resources on the North Slope of Alaska (Figure II-28), in an area that includes state, federal, and Native lands. The USGS estimates that there are about 85 Tcf of undiscovered, technically recoverable gas resources within gas hydrates in this area (Collett, et al, 2008). The research project in support of this assessment was a cooperative effort with the BLM and the State of Alaska. This effort was possible because of (1) the quality of data available on the North Slope of Alaska, (2) recent USGS research advances that allow for direct detection of gas hydrates in the subsurface, and (3) recent collaborative efforts between U.S. Department of Energy [DOE], USGS, and others that have provided important new insights into the characterization and producibility of gas hydrate reservoirs (Boswell, et al, 2008). This has allowed some gas hydrate accumulations to be considered technically recoverable. The USGS and BLM will continue to focus on improving our understanding of gas hydrates as an energy resource and quantifying the ultimate impact of gas hydrate development and production, so that gas hydrates can be more effectively regulated and managed as a national resource. This project will also contribute to the DOE- and industry-led field programs designed to test existing and emerging gas hydrate production technology. All of this information will contribute to our understanding of gas hydrates in a variety of settings, including offshore in the Federal OCS.

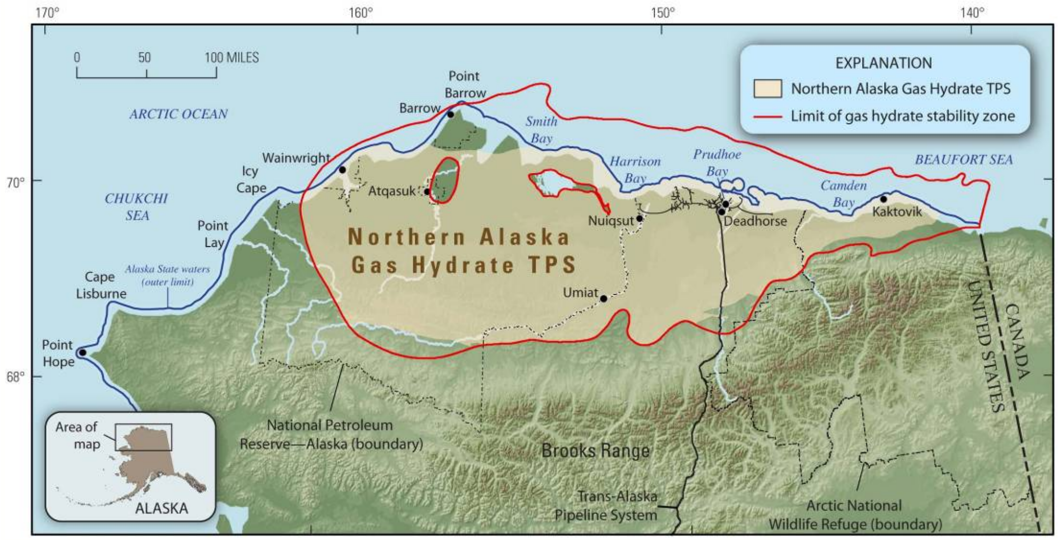



Figure II-28. The Northern Alaska Gas Hydrate Total Petroleum System (TPS) (shaded in tan) and the Limit of Gas Hydrate Stability Zone in Northern Alaska (red outline)

Understanding gas hydrate distribution and resource potential in the deepwater marine environment is also a top priority of the U.S. Federal program. To this end, a multi-year exploratory drilling program in the Gulf of Mexico (the joint industry project, or JIP) has been led by Chevron and DOE, and supported by MMS, USGS, and other partners. Several well penetrations from the first JIP expedition in 2005 recorded the presence of gas hydrate in the GOM and established the basis for additional studies, and funding is in place to conduct a second expedition in 2009. Exploration technologies have improved such that the JIP has now identified several target areas where gas hydrate is expected to be encountered at relatively high saturation levels in reservoirs with properties similar to conventional gas targets

The MMS is in the process of completing the first comprehensive resource assessment of gas hydrates on the Federal OCS in nearly 15 years. The last national assessment was done in 1995 by the USGS, at the request of MMS. Ultimately, the final results of the current multi-year effort will provide estimates of the undiscovered in-place, technically recoverable, and economically recoverable gas hydrate resources for each OCS Region (Gulf of Mexico, Atlantic, Pacific and Alaska). As of February 2009, only preliminary results for the GOM have been published (MMS, 2008a), where the mean in-place gas hydrate resource is estimated to exceed 21,000 Tcf (Figure II-29). This estimate is similar to that published by the USGS 15 years ago.

As the in-place value includes all gas hydrate resources in a variety of sediment hosts and trap types, the fraction of this volume that can be technically recovered and brought to market will be identified in the next phase of the project. The MMS assessment methodology provides an opportunity to segregate the in-place resources by reservoir type, including sands, shales, and fractures. As recent field and laboratory testing suggest that commercial production volumes from gas hydrate can only be achieved from porous sandstone reservoirs, it is expected that the large in-place volume modeled in the GOM will be reduced significantly to include only those resources hosted in sands. The MMS is working with USGS to develop the methodology for this OCS assessment as it evolves from an in-place resource assessment to one that predicts technically recoverable resources.

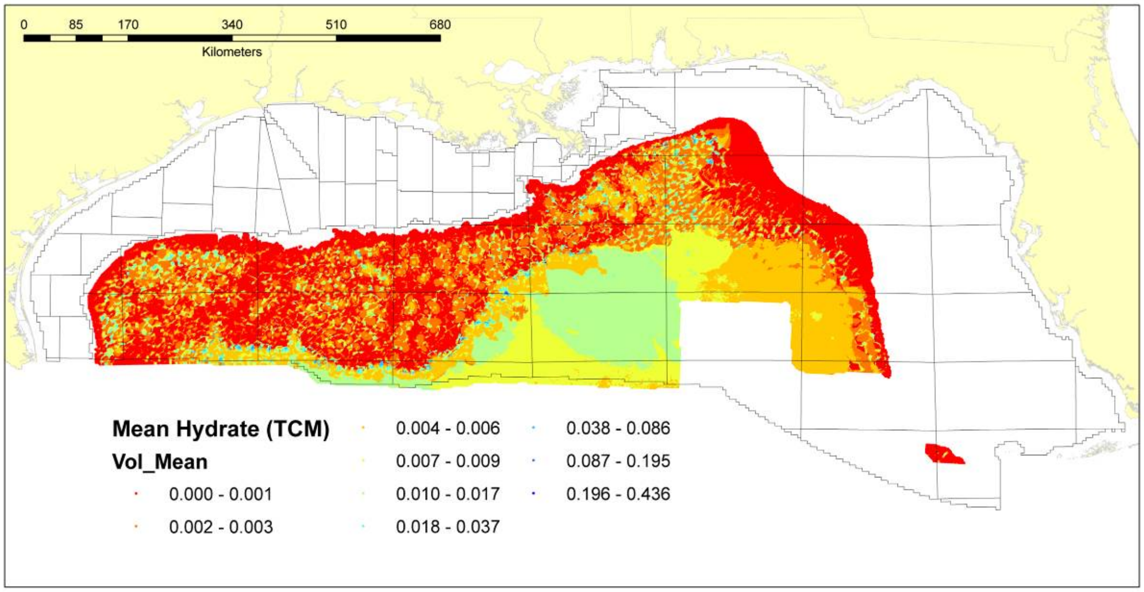



Figure II-29. Map Showing MMS Gulf of Mexico Gas Hydrate Assessment Area And Mean In-Place Volume Per Model Cell. Modeled Values Are in Trillion Cubic Meters (1 $m^3$ = 35.3145 $ft^3$).

**Information Gaps:** While global investment in gas hydrate research has accelerated over the past several years, large gaps remain in our scientific understanding of this unconventional resource. A series of recent major marine expeditions in Japan, India, China, Korea, and the United States have successfully located gas hydrates, and in doing so continue to reveal the natural complexity and heterogeneity of gas hydrate deposits. The USGS has been asked to participate in a number of these efforts and currently works closely with the Indian Government Directorate General of Hydrocarbons (DGH) in an effort to study, characterize, and explore for hydrates off the coast of India. Joint research to date includes comprehensive analyses and publication of research results of gas-hydrate-bearing marine sediments in a variety of settings (USGS, 2008). Future work will include additional characterization of data, examination of 3-D seismic, and more detailed study of offshore gas hydrates. The ultimate goal will be a gas hydrate production test in Indian waters. The data, syntheses, and analyses from the Indian collaboration will be invaluable in understanding world class hydrate accumulations in a variety of geological settings, and lessons learned will be transferable to U.S. domestic gas hydrate resources, especially in the U.S. OCS.

One of the biggest research needs is to gain a better understanding of the production potential from gas hydrates. Early results from recent Arctic field programs have provided important new insights into the characterization and producibility of gas hydrate reservoirs (Yamamoto and Dallimore, 2008). Limited data collection now allows some gas hydrate accumulations to be considered technically recoverable, yet there remain questions of long term producibility and economic feasibility. A DOE-industry-USGS-led effort on the North Slope of Alaska will attempt to establish the first long-term production test from a gas hydrate reservoir by the end of FY 2010. Results from this effort are needed to determine the viability of adding gas hydrates to our domestic energy resource base, whether it be onshore or from the OCS.

The science of detecting and quantifying gas hydrates in a marine environment still remains a challenge. Great advances have been made in direct detection methods, but the sparseness of data attest to the need for improvements in technology and methodology. The USGS, MMS, and partners will continue to focus on improving our ability to characterize and understand gas hydrates as an energy resource through programs such as the JIP. Additionally, MMS and USGS activities to understand marine gas hydrate accumulations include conducting seismic interpretation to map its presence; identifying and quantifying gas hydrates from well log analysis; mapping hydrate occurrence through integrated seismic attribute analysis and geological interpretation; measuring thermal properties of sediment-gas hydrate mixtures to constrain numerical modeling parameters; and determining physical properties of sediment-gas hydrate properties. The USGS research, when paired with MMS local and regional knowledge based on drilling and seismic data, forms a remarkable synergy for understanding gas hydrates on the U.S. OCS. These efforts will help to ensure that the Federal program meets its stated goal of understanding the economic potential of marine gas hydrate resources by the year 2025 (DOE, 2008a).

Another area needing additional research is the intersection of gas hydrates and climate change. The USGS and DOE are studying Alaskan gas hydrates to understand the potential impacts of climate change on gas hydrates. The Arctic is one of the places on Earth where climate change is most accelerated, and is the logical place to study how climate change may be affecting gas hydrate. This research effort is just starting, by asking the fundamental question of whether we can measure a gas hydrate signature in methane emissions at high latitudes. In linking gas hydrate and climate issues, the USGS is taking a full life-cycle view of this potential alternative energy resource.

# III. SENSITIVE ENVIRONMENTAL AREAS AND RESOURCES

## A. Introduction

The following section provides a general description of the various areas under discussion for future leasing activities that are not currently within the 5-Year Program (Figure II-2). For oil and gas activities, the proposed areas include the Atlantic Region, two areas in the Pacific Region, and a deepwater area in the Eastern Gulf of Mexico. Areas under consideration in Alaska are already a part of the current program; however, discussions are included for completeness. Hawaii is not included for consideration of oil and gas development because of the lack of these resources (see Section II). For renewable energy activities, all areas of the Atlantic, Pacific, and Gulf of Mexico Regions are under discussion. In the near future, wind development is expected off the Atlantic coast, wave development potentially could occur off the Pacific coast, and ocean current development potentially could occur off the eastern Florida coast where the resources have the greatest potential (see Section I). The Gulf of Mexico does not have renewable energy resources that match these other areas. Renewable energy development is not anticipated on the Alaskan Outer Continental Shelf (OCS) because of the harsh environment and lack of an energy market. While wave development is possible in Hawaii, these activities are occurring within State waters and activities in Federal waters are not anticipated because most shallow areas are incorporated in the Humpback Whale National Marine Sanctuary or the water depths are extreme. Ocean Thermal Energy Conversion or OTEC is not within Minerals Management Service (MMS) jurisdiction according to the Environmental Policy Act of 2005 (EPAct).

### 1. Overview of Environmental Review Process

The environmental review process for oil and gas or renewable energy development activities includes compliance with various laws and regulations. The National Environmental Policy Act (NEPA) of 1969 requires that all Federal Agencies use a systematic, interdisciplinary approach that will ensure the integrated use of the natural and social sciences in any planning and decision making that may have effects on the environment. Federal laws impose additional requirements on the offshore leasing process, including the Coastal Zone Management Act (CZMA); Federal Water Pollution Control Act Amendments; Marine Mammal Protection Act (MMPA); Endangered Species Act (ESA); Marine Protection, Research and Sanctuaries Act; and the Migratory Bird Treaty Act (MBTA).

The goal of the NEPA process is to help public officials make decisions based on an understanding of environmental consequences and take actions that protect, restore, and enhance the environment. It provides the tools to carry out this goal by mandating that every Federal Agency prepare a study of the impacts of proposed major Federal actions significantly affecting the quality of the human environment and provide alternatives to the proposed action. The NEPA also requires that Federal Agencies make a diligent effort to involve the interested and affected public before they make decisions regarding proposed major actions that would have impacts on the environment.

### a. Oil and Gas

As required in Section 20 of the Outer Continental Shelf Lands Act (OCSLA), the MMS has established a tiered process that evaluates the potential environmental consequences for each successive management decision starting with the proposed program, then individual lease sales, and finally project-specific plans. The 5-Year Programmatic Environmental Impact Statement (EIS) analyzes the proposed leasing schedule, focusing on the size, timing, and location of proposed lease sales for the 5-year period identified in the proposed program document. The Programmatic EIS takes a broad overview of the environmental effects from the potential activities.

Once the 5-year lease sale schedule is approved, a more detailed environmental analysis is conducted for each proposed lease sale in a given area. These lease sale EISs are more detailed, including analyzing scenarios of potential activities that could result, should a lease sale occur. At this point, MMS identifies lease stipulations, which are protective of the environment, to be included in the leases granted to industry. In some cases, an EIS is prepared for multiple lease sales in a program area. This Multisale EIS is the only environmental review conducted for the first sale held in a program area. An additional environmental review, in the form of an Environmental Assessment (EA) or supplemental EIS, is conducted for each subsequent proposed lease sale to address any new relevant information. Along with the preparation of a lease sale EIS or EA, the MMS carries out informal and formal consultations with other Federal Agencies, the affected States, and the public. This includes the ESA Section 7 consultations with the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Fish and Wildlife Service (FWS), an Essential Fish Habitat (EFH) consultation with NOAA, government to government consultations with tribes, and preparation of a consistency determination for each affected coastal State, as required in the CZMA.

After leases are issued, the MMS conducts environmental reviews for every exploratory and development plan to ensure that the proper environmental protective measures (mitigations) are employed. The MMS identifies site-specific mitigation measures in the form of conditions of approval. The mitigations may include avoidance of sensitive biological communities and archaeological resources, or inclusion of specialized discharge requirements.

### b. Renewable Energy

The MMS is the lead Federal Agency for NEPA compliance for renewable energy activities on the OCS. Some of the information MMS would require under it proposed rule would support other Federal Agencies' information requirements associated with compliance with the laws and regulations that they enforce. A tiered process would be used by the Renewable Energy Program (REP) to ensure that each management decision has undergone an appropriate environmental review with input from stakeholders and the public.

A Programmatic EIS was prepared by MMS in November 2007 to analyze key environmental issues identified during the establishment of the program and formulation of the rules. The process of preparing the Programmatic EIS facilitated input of concerns from the public early in the process. Unlike the oil and gas program, which has a mandated cycle of 5 years for evaluation of the program, it is conceivable that the REP will visit programmatic or national level issues only once. While a periodic national approach to planning and analysis could be instituted for the REP, it is more likely that subsequent environmental analysis and decision making will be focused on regional and local considerations. This is partly due to the type of decisions that will be made. While oil and gas supply has national implications, input to electrical markets is regional and local.

The EPAct requires that MMS issue leases for renewable energy activities on the OCS through a competitive process unless no competition exists. For the oil and gas program, MMS issues a call for nominations establishing interest by the industry in specific areas. This process has worked efficiently by identifying areas needing further attention while not expending government resources to evaluate areas where industry would not pursue development. Similarly, the MMS will query industry for interest in areas of the OCS for future renewable energy development. Based on industry response, MMS will focus further environmental evaluations on areas where development may occur. If there is interest only for a single project, then a project-specific NEPA analysis would be required. If competition is present within a specific area, then a lease sale will be held, and an appropriate NEPA analysis would be conducted. In all cases, consultations required under other Federal regulations will be conducted with the appropriate Federal or State agency. After leases are issued as the result of a lease sale, project-specific NEPA evaluation would still be required from each lessee when more specific details about the project are available.

## 2. Overview of Research Programs for the Outer Continental Shelf

### a. MMS Environmental Studies Program

The MMS Environmental Studies Program (ESP) was initiated in 1973 as a means to gather and synthesize environmental science and social and economic information to support decision making concerning the offshore oil and gas program. Early in the program, the focus was on obtaining baseline information on the vast biological resources and physical and chemical characteristics of the environment. These studies included biological surveys of marine species, basic oceanography and meteorology, and geologic and sea ice phenomena. As a broader base of information was established, it became possible to focus on more topical studies in smaller areas to answer specific questions and fill identified information needs as well as continuing to update baseline information. After a number of sales were held and exploration activities began monitoring of the possible effects of oil and gas activities on the environmental resources of these areas were initiated. In addition, generic studies were initiated to examine the potential effects of oil spills on biological resources, and different scenarios were developed to determine the most likely routes of transport and dispersion. Computer modeling techniques have been implemented to aid in the assessment of potential oil spills and other pollutant risks to the environment and to key species such as fur seals, sea otters and endangered whales. Modeling has also been used in ecosystem studies, especially where extrapolation to other areas provided valid analysis.

Since the ESP began, more than $840 million on environmental studies has funded disciplines such as physical oceanography, fate and effects of pollutants, protected and endangered species, wildlife biology, habitat characterization, and the social sciences. As information has been gathered, the goal of enhanced decision-support has required greater integration of various scientific disciplines. As the MMS and other Federal and State agencies collect more pertinent information, the MMS also funds studies to search and evaluate existing literature and data prior to initiation of field efforts. This prevents duplication of effort and saves valuable resources by focusing study efforts on the areas of greatest information need and highest usefulness to MMS decision needs.

In 2004, the U.S. Commission on Ocean Policy (USCOP) noted that "the MMS Environmental Studies Program (ESP) is a major source of information about the impacts of OCS oil and gas activities on the human, marine, and coastal environments" (USCOP, 2004). The ESP was evaluated by the U.S. Office of Management and Budget using the Administration's Program Assessment Rating Tool. The review found that the program is "very effective in providing timely and peer reviewed environmental research to decision makers."

The ESP was reviewed and evaluated by the National Research Council of the National Academy of Sciences (NRC, 1974, 1975, 1978, 1983, 1985, 1986, 1987, 1989a, 1989b, 1989c, 1990a, 1990b, 1992a, 1992b, 1993, 1994, 2003). These reviews were used to better focus and improve the information gathered through the ESP. The ESP is evaluated annually by a Federal Advisory Committee, which makes recommendations about the program direction.

As the Renewable Energy Program within MMS develops, the ESP will provide support to meet its information needs. The MMS sponsored a workshop and literature synthesis in 2007 to identify the information gaps in the areas of physical processes, marine species, birds and bats, and social and economic issues. Results from this effort were used to identify studies that could be funded through the MMS environmental studies program. Understandably, many of the information needs overlap with those for the oil and gas program. The MMS is already pursuing approximately $5 million in research efforts to support the new program including studies of seabirds and shorebirds along the Atlantic Coast, the effects of electric cables in the marine environment, the visual impacts on historic properties, and infrastructure needs along the Atlantic coast, to name a few. There are also recent documents and workshop outputs that examine environmental effects of alternative energy, including Boehlert et al. (2008), the U.S. Department of Energy (2008b), and Nelson et al. (2008) as well as international efforts by such countries as Denmark (e.g., Dong Energy, 2006) and England (COWRIE).

### b. Technology Assessment and Research Program (TA&R Program)

The MMS TA&R Program supports research associated with operational safety and pollution prevention as well as oil spill response and cleanup capabilities. The TA&R Program was established in the 1970's to ensure that industry operations on the OCS incorporated the use of the best available and safest technologies subsequently required through the 1978 OCSLA amendments. The TA&R Program is comprised of two functional research activities: Operational Safety and Engineering Research and Oil Spill Research. Recently, the program has funded several studies addressing issues for renewable energy technologies. These are addressed in more detail in Section I of this report.

The TA&R Program has four primary objectives:

- **Technical Support:** Providing engineering support to MMS decision makers in evaluating industry operational proposals and related technical issues and ensuring that these proposals comply with applicable regulations, rules, and operational guidelines and standards.
- **Technology Assessment:** Investigating and assessing industry applications of technological innovations and ensuring that governing MMS regulations, rules, and operational guidelines encompass the use of the best available and safest technologies.
- **Research Catalyst:** Promoting leadership in the fields of operational safety and engineering research and oil spill response and cleanup research activities by acting as a catalyst for industry research initiatives.
- **International Regulatory:** Providing international cooperation for research and development initiatives to enhance the safety of offshore oil and natural gas activities and the development of appropriate regulatory program elements worldwide.

### c. The United States Geological Survey

A close working relationship between the MMS and the United States Geological Survey (USGS) was established in response to Secretary Babbitt's August 1994 request to all Department of the Interior (DOI) Directors to strengthen the ties between DOI's science bureau, the USGS, and resource management bureaus such as the MMS. Since then, MMS and USGS interact regularly to discuss MMS information needs and the application of available USGS budgetary capacity and scientific expertise to address those needs. The USGS has contributed with studies of coastal and seafloor habitats, coastal and offshore fish and fisheries, seabirds, sea turtles, marine mammals, and environmental consequences of decommissioning platforms on fisheries. The USGS continues to collaborate closely with MMS in support of ecologic and oceanographic investigations that promote the understanding and management of coastal and offshore energy, minerals, and biological resources.

## 3. Relationships with Other Information Sources

The ESP also coordinates with other U.S. and local research entities such as: NOAA, FWS, National Park Service, U.S. Navy, National Oceanographic Partnership Program, Bureau of Land Management, National Aeronautics and Space Administration, National Science Foundation (NSF), Arctic Research Commission, Polar Research Board, and North Pacific Research Board to name a few. The ESP collaborates with many academic institutions such as: University of Alaska, Louisiana State University, Woods Hole Oceanographic Institution, Oregon State University, University of Washington, University of California-Santa Barbara, and University of Rhode Island; industry programs. The U.S. Department of Energy, through its National Laboratories, University research partners, and new National Marine Renewable Energy Centers, is undertaking research and development efforts in the area of marine renewable energy, and a relationship between MMS ESP and these entities should be developed.

Additional international linkages with other arctic nations' research and regulatory entities have been established. The United States and seven other arctic nations voluntarily agreed to cooperate on an Arctic Environmental Protection Strategy, which evolved into the formation of the Arctic Council in 1996. The ESP participates with Arctic Council activities, such as the Arctic Monitoring and Assessment Program, Conservation of Arctic Flora and Fauna, Arctic Climate Impact Assessment, and others. The ESP provides information to these working groups through review of reports and plans and helps to inform participants of available information sponsored by MMS. Further, the ESP identifies and facilitates specific studies that can coordinate and integrate with working group activities.

## 4. Overview of Marine Cadastre

The EPAct directs the Secretary of the Interior, in cooperation with the Secretary of Commerce, the Commandant of the Coast Guard, and the Secretary of Defense, to establish an OCS Mapping Initiative to assist in decision making related to alternative energy uses on the OCS. The goal of the initiative is the identification of OCS locations of federally-permitted activities; obstructions to navigation; submerged cultural resources; undersea cables; offshore aquaculture projects; and any area designated for the purpose of safety, national security, environmental protection, or conservation and management of living marine resources. The repository of this data is the Multipurpose Marine Cadastre - an integrated submerged lands information system consisting of legal, e.g., property ownership or cadastre; physical; and cultural information in a common reference framework. The endeavor requires joint planning, interaction, and commitment by Federal, State, local, territorial, and tribal entities working through public and private partnerships. The Multipurpose Marine Cadastre allows for direct access to information and resources necessary to promote and conduct good ocean governance. The current Multipurpose Marine Cadastre is the first phase in an ongoing project. Work is ongoing to add additional data layers and improve the functionality of the viewer.

In conjunction with the Marine Cadastre effort, NOAA and private organizations are collating information in the form of electronic atlases that depict the current human uses of the ocean environment. One effort is underway in California where NOAA's Marine Protected Areas Center and the Marine Conservation Biology Institute are teaming to depict the full range of significant human uses of the ocean and State and Federal waters off the coast of California. Another major effort is being led by the Nature Conservancy to present an integration of data on habitats, species, and marine resource use for the North and Mid-Atlantic coastal and OCS areas. Under the Joint Subcommittee on Ocean Science and Technology (JSOST), an Interagency Working Group on Ocean and Coastal Mapping is assembling a catalog of seafloor mapping projects. These are examples of the many mapping projects for coastal and marine environments that are ongoing in the Federal, State, and private sectors.

## 5. Oil Spill Risk Analysis

Oil spills are of major concern to the public, offshore industry workers and managers, and Federal and State regulators. Spill prevention offshore is achieved primarily through the implementation of extensive safety procedures, practices, drills and engineering requirements, such as the use of downhole shut-off valves and blowout prevention devices. The record shows good results in minimizing spills. In 2003, the NRC reported that (over the period 1990-1999) offshore oil and gas development was responsible for only 2 percent of the petroleum found in the marine environment for North America. The MMS employs advanced oil spill risk analysis efforts to inform its environmental assessments on offshore activities. Spill prevention, mitigation, and response plans are required and tested frequently to maintain readiness offshore.

The MMS analyzes historic records of oil spill data, along with studies of ocean winds and currents, to provide a formal risk assessment in its NEPA environmental documents.

### a. Oil Spills

Intervention to prevent oil spills has reduced the number and volume of worldwide and OCS spills over the last few decades. The MMS has jurisdiction over oil spill planning and preparedness for oil storage, handling, and transportation facilities that are located seaward of the coastline. In this capacity, MMS approves oil spill response plans, conducts unannounced oil spill drills, inspects oil spill response equipment, and verifies training of spill management and spill response operating team members. As the U.S. Coast Guard (USCG) serves as the Federal On-Scene Coordinator for oil spills from the subject facilities, the MMS role in actual response activities is limited to providing engineering, technical, or scientific support to the USCG especially as it relates to offshore oil and gas infrastructure design, operation, and repair. The one exception during response is that MMS is directly responsible for spill abatement—ensuring that the source of the spill is quickly identified, controlled, and shut down.

Laws such as the Oil Pollution Act and the OCSLA make interaction between MMS and the USCG an imperative not only during offshore incidents but during routine offshore operations as well. To help delineate areas of expertise and jurisdiction, develop common compatible regulations and policies, and optimize the use of government resources, the two Agencies have entered in a Memorandum of Understanding and a number of highly technical Memoranda of Agreement. The documents that address subjects ranging from floating offshore facilities and civil penalties, to oil discharge planning, preparedness, and response, also assist the regulated community in understanding requirements affecting their particular offshore operation. The MMS closely monitors and analyzes all reported incident-related data to gain insight about preventing accidents, including oil spills, and to estimate future oil spill occurrence for NEPA environmental analysis.

### (1) Oil in the Sea III

In 2003, the National Research Council (NRC) published "Oil in the Sea III" (NRC, 2003), its third examination of petroleum inputs into marine waters worldwide. Comparisons to the NRC's two earlier reports demonstrate that total petroleum inputs per year into the marine environment worldwide have decreased significantly over the past three decades (NRC, 2003: Figure III-1). The NRC estimates offshore oil and gas development was responsible for only 2 percent of the petroleum released into the marine environment annually for North America as compared to 4 percent worldwide (NRC 2003: Figure III-2).

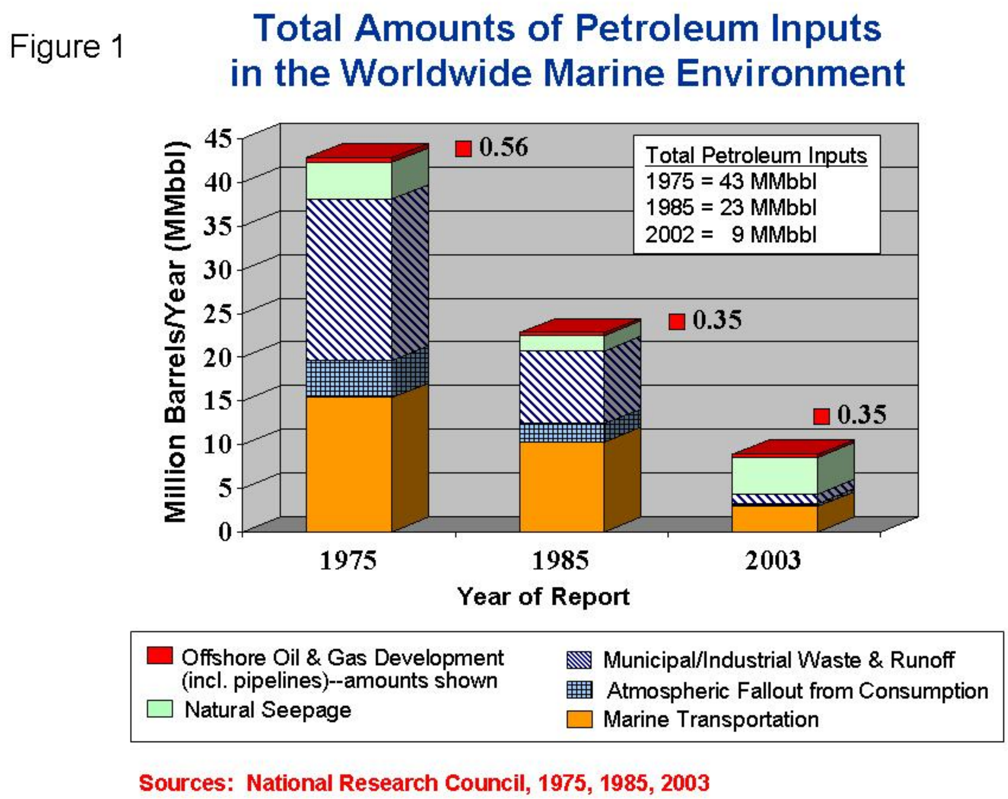



Figure III-1. Total Amounts of Petroleum Inputs in Worldwide Marine Environment

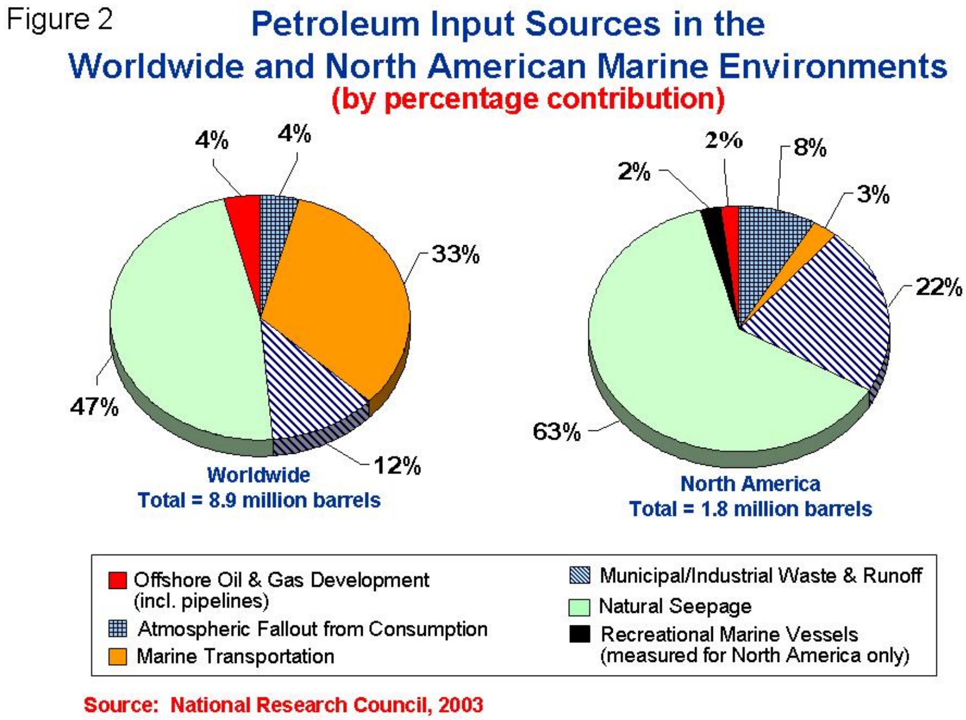



Figure III-2. Total Amounts of Petroleum Inputs in North American Marine Environments

#### (2) Natural Hydrocarbon Seeps

Natural hydrocarbon seeps are found where oil and natural gas bearing strata intersect the earth's surface, or where they are tapped by faults and fractures. In the 2003 NRC report, natural seepage was the largest single source of petroleum inputs into the marine environment (NRC, 2003: Figure 2). Natural seeps are common in the Gulf of Mexico, offshore southern California, and off coastal Alaska. Based on NRC (2003), 150 times more oil enters the marine environment from seeps than from Federal OCS oil and gas operations.

### b. Oil Spill Risk Analysis

The MMS assesses oil spill risks from offshore energy activities off the U.S. continental coast and Alaska in a formal analysis called the Oil Spill Risk Analysis (OSRA). Each analysis is conducted by a multidisciplinary staff with expertise in physical oceanography, biology, social sciences, computer programming, and operations research.

The OSRA estimates the relative oil spill risk associated with the production and transportation or storage of petroleum based on the historic spill record and trend analysis. As might be expected, small spills (typically on the order of less than 5 barrels) are more common than larger spills. The MMS analysts, who prepare pertinent environmental documents, identify the environmental, social, and economic resource areas within the study area of concern. The information from the OSRA model is used in the risk analysis contained in NEPA environmental documents. The analysts use this information to evaluate how a hypothetical large oil spill could impact specific environmental, social, or economic resources. The use of formal tools such as the OSRA enables MMS to better evaluate risk to environmental, social, and economic resources, and thus, facilitates informed and environmentally responsible decision making.

## 6. Geologic and Meteorologic Hazards

Seafloor instability is the principal geologic hazard and thus engineering constraint to the emplacement of offshore bottom-founded structures. Seafloor instabilities caused by seabed and sub-seabed geologic features and processes can cause damage to offshore infrastructure that could, in turn, result in adverse economic and environmental impacts. Geologic hazards in the offshore environment include, but are not limited to, (1) sediment transport events, leading to erosional scouring or burial; (2) ice gouging of the seafloor by free-floating icebergs and ice islands; (3) strong ground motions, liquefaction, and possibly ground rupture from earthquakes; (4) submarine landslides; (5) tsunamis; and (6) diapiric intrusions. Hazards assessments for each OCS Planning Area vary with respect to the geologic setting which governs the level of risk for each hazard type. For example, earthquakes, tsunamis, and submarine landslides are larger issues in the Pacific and Alaska OCS Regions, and ice gouging is an issue only in Alaska. The MMS is aware of these hazards and addresses and mitigates them through the regulatory process. The MMS and USGS also conduct ongoing research that identifies and assesses hazards to the offshore infrastructure. The USGS conducts National Seismic Hazard Maps for the onshore United States and parts of the OCS, and could expand this effort to include the entire OCS under consideration for leasing, and is also involved in tsunami hazard assessments for many parts of the United States. The USGS is also involved in studies to better understand hazards associated with drilling in areas with gas hydrates. Further research is needed to fully develop and update existing hazard assessments and related tools.

New data and hazards assessment support the updating of regulations, offshore infrastructure design criteria, and NEPA documents. Regional-scale geologic hazards are identified in MMS NEPA documents where appropriate mitigations are stipulated. Prior to the construction of offshore energy infrastructure, site-specific hazards are identified in shallow hazard surveys carried out by the operator. These surveys identify potential hazards associated with site-specific seafloor, sub-bottom, and geotechnical conditions, as well as the locations of magnetic anomalies which may indicate the presence of man-made features (such as pipelines) or potential cultural resources. The integrity of offshore infrastructure is also subject to the forces caused by changing ocean conditions and extreme weather events that generate intense winds, strong ocean and tidal currents, large waves, and heavy storm surges.

With a large portion of OCS production located in an active hurricane corridor, many changes in industry requirements have taken place due to the recent damages and curtailment associated with Hurricanes Ivan, Katrina, Rita, Ike, and Gustav. Most notably, the MMS meteorological and oceanographic conditions criteria used to design offshore infrastructure has been revised since the 2005 hurricane season. Besides upgrades in structure design, the MMS has recommended the installation of Global Positioning System locators and black box information storage systems on Mobile Offshore Drilling Units, which will continue to monitor on-site conditions after evacuation of personnel as well as track the location of the unit should it drift from its position. Additional guidance has been developed or made available to assess vulnerabilities for existing structures; applying modifications to minimize damage; identifying the best seafloor and soil conditions for jack-up rigs; and determining where and when a particular jack-up rig can be used during Hurricane Season. In addition, MMS has adopted a requirement that drilling contractors upgrade their mooring systems for mobile drilling units. This requirement involved an increase in the number of mooring lines from 8 to 12 to 16, and additional requirements for the type and strength of anchors and mooring lines used by mobile drilling units. A mandatory detailed checklist is used to assess the safety of a mooring system.

The MMS is continuing efforts with industry workgroups to address hurricane-related issues, manage risk, and minimize damages associated with future storms that enter the OCS of the Gulf of Mexico. This enhanced scientific information will provide a better basis for evaluating meteorological hazards and requirements for engineering design of offshore energy infrastructure.

## B. Overview of Environmental Resources

The following sections describe, in general, the baseline information and understanding for each of the key biological resources on and adjacent to the OCS. The resources include seafloor habitats, coastal habitats, fish and fisheries, marine mammals, sea turtles, marine and coastal birds, and the human environment (socioeconomics). Air and water are also vital resources, and measures used to protect air quality and water quality are presented. The discussions represent a general overview reflecting research that has been conducted and the many ongoing efforts to continuously learn more about the offshore environment. The discussions are neither detailed nor exhaustive but demonstrate the basic understanding of the environment in which offshore activities may occur.

### 1. Seafloor Habitats

The OCS includes the continental shelf, continental slope, continental rise, and abyssal plain of the U.S. Exclusive Economic Zone. These areas range in water depth from tens of meters near the coast and on shallow topographic features to thousands of meters on the Pacific abyssal plain not far offshore Alaska, California, Oregon and Washington. Substrates can range from the finest particulate silts and clays to coarser grain sediments including sand and gravel, to various hard bottom substrates ranging from rock to carbonate coral reefs. Benthic (bottom dwelling) communities living in or on the surface of these various substrates are affected by a wide variety of factors, including sunlight, temperature, salinity, turbidity, currents, the spatial and seasonal variation of these parameters, and complex species interactions. Most life in benthic habitats relies on the vertical rain of food from the water column above. One important exception to this is chemosynthetic communities. These communities, which include large animals or megafauna, can thrive in areas of natural hydrocarbon seepage or “cold seeps” where they obtain carbon food sources through internal symbiotic chemosynthetic bacteria rather than photosynthesis. Cold seep communities have been found in numerous locations worldwide, including many areas of the OCS including the south Atlantic (Blake Ridge off

South Carolina); the GOM; and offshore California, Oregon, and Washington as well as a few sites that are characterized as hydrothermal vents in the Pacific Northwest. Predictive capability for the likely presence of chemosynthetic communities has greatly increased utilizing exploration three-dimensional (3-D) seismic data.

Numerous Federal and State agencies, as well as universities and other institutions, are involved in the survey and study of coastal and offshore benthic habitats. These entities include all coastal States and many Federal Agencies including the USGS, MMS, FWS, National Park Service, NOAA, and the U.S. Navy. In addition to NOAA, USGS and others, the U.S. Navy has also created an extensive database on most of the marine habitats of the country including the Atlantic, Gulf of Mexico, and Pacific coastal areas and deepwater habitats (e.g., Department of the Navy 2006). Several significant studies of lesser known habitats, including deepwater coral habitats and chemosynthetic communities, are currently being performed by MMS, NOAA, and USGS.

There is a lack of detailed mapping in some offshore regions of the United States and high resolution mapping and ground truthing may be required if seafloor habitats of concern are subject to potential impacts. In the case of oil and gas activities, 3-D seismic surveys followed by required site specific high-resolution "hazard" surveys provide detailed information about the seabed with regard to hazards to drilling, but are also used in evaluation of seafloor habitats.

In water depths below about 200 m, 3-D seismic survey data at the sea bed is particularly useful for biological evaluations. In some cases, reconnaissance-scale methodologies (multibeam, 3-D seismic, etc.) may not be capable of detecting benthic habitats of concern. In these instances, higher resolution and in situ visual techniques could be required for mapping and avoidance of benthic communities of concern on a site specific basis.

### a. Atlantic OCS Region

The Atlantic OCS Region includes the area from the Canadian border to the Dry Tortugas. Within this region are a number of biological provinces, shaped in part by differences in water temperature and other water mass characteristics and recognized by their characteristic fauna. Major biogeographic boundaries for marine organisms on the continental shelf occur at Cape Cod, separating boreal and temperate provinces, and at Cape Hatteras, where the Gulf Stream turns eastward, separating the temperate and tropical provinces (Cerame-Vivas and Gray, 1966). A similar faunal break is less obvious on the slope, although this area does appear to be a region of considerable faunal change (Blake et al. 1987).

There are numerous topographic features located throughout the Atlantic OCS, one of the best known being Georges Bank, an elevated region of the seafloor in the northern Atlantic region that covers an area of approximately 29,000 square kilometers ($km^2$) (11,972 square miles [$mi^2$]). This important fishing habitat was extensively studied by MMS in the 1970's and 1980's, and has been continued to be extensively studied by many other researchers since then (for example, the NSF-funded GLOBEC project). Cape Hatteras is a major landform at the southern end of the middle Atlantic Bight. The Oculina Bank, located near the continental shelf edge off the coast of eastern central Florida, is a 90-mi strip of deepwater coral habitat that is named for the presence of banks, thickets, and rubble zones of a stony coral *Oculina varicosa*, (South Atlantic Fishery Management Council, 2005). In deeper water, nearly 400 areas of the deepwater coral *Lophelia* have been discovered and studied in recent years. Recently proposed Habitat Areas of Particular Concern with new deepwater coral areas include Cape Lookout, Cape Fear, Stetson/Savannah/East Florida Lithoherms, Pourtales Terrace and the Blake Ridge Diapir. Some of the features have relief of several hundred feet (Lumsden et al., 2007; Reed, 2002)

Numerous submarine canyons, V-shaped valleys that resemble land canyons of fluvial origin, are prominent features of the continental slope along the northern Atlantic coast. The heterogeneity of canyon environments and the associated hard substrate result in benthic communities that are generally richer biologically than those on the adjacent shelf and slope. These features have been studied in the past, many through projects funded by MMS (Hecker et al., 1980; Lamont-Doherty, 1983), but the significance of coral communities associated with these features is not well described. Most of the canyons have not been mapped with modern high-resolution techniques.

Extensive, shallow, coral reef formations occur along the Atlantic coast of Florida, extending throughout the Florida Keys to the southern tip of Key West. There are also patches of live bottom on the shelf south of Cape Hatteras that extend all the way to the Keys. These areas are documented through the SEAMAP program coordinated by the Atlantic States Marine Fisheries Commission (SEAMAP, 2001). While mapping of these habitats has been a major priority, there is limited information on the organisms that inhabit these regions, including their temporal and spatial patterns in species abundance and biodiversity.

### b. Gulf of Mexico OCS Region

The Gulf of Mexico OCS Region includes the area from Florida to Texas; however, only a portion of the Eastern Gulf of Mexico Planning Area is being considered in this document as a potential new leasing area. There is a diversity of topographic and geomorphic features that contribute to unique seafloor habitats and communities. The continental slope of the Gulf is considered the most complex geophysical region in the world related to wide spread features and faulting caused by the movement of underlying salt deposits. In deepwater regions of the eastern Gulf, including the DeSoto Canyon, chemosynthetic communities related to hydrocarbon seepage are not expected based on existing seismic and other geophysical information. The geological formations creating conduits for hydrocarbon seeps are very uncommon or absent east of the Sigsbee Escarpment in the Central Gulf of Mexico Planning Area. Chemosynthetic communities and more recently, deepwater coral habitats, have been extensively studied by MMS in these other regions since the mid 1980’s. Existing 3-D seismic data in a portion of this area indicates an absence of seafloor amplitude anomalies and the associated potential for the presence of chemosynthetic communities. The majority of the seafloor of the area is in very deep water, and the bottom is composed of soft sediments with characteristic fauna living within the sediment grains including some low density animal populations that live on the seafloor (e.g., crabs, sea cucumbers, limited deepwater fishes).

A part of the expanded Eastern Gulf of Mexico Planning Area will overlap with the steep face of the Florida Escarpment. This feature connects to the west coast of Florida, but at the face of the escarpment it plunges to more than 3,000 m of depth over a very short distance. The first chemosynthetic community discovered in the Gulf (at a location further south at the base of the escarpment (Paull et al., 1984)) is associated with brine seeping through the carbonate structure. There is potential for chemosynthetic communities at other locations along the base of the escarpment, as well as the possibility of hard bottom communities attached to carbonate blocks that have been sloughed from the top of the escarpment. These steep gradient areas would be avoided by any development activities, but they will still be investigated as part of a current MMS/USGS/NOAA study investigating deepwater coral communities in the Gulf of Mexico: Lophelia II and USGS DISCOVRE EXPEDITION.

### c. Pacific OCS Region

The Pacific OCS Region includes areas along the coasts of Washington, Oregon, and California. Within this region, two major biogeographic provinces that differ in abundance and composition of marine fauna have been identified: the Oregonian Biogeographic Province and the Californian Biogeographic Province. A faunal boundary occurs between these two provinces where the California Current meets the Southern California Countercurrent at Point Conception, with the Oregonian Province located northward. In addition to this latitudinal change in species composition, the diversity of species on the continental shelf also changes with depth due to species-specific tolerances for temperature, exposure to light, nutrient input, and biological interactions among species.

While the majority of the continental shelf in the Pacific OCS Region is sandy, portions contain softer sediments. There are also rocky outcrops in some areas that form submerged reefs, seamounts, and other important habitat features. Many areas of communities and associated hard bottoms related to both cold hydrocarbon seeps as well as hydrothermal vents. Offshore California is known for its rugged topography, including numerous uplifted banks and deep submarine canyons. At the shelf break, the continental slope drops to depths of more than 3,000 m (9,840 ft). Below the rise, the abyssal plain is relatively flat, with occasional features such as seamounts and small depressions.

Due to the fact that leasing activities have not occurred offshore northern California, Oregon, or Washington for over 20 years, available environmental information has not been recently assembled for direct use by MMS for the purpose of offshore leasing and environmental protection. Numerous institutions and Federal agencies have continued work in the Pacific region, and there is some information available from both academic and nonacademic sources. Earlier projects have included those funded by MMS, including a benthic reconnaissance study of central and northern California in 1989 and a summary study of knowledge of the Oregon and Washington coastal zone and offshore areas in 1977. More recently, a comprehensive marine resource assessment has been released by the U.S. Navy (Department of the Navy, 2006). This report provides a compilation of the most recent data and information on the occurrence of marine resources in the Pacific Northwest. It includes a discussion of the physical environment and coastal and oceanic habitats.

### d. Alaska OCS Region

Most of the seafloor in the Arctic, which includes the Chukchi and Beaufort Seas, consists of a soft-bottom, featureless plain composed of mud or sand (MMS, 2002). Few species inhabit the seafloor in waters shallower than 2 m deep due to bottom fast ice that prohibits overwintering of most organisms. The seafloor is gouged by ice keels, which creates a habitat for opportunistic infauna, such as small clams and other invertebrates, which are fed on primarily by seabirds, fishes, and walrus. Cobble and boulders are found distributed sporadically in the Arctic (MMS, 2002). The largest kelp community located on the Stefansson Sound Boulder Patch is the only known kelp bed on the Alaskan Arctic coast that is characterized by high benthic diversity (Dunton et al., 2004). These bolder patch communities have been studied extensively for decades.

The Bering Sea is one of the most productive ecosystems in the world (Loughlin et al., 1999). Benthic invertebrates near the Bering Strait are Pacific species that are carried north by currents into the Chukchi Sea (MMS, 2002). A regime shift in the Bering Sea ecosystem during the mid-1970's and unusual blooms of a phytoplankton species during the past decade are considered to be indicators of climate change (Miller and Trites, 1999; Stabeno et al., 2004).

The intertidal and shallow habitats of lower Cook Inlet and Shelikof Strait support both infaunal (living in the substrate) and epifaunal (living at or above the substrate) organisms, as well as floral communities. These communities are strongly influenced by the effects of seasonal ice and exhibit strong affinities to those of the Bering and Beaufort Seas. In the ice-free eastern Lower Cook Inlet, communities are similar to those of southeastern Alaska, British Columbia, and Washington (Lees et al. 1986). The lower intertidal and shallow subtidal areas are dominated by kelps out to depths of about 20 m. In Kachemak Bay and lower Cook Inlet, several distinct communities have been identified on substrates of rock, sand, silt, and/or shell debris.

## 2. Coastal Habitats

The land and areas along the shoreline of the United States are composed of a variety of coastal habitats that include beaches and tidal flats, salt marshes, corals, mangroves, seagrasses, and seaweed communities. The coastal area provides habitat for a wide variety of wildlife and plant species, some of which are endangered or threatened. Coastal wetlands provide nurseries for many important commercial fisheries including fish, shrimp, and crabs. Information about these habitats is acquired and maintained by Federal agencies such as the National Park Service, Fish and Wildlife Service, and Bureau of Land Management that manage the extensive ocean parks, refuges, and other public lands along the entire US coastline as well as USGS and NOAA that have coastal programs. The Army Corps of Engineers maintains much of the extensive infrastructure along the coasts such as the intracoastal waterway. Coastal States also collect and maintain information about their coastal habitats. Coastal habitats are classified for risk analysis from oil spills using the Environmental Sensitivity Index (ESI), developed by NOAA. The ESI represents a basic compilation of the various habitat types along all coasts of the United States as well as indicating the usage by biological resources (birds, seals, etc.) and humans (public beaches, parks, etc.).

### a. Atlantic OCS Region

A variety of habitats are found along the Atlantic coast, including rocky shores, sand and gravel beaches, and tidal flats. Rocky shorelines are more common along the northern Atlantic coastline. Mudflats exist along the shores of many of the bays and sounds, with the most extensive ones found along the shores of Delaware and Chesapeake Bays and along the coast of Georgia. The central and south coastal region is characterized by continuous barrier islands and capes (spits) interrupted by inlets and large embayments with drowned dendritic river valleys such as the Delaware and Chesapeake Bays. Extensive wetlands and marshes occur in areas where sediment and marsh vegetation have partially filled the lagoons behind barrier islands (Morton and Miller, 2005; USACE, 2002). In the mid-Atlantic region, marshes are larger than those of the northern coast, and extensive areas of wetlands are associated with the Narragansett, Raritan, Delaware, and Chesapeake Bays. The States with the most extensive coastal wetland habitats are North Carolina, Virginia, and New Jersey. Many of these systems have been modified by man, but some retain a near natural condition. The coastline of South Carolina and Georgia includes significant freshwater input and some of the most expansive tidal marshes in the world protected by numerous irregularly shaped islands (Beccasio et al. 1980). Long barrier islands protect an extensive series of high-salinity shallow lagoons, with limited freshwater inflow, along much of the Florida coast. Tidal salt marsh and seagrass beds occur on the lagoon margins in the north, with mangroves prominent to the south (Beccasio et al. 1980).

### b. Gulf of Mexico OCS Region

Habitats found along the Western, Central, and Eastern GOM coasts include (1) fresh, intermediate, brackish, and tidal salt marshes; (2) mud and sand flats; (3) forested wetlands and mangrove swamps; (4) barrier islands and seagrass beds; and (5) deep coral reefs and sponge beds. Coastal wetland habitats occur as bands around waterways and as broad expanses. Within the Gulf of Mexico region, the estimated area of all wetlands in 2004 exceeded 15.5 million acres (Stedman and Dahl, 2008). Louisiana's coastal wetlands support more than two-thirds of the wintering waterfowl population of the Mississippi Flyway, including 20-25 percent of North America's puddle duck population. Wetlands provide habitat for a large number and wide diversity of invertebrates, fish, reptiles, birds, and mammals and support a multi-billion dollar industry.

Barrier islands are long narrow islands with sandy beaches that parallel the shoreline along the Gulf of Mexico. These dynamic ecosystems migrate landward as sea level rises and provide a first defense against storm surge. Beaches, dunes, and marshes provide stopover habitat for migrating birds and important nesting grounds for federally listed birds, such as the brown pelican. Three million hectares (7,413,100 ac) of submerged seagrass beds are estimated to exist in exposed, shallow coastal waters of the northern Gulf.

### c. Pacific OCS Region

A variety of shoreline types occur along the Pacific Coast, including rocky cliffs and rocky, gravel, or sand beaches. The two most prominent beach types found in the Pacific region are rocky shores and sand beaches, the latter of which are the most common in this region. Along the coast of northern Washington, rocky bluffs and cliffs are interspersed with beaches ranging from sand to cobble. Sand dunes occur in areas of the south Washington coast. Sand beaches are scattered along the coast of southern Washington and much of Oregon; an 85-km (53-mi) sand beach occurs along the central Oregon coast. Along the rugged coast of southern Oregon, small bays, with narrow beaches of coarse sand and gravel, and rocky cliffs are frequent. Rocky shore habitats are more abundant from southern Oregon to central California, and along the Channel Islands offshore southern California. The intertidal rocky shore substrate forms a solid surface on which macroalgae and sessile invertebrates (e.g., mussels) attach and hold firm against the forces of waves, wind, and currents. Kelp forests are important, ecologically diverse, algal communities that occur in these subtidal areas.

Wetland habitats along the Pacific coast consist of tidal salt marshes, fresh and brackish water marshes, and mudflats. Eel grass (*Zostera marina*) beds occur in some subtidal areas, and tend to be associated with estuaries of larger streams. Estuaries contain a greater diversity of species per unit surface area than any other marine habitat. The mudflat habitats found in association with these components are rich in invertebrates, including clams which are an important food source for fish. Coastal estuaries in the Pacific region are inhabited by thousands of migratory birds traveling along the Pacific Flyway, one of the four principal bird migration routes in North America. In the Pacific Northwest, 52 percent of the harvested commercial fish and shellfish are dependent on estuaries.

### d. Alaska OCS Region

The Alaska OCS Region is one of the most productive areas of the world's oceans, supporting large populations of salmon, groundfish, crabs, marine mammals, and seabirds. Alaska leads all other States in pounds of fish landed and their dockside value. Most of these species are either dependent or interdependent on one of the various wetland habitats found in this region either through their food source, nutrients inputs for secondary food chain, or cover or nursery areas provided by these habitats. Although wetlands comprise 174.6 million ac (45 percent) of the State, the distribution of wetlands in Alaska varies considerably within the state's physiographic regions.

The coastline of the Beaufort Sea includes eroding bluffs, sandy beaches, lower tundra areas with some saltwater intrusions, sand dunes, sandy spits, and estuarine areas where streams enter the Beaufort Sea. Barrier islands are scattered along the Beaufort and Chukchi Sea coastlines and also support tundra communities. These islands are generally narrow (less than 250 m wide) and low-lying (less than 2 m in elevation) and are washed over in large storms. The Arctic coastline is disturbed seasonally by the movement of sea ice across the coastal landscape usually scouring and scraping the coastline, leaving the area venerable to wave erosion. Vegetation growth is limited due the seasonal extent of the sea ice and the permafrost that remains even after the short retreat of the sea ice during the summer. However, salt marshes are scattered along the Arctic coastline and support emergent vegetation communities. Dense marine algae (kelp) communities occasionally grow in shallow nearshore areas, and generally in protected areas such as behind barrier islands and shoals with hard substrates (MMS, 2003c). The most productive areas are near the major river deltas in the Beaufort Sea, such as the Colville River, Sagavanirktok River, and Canning River deltas. These river deltas provide habitat for many waterfowl and anadromous fishes.

Barrier landforms of sand and gravel are found in numerous locations along the north side of the Alaska Peninsula and the north coastline of Bristol Bay. Islands and spits occur on the outer margins of many lagoons and often contain a mixture of fresh and salt water. Narrow barrier beaches also lie between small lakes along the coastline and Bristol Bay. Rocky cliffs and shores, sand beaches (mostly coarse-grained sand), gravel beaches (including mixed sand and gravel), and eroding peat scarps are found along the northern shoreline of the Alaska Peninsula. Wave-cut platforms many meters above the present sea level are found on the Peninsula and on many of the islands in Bristol Bay. Tidal flats occur along much of the coastline, particularly in bays and lagoons, and support intertidal habitats of mud, sand, or gravel substrates. Tidal flats support diverse plant and animal communities in protected areas and low-to-moderate densities in exposed areas. Low intertidal and shallow subtidal habitats support kelp beds and eelgrass beds, while mid- and upper-intertidal areas support communities of marine algae, mussels, and barnacles. Eelgrass beds are found on soft substrates and commonly occur along the Peninsula in protected areas such as inlets, bays, and lagoons.

Coastal forest occurs along much of Alaska’s southern coast and on the coastal islands, and is predominantly evergreen forest composed of Sitka spruce and western hemlock. Also occurring along or near the shoreline are forested wetlands, wetlands with emergent vegetation, and shrub wetlands that are not tidally influenced but that have saturated soils or are flooded seasonally or continuously. Extensive freshwater marshes and salt marshes composed of sedge and grass wet meadow communities occur on river deltas along the coast. Coastal habitat in the Gulf of Alaska includes several large estuaries and wetlands. The Copper River Delta in the northeast Gulf of Alaska is the largest contiguous area of coastal wetland on the Pacific Coast of North America. In some areas of the south Alaskan coastline, numerous peninsulas and islands with irregular shorelines form bays, lagoons, and steep prominences. Much of the shoreline consists of steep slopes with a narrow zone of tidal influence.

## 3. Marine Fish Resources

Marine fish resources include fish and shellfish, as well as squid, jellyfish, sea urchin, and seaweed, etc., which are among the living components that are being harvested or used. Fish resources depend on many different habitats ranging from coastal habitats, shoals, banks, seamounts, and submarine canyons to the deepwater plain. Only NOAA-Fisheries and coastal states are involved in management of marine fisheries; however, all coastal States and many Federal agencies are involved in the direct and/or indirect study of fish resources and fishing in the United States. The USGS and MMS study many aspects of fish resources and offshore energy production. NOAA Fisheries studies fish resources important to commercial and recreational fishing within Federal waters under the Magnuson-Stevens Fishery Conservation and Management Act and designates Essential Fish Habitat. NOAA Fisheries shares joint responsibility with the FWS over threatened and endangered fish species under the ESA. State fish and wildlife agencies assist in the management of fish and fishing in State waters. Federal and State-designated marine areas afford differing kinds and levels of protection for fish resources.

Fish resources and their habitats are relatively well studied, especially for those species that are or have been of economic importance. The NOAA-Fisheries, USGS, and MMS have funded and continue to fund major research concerning fish resources. The MMS concentrates studies in those areas of likely offshore energy production and where species interact with existing production structures, oil and gas production discharges, and oil spill accidents. Long-term data are available to study the sustainability of selected U.S. fish resources. Not all OCS habitats and not all fish resources have been completely studied. Thorough assessments have been done for about half of fisheries' stocks, and life history and habitat information is limited, especially for highly migratory species. However, most of our domestic fish resources have been studied and are regularly assessed, and many of the essential habitats for these stocks are known and/or being mapped. In most areas, there is sufficient environmental information regarding fish resources and habitat to consider decisions for offshore leasing (MMS, 2007a, 2007b; NOAA 2008a, 2008b, 2008c, 2009a, 2009b; NRC 1989, 1994, 2003, 2005).

***Commercial Fishing:*** Commercial fishing is the hunting, gathering, and sale of seafood for human consumption or as input into other industrial processes. For many, it is a way of life as well as profit. Commercial fishing uses both fixed and mobile gear in the water column and on the seafloor to harvest seafood. Commercial fishing has a long history, and although fishing globally is a troubled industry, it remains important to the economy of the United States. In 2007, commercial fishing landed 9.2 billion pounds valued at $4.1 billion. Commercial fishing for marine species in the United States is overseen by the Fishery Management Council system, which was established by the Magnuson-Stevens Fishery Conservation and Management Act. The eight regional Fishery Management Councils are decision making bodies that develop and recommend specific management measures. There is a Council that overlaps with each of the OCS areas for offshore energy leasing and development.

The quantity and quality of the data for commercial fishing landings and value are sufficient, long-term, and important to study and forecast the sustainability of U.S. fish resources. Commercial fishing tends to be geographically clustered, and most commercial fishing areas are well known, but fishing locations are subject to change. Loss of gear and damage due to offshore oil and gas are compensated by the Fishermen's Contingency Fund, administered by NOAA under the OCSLA. Although exact information pinpointing the location of fishing is limited for some OCS areas, there is sufficient information regarding commercial fishing to consider decisions for offshore leasing (MMS, 2007a, 2007b; NOAA 2008a, 2008c, 2008d, 2009a; NRC 1989, 1994).

***Recreational Fishing:*** Recreational fishing is a multi-billion-dollar industry. It is also a personal experience that puts individuals into the outdoors. Recreational fishing is a year-round activity concentrated during spring through fall involving a number of gear types using three different modes of fishing: shore, private/rental, and charter/party boats. Across the United States, there were 13.6 million recreational anglers in 2006. These anglers took 87 million saltwater fishing trips, spending $5.8 billion on trips and $25.6 billion on equipment. The 2006 expenditures added $82 billion in sales to the U.S. economy and supported over 500,000 jobs.

The quantity and quality of the data for recreational fishing are good, long-term, and important to study and forecast the sustainability of U.S. fish resources. The Marine Recreational Fisheries Statistics Surveys provide at least 30 years of information for U.S. marine waters through the coordination and administration of recreational fisheries surveys nationwide. Offshore man-made structures are specific destinations for recreational fishing. The MMS has studied the use of offshore oil and gas structures by recreational fishermen. Recreational fishermen will choose to fish at offshore structures when access is permitted. Fishing opportunities at man-made structures can be a significant part of recreational fishing opportunities. There is sufficient information regarding recreational fishing to consider decisions for leasing (Hiett and Milon, 2002; MMS, 2007a, 2007b; NOAA 2006, 2008d; NRC 2005).

***Subsistence Fishing:*** Subsistence fishing is the customary and traditional gathering of wild fish and shellfish for immediate personal or family consumption and trading. Subsistence fishing is important as a food source and as a way to remain culturally connected and continue the culture of indigenous people and Native Americans. It occurs to some degree in all coastal areas but is a way of life in Alaska and in some locations in Washington, Oregon, and northern California. Many thousands of Native Americans, and non-Native Alaska residents, participate in fishing for marine species in the open ocean, in the nearshore environment, in the intertidal zone and upstream in rivers where anadromous species, particularly the five Pacific salmon species, occur.

The quality of the data for subsistence fishing is good, but these data are difficult to acquire and quantify. Food is one of the most important subsistence uses of wild resources. The current U.S. subsistence harvest is about 354 pounds of food per fisher per year and is more than the U.S. annual average consumption of 255 pounds of domestic meat, fish, and poultry. Although very important as a food source and for cultural continuity, subsistence fisheries accounts for about 2 percent of fish harvested in the United States. Native Americans barter subsistence fish and shellfish within their village and reservations and commonly share among communities. In doing so, Native Americans reinforce the continuation of long-standing traditions in the region and assist one another during times of subsistence food shortages. Traditional celebrations and rituals are common practices associated with subsistence fishing. In some areas, it provides a significant link to the market economy in the making and selling of home goods and handicrafts from the nonedible parts of fish and shellfish. It is likely that there is sufficient information regarding subsistence fishing to consider decisions for leasing (MMS, 2007a, 2007b; ADFG, 2009).

### a. Atlantic OCS Region

The diversity of fish resources is large and the manner of fishing varied. In New England and the northern mid-Atlantic, offshore banks and major inshore marshes and estuaries are important habitats and fishing areas. In the southern mid-Atlantic and eastern Florida, open water and reefs are important for fish resources and fishing. Fishing along the Atlantic seaboard supports direct and indirect food sales, and industrial processing, and provides valuable recreational experiences. In 2007, commercial fishery landings in the Atlantic Region totaled approximately 1.4 billion pounds with a value of over $1.4 billion. In 2007, residents and visitors took over 58 million marine recreational fishing trips, with over a quarter of these trips occurring in eastern Florida and with lower percentages north up the East Coast. A number of offshore areas have been declared Habitat Areas of Special Concern under EFH, and major inshore bays, estuaries, and seagrass beds are under various programs of protection and management.

### b. Gulf of Mexico OCS Region

Almost all finfish and shellfish resources are linked to the vast marshes and estuaries that ring the Gulf. About 46 percent of the entire southeastern United States wetlands and estuaries important to fish resources are located within the GOM. The density of fish resources is highest near shore off the central Gulf coast; subsequently, commercial fishing is concentrated there. Commercial and recreational fishing within the Gulf, as industries or pastimes, were devastated by hurricanes within the last decade and are still recovering. In 2007, commercial fishery landings in the GOM totaled approximately 1.3 billion pounds with a value of over $673 million. In 2007, residents and visitors took over 24 million marine recreational fishing trips, with over half these trips occurring from west Florida and another quarter from Louisiana. A number of the offshore areas and much of the coastal marshes and estuaries are under various programs of protection and management.

### c. Pacific OCS Region

The coasts of Washington, Oregon, and California support a mixture of fish and shellfish species from a variety of marine habitats including coastal beaches, marshes, rocky intertidal shorelines, seamounts, banks, and submarine canyons. The majority of fish listed as endangered or threatened under the ESA are Pacific salmonids, and all of the listed shellfish occur only off the Pacific coast. In 2007, commercial fishery landings in the Pacific region totaled about 1.0 billion pounds, with a value of over $430 million. In 2007, nearly 200 thousand residents and visitors took over 730 thousand marine recreational fishing trips. Over half of marine recreational fishing occurs off southern California, with lower percentages north up the west coast. About half of the recreational fishing trips occur in nearshore saltwater and inshore areas. The Pacific OCS Region is one of only two Regions where offshore structures and production exist on the OCS; all of the structures and production are clustered in southern California, close to shore, and represent important habitat for overfished commercial species and destinations for recreational fishing (Love et al., 2002, 2003). Additional areas offshore California, and a large part of offshore Washington, are National Marine Sanctuaries (NMS) where no oil and gas energy development can take place. West Coast NMS Advisory Councils recently recommended that renewable energy also not be allowed within NMS boundaries. A number of the offshore areas have been declared marine protected areas and/or habitat areas of special concern under EFH, and major bays and estuaries are under various programs of protection and management.

### d. Alaska OCS Region

Fisheries are a critical part of Alaska. The abundance and diversity of fish resources is extraordinary (Mecklenburg et al., 2002). Fishing efforts in Alaska support every aspect of life from industrial processing and far ocean harvesting, to a variety of quality recreational fishing experiences, to feeding and sustaining a small village. In 2007, Alaska led all States in fisheries catches by volume at 5.3 billion pounds and value at $1.5 billion. This is more than 50 percent of the landings and nearly 40 percent of the value of the total U.S. commercial catch. A recent survey of fishing, hunting and wildlife-associated recreation found that, in 2001, U.S. residents spent over $500 million on fishing trips and equipment in Alaska. Fisheries-related jobs provide about 74 percent of the wages in western Alaska and provide at least $50 million in taxes, second only to the oil industry. Many thousands of Alaskans participate in subsistence fishing and processing, and it is an important element of Alaska's social and cultural heritage. Alaska, both in coastal and offshore areas, represents one of the best investigated, monitored, and managed fishery areas in the world.

## 4. Marine Mammals

There are about 125 species of marine mammals throughout the world's oceans, including 70 species of cetaceans (whales, dolphins, and porpoises), 33 species of pinnipeds (seals, sea lions and walrus), 2 species of sirenians (manatees and dugongs), and two species of carnivores (sea otters and polar bears). About 68 of these species inhabit the OCS waters, although their presence in a particular area may be seasonal given the migratory patterns of some species.

All marine mammals are protected in the United States by the MMPA. In addition, over 20 species or stocks are also listed as endangered or threatened under the ESA. Internationally, there are also transboundary laws and treaties which serve to minimize impacts to marine mammals from key threats, such as entanglement in fishing gear, alteration of critical habitats, pollution, overharvest, ship strikes, and disturbance from anthropogenic sound (human-made noise from commercial shipping, military sonar, oceanographic research, energy exploration and production and other human activities). This section discusses the presence of marine mammals across different regional areas of the OCS, the adequacy of existing information in determining life history traits, as well as potential effects from OCS energy and minerals mining activities, and the priority information needed to support decision making.

There are many scientifically-sound studies and peer-reviewed documents that have increased our understanding of the life history and behavior of marine mammals and the potential for impacts on these species from a variety of human activities. A summary of the existing information on most marine mammal species and populations can be found in the NOAA-Fisheries and FWS Marine Mammal Stock Assessment reports. The latest detail on the range of potential effects from OCS energy activities, and the research undertaken to study these effects, can be found in MMS's NEPA documentation (e.g., MMS, 2008b and 2008c). The FWS and USGS have also extensively studied walrus, manatees, sea otters, and polar bears.

For the most part, MMS, the U.S. Navy, NOAA-Fisheries, and NSF have been the most active in investigating marine mammal life history, with a large effort focused on research to better understand the effects of anthropogenic sound on marine mammals. The MMS sponsored a literature review on the state of knowledge through 1990 of human-generated and natural underwater sounds and their potential impacts on marine mammals. The U.S. Navy then funded the conversion of this review into the classic book on marine mammals and noise (Richardson et al., 1995). Southall et al. (2007) more recently provided an update on best available information on noise issues. The Joint Subcommittee on Ocean Science & Technology's Interagency Task Force on Anthropogenic Sound and Marine Life, of which MMS was a member, then summarized Federal agency science and technology efforts on the noise issue and recommendations for priority research actions. The MMS also participates in important collaborations with domestic and international research organizations, such as the National Oceanic Partnership Program, the U.S. Navy, NOAA-Fisheries, and the Joint Industry Programme on Sound and Marine Life . These efforts also add greatly to the knowledge base on marine mammals. Ongoing MMS funded studies are designed to address identified information gaps.

Collectively, the information and collaborations above provide an adequate overall baseline for understanding the generalities of marine mammal presence and life history traits throughout the OCS and the range of potential impacts from OCS energy and other activities. For some species, information is extensive (e.g., sperm whales in the northern GOM) while data on other species are limited (e.g., North Pacific right whale distribution in Alaskan waters). Effects for some activities are well understood (e.g., contaminants and marine debris, vessel strikes) while less known for others (e.g., anthropogenic noise, climate change, oil spill effects in icy environments).

### a. Atlantic OCS Region

Approximately 30 species of marine mammals occur in the Atlantic, including all large whale species, dolphins and porpoises, seals, and manatees. The existing information base for marine mammals in the Atlantic would be considered adequate, insofar as we know the occurrence of cetacean species is generally widespread, with many of the large whale species migrating along the U.S. east coast and populations of smaller, toothed whales found in more resident locations along the coast. Further, baleen whales tend to be in the North Atlantic during the summer months for feeding, the South Atlantic during the winter months for breeding and/or caring for young, and pass through the mid-Atlantic during the migratory routes primarily between March and April and then September to December. Manatees mainly occur in the south Atlantic area, but individual animals have been documented to travel as far north as Massachusetts. Seals are found in the mid and north Atlantic, with harbor and gray seals being the most common and harp and hooded seals being less common. The ESA-listed marine mammals species found in the Atlantic include the North Atlantic right (highly endangered), humpback, fin, sei, blue, and sperm whales and the West Indian manatee. More detail on marine mammal distribution and presence in the Atlantic can be found in the NOAA-Fisheries annual stock assessment reports.

### b. Gulf of Mexico OCS Region

For the most part, there is adequate information on marine mammals in the Gulf. Twenty-nine species inhabit the Gulf, including 28 species of cetaceans and the manatee. Pinnipeds are not found within the Gulf and ESA-listed baleen whales (North Atlantic right, blue, fin, sei and humpback) are rarely seen. The West Indian manatee generally inhabits only coastal marine, brackish, and freshwater areas. The ESA-listed, toothed sperm whale is most associated with the Gulf, with aggregations commonly found in waters over the shelf edge in the vicinity of the Mississippi River Delta throughout the year. Additional detail on marine mammal presence and distribution in the Gulf can be found in the MMS and USGS Gulfcet study, MMS Sperm Whale Seismic Study (SWSS; research on biology, behavior and habitat use of sperm whales in the northern Gulf and an analysis of changes in behavior of sperm whales from seismic airgun sound sources). More detail on marine mammal distribution and presence in the Gulf can be found in the NOAA-Fisheries annual stock assessment reports.

### c. Pacific OCS Region

Marine waters off the coasts of Washington, Oregon, and California are characterized by the presence of at least 34 different species of marine mammals, including cetaceans, pinnipeds and the sea otter. There are six ESA-listed cetacean species that may occur in nearshore or offshore waters of the Pacific, including the blue, fin, humpback, North Pacific right whale, sei, sperm, and killer whale. The ESA-listed Guadalupe fur seal, Steller sea lion and southern sea otter can also be found. More detail on marine mammal distribution and presence in the Pacific can be found in the NOAA-Fisheries annual stock assessment reports. From 1999–2002, USGS and collaborators worked with MMS to conduct a multi-year aerial survey study that quantified the at-sea distribution and abundances across a large area from the California–Mexico border to central California for all marine birds (485,000 individuals, 67 species) and marine mammals (64,000 individuals, 19 species). This study provided resource managers with updated information on distribution and abundance patterns and compared results to information from the early 1980's.

### d. Alaska OCS Region

Marine mammals are found throughout Alaska OCS waters, with the number of species lessening further north where waters are colder. The Arctic waters off Alaska are inhabited by 11 resident or seasonal species, the Bering Sea by 17 marine mammal species, and South Alaska with 21 species. Alaskan waters are home year-round or seasonally to a variety of ESA-listed marine mammal species. In the Arctic, these include bowhead, fin, and humpback whales and polar bears. The MMS has conducted aerial surveys of bowhead whales in the Beaufort for 30 years and more recently expanded study efforts into the Chukchi Sea. The Bering contains the ESA-listed North Pacific right (most highly endangered marine mammal), humpback, fin, and sei whales; Steller sea lions; and the southwest Alaska stock of the northern sea otter. The ESA-listed North Pacific right, sei, blue, fin, humpback and sperm whales; Cook Inlet stock of beluga whales; northern sea otters; and the Steller sea lions are found in south Alaskan waters. More detail on marine mammal distribution and presence in Alaskan waters can be found in the Marine Mammal Stock Assessment Reports.

It is important to note that some marine mammal species are subsistence resources for Alaskan Natives, and a large body of traditional and local knowledge about these animals exists. Many Alaskan Native governmental organizations, such as the North Slope Borough Department of

Wildlife Management, represent sources of historical information and potential collaborators for research.

## 5. Sea Turtles

There are six species of sea turtle that are observed in OCS waters: Hawksbill, green, olive ridley, Kemp's ridley, loggerhead, and leatherback sea turtles. All sea turtle species are protected under the ESA as either Threatened or Endangered. The ESA provides for protection of sea turtles in both sea and land habitats. NOAA-Fisheries and FWS share jurisdiction for marine turtles, with NOAA-Fisheries having the lead for sea turtles in the marine environment and FWS responsible for turtles when they are on nesting beaches.

The NOAA-Fisheries and FWS are responsible for collecting information about sea turtle distribution and abundance. The NOAA-Fisheries conducts aerial surveys for collection of marine mammal stock assessment data and collects sea turtle information during these surveys. The FWS collects data when sea turtles come ashore at nesting beaches. For each of the six species that occur in the United States, recovery plans have been written that outlines the current status of the species, threats to recovery, and recovery goals and objectives. These documents synthesize and present the current information about each species including population status and trends. In addition to recovery plans, each species of sea turtle recently underwent a 5-year review to gather and synthesize information regarding species status. Both the recovery plans and the 5-year review documents are prepared jointly by NOAA-Fisheries and FWS.

The diversity of a sea turtle's life history leaves them susceptible to many natural and anthropogenic impacts worldwide, while they are on land, in the benthic environment, and in the pelagic environment; these impacts include beach nourishment, poaching, pollution, marine debris entanglement, and fisheries interactions. Sea turtles may also be affected by anthropogenic sound, such as those from seismic surveys. However, very little is known about sea turtle hearing and what may cause injury to it. Worldwide, government agencies, non-profit organizations, and animal advocates find ways to protect sea turtles and their habitat.

### a. Atlantic OCS Region

Five species of marine turtles can be found in the Atlantic. These include the leatherback, loggerhead, green, hawksbill, and Kemp's ridley. In the western Atlantic, most loggerhead sea turtles nest from North Carolina to Florida, and along the Gulf coast of Florida. Loggerhead sea turtles are year-round residents of central and southern Florida. In U.S. Atlantic waters, green turtles nest in small numbers in the U.S. Virgin Islands and in Puerto Rico, and in larger numbers along the east coast of Florida. Leatherback nesting in the continental United States is limited to the Atlantic coast of Florida. Hawksbill nesting within the continental United States is limited to southeastern Florida and the Florida Keys. Kemp's ridley's are the smallest sea turtle species, and their preferred habitat is shallow coastal waters. Apparently, many reproductive females return to one Mexican beach to nest; however, nesting has been documented in North and South Carolina, and both coasts of Florida.

### b. Gulf of Mexico OCS Region

Within the GOM, there are five species of sea turtles. These are the leatherback, loggerhead, green, Kemp's ridley, and the hawksbill. Surveys have recorded leatherback, loggerhead, and Kemp's ridley sea turtles in the continental shelf and slope areas of the GOM. The leatherback is the most abundant sea turtle in waters over the northern GOM continental slope. Loggerhead sea turtles primarily nest along the Florida Panhandle and in the Yucatan Peninsula of Mexico, but regular nesting also occurs in Alabama, and occasional nesting from Texas through Mississippi. Kemp's ridley sea turtles mainly nest on the beaches of Tamaulipas and Veracruz in Mexico; however, increasing numbers of nests have been documented along the Texas coast in recent years. Scattered nesting has also been reported in Alabama, Florida, Georgia, South Carolina, and North Carolina. Green turtles nest annually in small numbers along the Gulf coast.

### c. Pacific OCS Region

Historically, four species of sea turtles have been recorded in the eastern North Pacific: leatherback, green, olive ridley, and the loggerhead. However, leatherbacks are the most common sea turtle in Pacific U.S. waters north of Mexico. Inshore waters off California, between Pt. Conception and Pt. Arena, are visited annually by approximately 150 to 170 leatherback turtles, with the greatest numbers occurring during early fall. There are no known nesting sites for any sea turtle species on the Pacific OCS.

### d. Alaska OCS Region

Leatherback sea turtles in the Pacific Ocean range as far north as Alaska and the Bering Sea. In Alaska, leatherback turtles are found as far north as the southern portions of Gulf of Alaska as far west as the Aleutian Islands. However, they are considered uncommon in Alaskan waters.

## 6. Marine and Coastal Birds

Birds are abundant, highly visible, and often strongly dependent on marine and coastal environments which often are already heavily impacted by construction development. Marine birds (seabirds) spend most of their lives at sea, coming ashore mainly to breed or to avoid extreme environmental conditions. Birds are sensitive to a variety of ecological functions, and offer sensitive and widespread barometers of environmental change. A number of bird species are federally- or State-listed as threatened, endangered, or identified as candidates for listing. The Federal ESA and similar State laws mandate that special care must be taken to avoid adversely impacting any species listed as threatened or endangered. There are listed species of coastal and marine birds found at least seasonally along every coast of the United States. The Migratory Bird Treaty Act (MBTA) forbids the "take" of nearly all migratory birds native to North America, more than 800 species. In addition, Executive Order (EO) 13186: *Responsibilities of Federal Agencies To Protect Migratory Birds* outlines certain actions that Federal agencies must follow in order to implement the MBTA.

Tens of millions of Americans care about the conservation of birds, and public recreational use of birds is a multi-billion dollar industry. In 2006, 2.3 million American hunters spent $1.3 billion on migratory bird hunting, including 20 million days hunting on 16 million hunting trips (U.S. Department of the Interior, Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau, 2006). In addition, 71.1 million Americans (up 8 percent since 2001) spent $45.7 billion on wildlife-watching recreation, mostly bird-related.

### a. Atlantic OCS Region

The Atlantic coast of the United States is vitally important to many bird species. The Atlantic Flyway is a major route for migratory birds traveling along the Atlantic Coast between their northern breeding habitats in New England, Canada, and the Arctic and their winter habitats in subtropical and tropical areas of North, Central, and South America. For example, about 50 species of landbirds that breed in New England follow the Atlantic coastline southward to Florida and beyond (Lincoln et al., 1998). Hundreds of thousands of ducks and geese that breed in the northern United States and Canada overwinter on the Atlantic coast, from Barnegat Bay, New Jersey, to Delaware Bay and the Chesapeake Bay.

Several areas along the Atlantic OCS are notable as places where a large number of seabirds are observed to feed during certain times of the year. Georges Bank and its associated shelf/slope waters provide an area of high productivity creating a feeding ground for a variety of seabirds (NRC, 1991) based on annual seabird surveys conducted by the Manomet Bird Observatory from 1978-1988. The western wall of the Gulf Stream between the Virginia-North Carolina border and Cape Canaveral (South Atlantic Bight) provides habitat for pelagic seabirds during the spring and summer. This is an area where the Labrador Current converges with the Gulf Stream and hosts a high species diversity that includes one endangered species, the Bermuda Petrel, and several other species of special concern (e.g., Black-capped Petrel, Madeira/Fea's Petrels, Herald Petrel, and Audubon Shearwater). These species are documented as occurring on the OCS off Cape Hatteras in the area called "The Point" (Lee, 1999).

### b. Gulf of Mexico OCS Region

The Gulf of Mexico is an important pathway for migratory birds, including not only coastal and marine species, but large numbers of terrestrial species as well. Most of the migratory birds that overwinter in the neotropics and breed in eastern North America either fly directly across the Gulf or move around the edge of the Gulf Coast. Every spring hundreds of millions of neotropical migratory birds which spent the winter south of the United States return in (mostly nocturnal) trans-Gulf flights, landing in large numbers in "stopover areas" on the Gulf Coast of the United States from Texas to the Florida Panhandle. Adverse weather over the Gulf or poor physical condition of birds can cause many of them to "fall out" and land in the waters of the Gulf. Occasionally large numbers of them wash up dead on the northern Gulf Coast. Sometimes many of these exhausted birds alight on oil and gas platforms in the northern Gulf of Mexico, where they rest and feed on insects found on the platforms (Russell, 2005).

### c. Pacific OCS Region

Many bird species follow the Pacific Coast to migrate between summer breeding habitats in Alaska and Canada (as far north as the Arctic) and overwintering areas as far south as subtropical and tropical areas of Mexico and Central and South America (Lincoln et al., 1998). This coastal component of the Pacific Flyway is especially important to waterfowl, and important staging areas for migrating shorebirds occur in Puget Sound and Gray's Harbor in Washington, Coos Bay in Oregon, and in Humboldt Bay and San Francisco Bay in northern California.

An estimated 6 million seabirds are offshore from California, and another 1.8 million off the coasts of Oregon and Washington. These represent more than 100 species (FWS, 2005). Migration of certain species can add millions of birds to the number occurring offshore, and 28 species are identified as breeding along the Pacific Coast of Washington, Oregon and California according to the USFWS Seabird Conservation Plan - Pacific Region (FWS, 2005). From 1999–2002, USGS and collaborators worked with MMS to conduct a multi-year aerial survey study that quantified the at-sea distribution and abundances across a large area from the California–Mexico border to central California for all marine birds (485,000 individuals, 67 species). This study provided resource managers with updated information on distribution and abundance patterns and compared results to information from the early 1980's (Briggs et al., 1987).

### d. Alaska OCS Region

Most of the marine birds in the Beaufort and Chukchi seas are there only during the open water season, following the formation of leads through the ice to their coastal breeding areas in spring. This includes many colonial nesting birds that nest on cliffs, including as many as 100,000 murres (common murres and thick-billed murres) and 18,000 horned puffins and tufted puffins. All four species feed on dispersed schools of offshore fish, which makes them vulnerable to oil spills. The Beaufort and Chukchi seas also support breeding populations of a number of sea ducks, including the long-tailed duck, king eider, common eider, and the largest breeding population of the threatened spectacled eider in North America. Also present are several species of geese, loons, and shorebirds.

The MMS is currently funding researchers at the University of Alaska, Fairbanks to study king eiders using satellite tracking. The USGS and FWS have undertaken the task of consolidating and providing comprehensive geographic data on the pelagic distribution of seabirds in Alaska and the North Pacific. The North Pacific Pelagic Seabird Database (NPPSD) project has collected data from researchers in Canada, Russia, and the United States (1972-2003). The NPPSD is an ongoing project to serve as a repository for future pelagic survey data from the North Pacific. The Seabird, Fish, Marine Mammal and Oceanography Coordinated Investigations (SMMOCI) project is conducted annually to characterize the marine environment in the vicinities of nine seabird colonies within the Alaska Maritime National Wildlife Refuge.

## 7. Socioeconomics

Socioeconomic effects of the OCS program have been studied by MMS and others over many years. In addition to substantial revenues generated by offshore oil and gas development, the offshore oil industry is comprised of a great number of enterprises that provide innumerable goods and services in support of the exploration, development, and production of offshore oil in U.S. waters and abroad. Receipts from bonuses, rents and royalties from its 8,000 plus leases have averaged approximately $9 billion annually during the past 5 years. Directly and indirectly, the program generates significant employment. It is estimated that the current 5-Year (2007-2012) Oil and Gas Leasing Program will account for over $500 million in personal income annually. The OCS is also a significant source of the Nations energy, accounting for about 27 percent of its domestic oil production and 14 percent of its domestic gas. Overall, an adequate baseline of information exists to address the socioeconomic effects of the OCS oil and gas program and the renewable energy program for leasing decisions. However, predictions of future industry activities are best built on past industry behavior. Therefore, as the renewable energy industry develops, new data on OCS operations will be needed to improve MMS estimates of the economic and demographic consequences.

Socioeconomic benefits of the OCS program are significant to the Nation and to participating States and communities. However, States and communities also can experience negative consequences, as new jobs may increase local revenues, but they also may create fiscal burdens for locals by increasing demands for housing, schools, public utilities, and public services. Noise from seismic or supply operations or platform and pipeline installation may disrupt commercial, recreational, or subsistence fishing and hunting. Offshore structures may be visible from shore, and offshore and onshore structures may physically limit access to a resource. Besides normal industry operations, oil spills and other accidental releases can have negative socioeconomic consequences by fouling recreational and residential beaches, wetlands, and animal populations.

The MMS funded decades of research on socioeconomic issues important to bureau decision making (for reviews and workshops, see Argonne National Laboratory, 2007; Bio/Tech Communications, 1988; Carney ed., 1998; Gramling and Laska, 1993; McKay and Nides eds., 2005; NRC, 1989c; 1991a; 1992a; 1994; Petterson and Downs, 1985; Smith, 2000; Vigil ed., 1998). Models for estimating programmatic-level economic and environmental benefits and costs and models for estimating employment and expenditure effects have been developed using systematized economic data on OCS-related activities. The socioeconomic consequences of operational issues, such as pipeline/trawler conflicts, platforms as artificial reefs, the use of Floating Production and Storage Offloading platforms in the Gulf, worker enclaves in the Arctic, and offshore work scheduling on families have been examined.

Industry interest is focused on the Beaufort and Chukchi Seas (Arctic) and Bristol Bay (sub-Arctic); their rural coasts and largely Native Alaskan populations raise socioeconomic challenges related to subsistence and to the economic context in which subsistence occurs. Of preeminent concern is that OCS-related infrastructure, operations, and oil spills will deny, limit, or disrupt Native subsistence through impacts to the behavior, distribution, health, or number of species or through interference with user access. Severe harvest reductions might affect diet and human health, although questions such as this that relate to the evaluation of subsistence system effects have proven difficult. Some level of impact to access has occurred, yet substantial research and monitoring efforts have not definitively identified subsistence system effects (e.g., Galginaitis and Funk, 2004; 2005).

## 8. Air Quality

The Clean Air Act (CAA) of 1970 established the National Ambient Air Quality Standards (NAAQS) for six pollutants, known as "criteria" pollutants—sulfur dioxide ($SO_2$), nitrogen dioxide ($NO_2$), carbon monoxide (CO), ozone ($O_3$), particulate matter ($PM_{10}$ and $PM_{2.5}$), and lead (Pb) (40 CFR 50). Collectively, the criteria pollutants are indicative of the quality of the ambient air. The primary standards are referred to as "health effects standards." These standards are set at levels to protect the health of the most susceptible individuals in the population: the very young, the very old, and those with respiratory problems. The U.S. Environmental Protection Agency (EPA) has designated secondary standards to protect public welfare. These are referred to as "quality of life standards." The EPA has established classification designations based on regional monitored levels of ambient air quality in accordance with the CAA Amendments of 1990. These designations impose Federal regulations on pollutant emissions that violate the standards and a time period in which the area must again attain the standard, depending on the severity of the regional air quality problem. Unclassified is the attainment status for Federal OCS waters since there is no provision in the CAA for classifying waters outside the boundaries of State waters.

The OCS activities that have the potential to affect air quality are controlled by several Federal and State authorities. Section 328 of the Clean Air Act Amendments of 1990 directs that rules establishing air pollution control requirements for OCS sources be promulgated, ensuring attainment and maintenance of Federal and State ambient air quality standards in corresponding onshore areas and equitable treatment of onshore and OCS sources. Under Section 328, authority for control of air emissions from OCS sources was divided between EPA and MMS. The MMS has authority over all OCS sources located in the Gulf of Mexico west of 87.5° W. longitude (at approximately the Florida-Alabama border) and EPA has authority over the rest of the OCS. The EPA rules were codified as 40 CFR Part 55. Under authority of OCSLA, the MMS has promulgated regulations in 30 CFR 250 for oil, gas, and sulfur operations.

The MMS monitors onshore impacts from OCS sources periodically to ensure OCS emissions sources are not contributing to violations of air quality standards at adjacent onshore areas. For offshore oil and gas activities, emissions that could potentially affect onshore air quality include emissions from platforms, support vessels and helicopters. In the Gulf of Mexico, MMS updates these air emissions every three years to aid in impacts analyses on coastal environments. The MMS also reviews plans submitted by operators to ensure that proposed activities do not adversely affect air quality. The MMS inspectors visit offshore facilities to ensure compliance with regulations and proper maintenance of equipment on platforms. Regarding alternative energy, the actual structures are not expected to emit air pollutants, however, vessels used for construction and maintenance will make some contributions and may be required to have permits depending on local air quality regulations as determined by EPA.

## 9. Water Quality

Water quality can be defined as the ability of a water body to maintain the ecosystems it supports or influences. In the case of coastal and marine environments, the quality of the water is influenced by the rivers that drain into the area, the quantity and composition of atmospheric deposition, and the influx of chemicals from sediments. There are several seasonal or occasional natural events that contribute to water quality and to which natural systems are adapted. Examples of these events include: hydrocarbons from natural oil seeps; sediment from coastal erosion; sediment derived from glacial-fed rivers; natural levels of nutrients from river flooding; and metals from volcanic eruptions and rock erosion. Several metals, such as zinc and iron, in low natural concentrations are essential for life processes in the marine environment. Besides the natural inputs, human activity can contribute to water quality through industrial discharges, sewage discharges, runoff, dumping, air emissions, burning, and spills. Also, mixing or circulation of the water can either improve the water through flushing or be the source of factors contributing to the decline of water quality.

Evaluation of water quality is determined by measurement of factors that are considered important to the health of an ecosystem. The primary factors influencing coastal and marine environments are temperature, salinity, dissolved oxygen, nutrients, potential of hydrogen (pH), pathogens, and turbidity or suspended load. Trace constituents such as metals and organic compounds can also affect water quality. The water quality and sediment quality may be closely linked. Contaminants, which are associated with suspended particles, may ultimately reside in the sediments rather than the water column.

Oil and gas operations can affect water and sediment quality through localized discharges of produced water and drilling muds and cuttings along with other minor routine discharges (e.g. deck runoff, vessel discharges, etc.). All discharges are regulated by the EPA through National Pollutant Discharge Elimination System Permits issued to each offshore facility and by both the EPA and the USCG through regulations that affect the discharges from vessels. The MMS and EPA established a Memorandum of Agreement in 1984 whereby MMS conducts inspections on offshore facilities to ensure compliance by operators with EPA discharge permits. Renewable energy facilities are not expected to produce operational discharges at this time based on the current state of the technology. Vessels that support the construction and operation of renewable energy facilities will be required to meet USCG and EPA requirements.

The MMS, EPA, and the oil and gas industry have funded numerous studies and reviews of the impacts from operational discharges (e.g. Engelhardt et al., 1989; Ray and Engelhardt, 1992). The MMS and industry have also funded studies after development to evaluate the impacts around platforms. Produced water discharges in the marine environment rapidly dilute to below detection limits within 100 feet of the discharge point. Discharges of drilling muds and cuttings can be detected for several hundred feet to several thousand feet. In general, the EPA discharge requirements are protective of the environment for routine discharges.

## C. Activities that Impact the Environment—Oil and Gas

The following table summarizes the major activities associated with OCS oil and gas leasing during each phase (exploration, development, production, and decommissioning). Also included in the table are the primary factors that have the potential to impact environmental and socioeconomic resources. These activities and their potential impacts have been analyzed in several EAs and EISs published by MMS, including those cited below.

Table III-1. Major Activities with OCS Oil and Gas Leasing that Have the Potential to Impact Environmental and Socioeconomic Resources.[1,2,3]

| Activity | Primary Factors |
|---|---|
| **Exploration** | |
| Seismic surveying[4] | Noise effects on marine species, space-use conflicts with commercial fishing |
| Rig fabrication | Dredging and coastal development, noise effects on marine species |
| Rig emplacement | Bottom disturbance from anchoring, noise effects from pile driving |
| Exploration drilling | Bottom disturbance, discharges, vessel collisions, risk of blowouts, noise effects on marine species |
| Routine rig operations | Deck drainage and sanitary wastes |
| Rig servicing | Discharges from support vessels and coastal port development |
| **Development** | |
| Platform fabrication | Land-use conflicts, dredging and coastal development, noise effects on marine species |
| Platform installation | Noise effects from pile driving on marine species, bottom disturbance |
| Development drilling | Discharges, risk of blowouts, noise effects on marine species |
| Installation of pipelines | Bottom disturbances, trenching, air emissions |
| **Production** | |
| Infrastructure presence | Space-use conflicts, aesthetic interference, bottom debris, trash, habitat loss for certain species |
| Separation of oil and gas from water | Generation of produced water |
| Transportation of production | Risk of spills, vessel collisions |
| Transportation of supplies and personnel | Vessel collisions, disturbance from aircraft, strain on coastal infrastructure |
| Use or expansion of coastal infrastructure | Increased employment, strain on local communities, runoff, land-use changes, habitat loss for certain species |
| Workovers | Discharges, risk of blowouts and spills |
| **Decommissioning[5]** | |
| Severance | Noise effects from explosive removals on marine species |
| Site-Clearance Activities | Bottom disturbance |

[1] MMS (2007a)
[2] MMS (2007b).
[3] Neff (1987).
[4] Continental Shelf Associates, Inc. (2004).
[5] MMS (2005).

## D. Activities that May Impact the Environment—Renewable Energy

The following table summarizes the major activities associated with OCS renewable energy (i.e., wind, wave, or current energy) during each phase of development (technology testing, site characterization, construction, operation, and decommissioning). Also included in the table are the primary factors that have the potential to impact environmental and socioeconomic resources. These activities and their potential impacts have been analyzed in several EAs and EISs published by MMS including those cited below.

Table III-1. Major activities Associated with Offshore Renewable Energy (i.e., wind, wave, or current energy) that Have the Potential to Impact Environmental and Socioeconomic Resources.[1]

| Activity | Primary Factors |
|---|---|
| **Technology Testing** | |
| Installation | Bottom disturbance, space-use conflicts |
| **Site Characterization** | |
| Site assessment surveying [2] | Noise effects on marine species |
| Data collection equipment (i.e., meteorological tower) | Bottom disturbance, space-use conflicts, bird and marine mammal collisions, noise effects from pile driving on marine species, aesthetic interference |
| **Commercial Facility Construction [3]** | |
| Site assessment surveying [2] | Noise effects on marine species; space-use conflicts with commercial fishing |
| Onshore Fabrication | Dredging, noise effects on marine species |
| Offshore Fabrication | Bottom disturbance, habitat alteration, vessel collisions, noise effects from pile driving on marine species, air emissions, risk of spills |
| Installation of transmission cables | Onshore excavation, air emissions, trenching |
| **Commercial Facility Operation [3]** | |
| Presence | Space-use conflicts, aesthetic interference, entanglement with mooring lines, collisions, alteration of wave/current regime, habitat loss for some species, effects on migratory pathways, disrupt radar |
| Maintenance | Vessel traffic and collisions |
| **Commercial Facility Decommissioning [4]** | |
| Site assessment surveying [2] | Noise effects on marine species |
| Severence | Noise effects on marine species, vessel traffic |
| Site-clearance activities | Bottom disturbance |

[1] USDOI, MMS (2007b).
[2] Continental Shelf Associates, Inc. (2004).
[3] USDOI, MMS (2009).
[4] USDOI, MMS (2005).

# E. Key Challenges and Information Needs

The following sections describe the key challenges and information gaps for each of the resources discussed in Section III.C above. The discussion is broken into geographic areas with some of the challenges and information gaps common to all areas discussed first.

## 1. All OCS Regions

### a. Key Challenges for Oil and Gas Development

***Seafloor Habitats:*** The key challenges related to seafloor habitats include the impacts caused by anchoring, infrastructure and pipeline emplacement, infrastructure removal, blowouts, drilling discharges, produced water discharges, and possible oil spills. Blowouts and oil spills are very rare. The basic approach to mitigate physical impacts to sensitive biological communities on the sea floor is to identify their location and avoid those areas by impacting activities. Effectiveness of this process is demonstrated at the Flower Garden Banks in the Gulf of Mexico, which coexists in close proximity to numerous oil and gas operations, while continuing to be one of the healthiest coral reefs in the western hemisphere.

***Coastal Habitats***: For coastal habitats, key challenges are the placement of pipelines, increased usage of ship channels, a lack of existing onshore infrastructure capable of supporting the offshore activity, and oil spills. Careful site selection for onshore support bases, pipeline placements, and new channels required for OCS offshore access can be used to minimize damage to coastal habitats. Shore base development must be closely coordinated with the affected states' Coastal Zone Management authority as well as the appropriate Federal resource and regulatory agencies (USFWS, NOAA, and Army COE) in order to assure that impacts to sensitive coastline features and wetland areas are avoided or minimized. Maximizing the use of existing onshore facilities for fabrication, staging, support base construction utility corridors or drainage rights of way as well as other previously disturbed areas for pipeline landfalls would minimize or eliminate damage to sensitive areas. Staging of oil spill response equipment and adequate response planning would minimize coastal impacts from oil spills.

***Marine Fish Resources:*** Key challenges for oil and gas development that are common to all OCS areas include the threat of accidental oil spills, space-use conflicts, habitat alteration, and seismic surveys. The threat of an oil spill and its effects both directly and indirectly on fisheries is central to the concerns about offshore oil and gas. There is extensive information on the detrimental effects of oil on fisheries in coastal and ocean situations (NRC, 2003). Much of this research was and continues to be funded by MMS. Space-use conflicts, at the dock or offshore, and habitat alteration, as pipelines are installed and come onshore, are important challenges that can be met by working closely with stakeholder groups including industry at the time of specific projects, encouraging multiple-use of infrastructure, and open consideration of alternative locations and routes. Seismic surveys are a challenge, as noise from such activity negatively affects fish resources, temporarily affects the ability to catch fish, and limits access to an area. Mitigations for seismic surveys on fisheries include timing and notification so that there is the least amount of interference with fishing, avoidance of fish spawning locations, spawning seasons, and areas of concentrated fishing activity, limitation to the smallest area possible for the shortest amount of time, modifying frequency and duration of air-gun noise emission for least impact, and ramping-up so that sound energy emissions are gradually increased.

***Marine Mammals*:** The key challenge for OCS oil and gas development activities to coexist with marine mammals is the issue of anthropogenic sound (i.e., noise generated from commercial shipping, offshore energy activities and other human activities). Sound is of vital importance to marine mammals, and anthropogenic sound can temporarily or permanently impair their ability to process and use sound. To date, there have been no documented instances of mortality or serious injury of marine mammals as a result of noise produced by the OCS energy activities, although this level of impact has not been directly tested for and is likely difficult to detect (i.e., non-immediate mortality, sinking of carcasses). Some existing research has shown behavioral impacts to marine mammals from oil and gas industry-produced sound while other studies have shown little to no effects. The use of a ramp-up may reduce or prevent the sudden exposure of cetaceans to maximum airgun output levels, and potentially permits cetaceans in the area to leave the immediate vicinity before maximum sound output levels are reached. The MMS also requires that visual monitoring and clearance be conducted for a 500-m (radial distance ) exclusion zone around an array and in the immediate vicinity of the survey vessel.

Secondary to the sound issue is the effect of accidentally spilled oil. This is especially true for sea otters, seals, sea lions, and polar bears where oil can affect the insulating properties of fur. Available information indicates that accidental oil spills could affect marine mammals in a number of ways, and the magnitude and severity of potential impacts would depend on the affected species, the age and sex of individuals, location and size of the spill, the type of product spilled, the weather conditions, the water quality and environmental conditions at the time of the spill, and the habitats exposed to the spill. Oil-spill response activities may also affect marine mammals.

***Sea Turtles:*** The key challenge for oil and gas development to sea turtles is anthropogenic sound resulting from the use of seismic airguns, explosive removals of structures, and pile driving. The available information on sea turtle behavioral responses to sound levels from seismic activities and construction activities indicates that individuals are likely to actively avoid areas with disturbing levels of sound. Monitoring and mitigation measures, such as protected species observers, the use of rigid turtle deflectors on dredges, and seasonal restrictions, are often put in place to lessen the likelihood of impacts. Other challenges include marine debris from ships, vessel strikes, oil spills and contaminants, and construction activities that disturb the sea-bottom floor.

***Marine and Coastal Birds:*** The key challenge to birds from oil and gas development would be a large oil spill. Seabirds are especially vulnerable to large oil spills, since they often congregate by the thousands in specific areas. Staging of oil spill response equipment and adequate response planning would minimize effects from oil spills.

### b. Key Challenges for Renewable Energy

***Seafloor Habitats:*** Many of the key challenges (discussed above) for oil and gas development would be similar for renewable energy. The installation of any renewable energy device on the sea floor would involve some kind of impact to benthic habitat. Sites for renewable energy development would be evaluated for sensitive biological habitats, initially through large-scale understanding of a particular region using existing information if available, and site-specific higher-resolution information if necessary. Once identified, sensitive areas would be avoided.

***Coastal Habitats***: Offshore alternative energy projects remove energy from the environment (i.e. wind or wave energy) and so have the potential to reduce currents and alter sediment transportation. Currents and sediment transportation patterns can change the type of habitat and organisms that are found in an area. The choice of location and distance from shore can reduce or eliminate these effects. Habitat alteration as power cables come ashore can be minimized by horizontal directional drilling and open consideration of alternative locations and routes.

***Marine Fish Resources:*** Key challenges for renewable energy development common to all OCS areas include offshore space-use conflicts, artificial reef effects, habitat alteration, noise from pile driving, and effects from electromagnetic fields (EMF) (Dunagan et al., 2007). The MMS has funded research into the nature of space-use conflicts and offshore oil and gas structure siting and is in the midst of a major study to delineate commercial fishing space-use conflicts for renewable energy. Space-use conflicts offshore are a challenge that can be met by working closely with stakeholder groups, including industry, at the time of specific projects. The artificial reef effect of offshore alternative energy structures will occur and the localized fisheries will likely change becoming more or less attractive to fishermen. Noise from pile driving is localized, temporary, and can be mitigated by the use of bubble-curtains, air gaps, and use of the quietest possible equipment and techniques. The subject of EMF continues to be studied globally, and MMS has an on-going study to further address EMF. Mitigations for EMF include cable burial and proper shielding.

***Marine Mammals*****:** There are two main challenges in assessing the potential range of effects of OCS renewable energy sources on marine mammals. The first is to better understand renewable energy technologies and how they are constructed and operate (i.e., do they have anchoring arrays and can this lead to entanglement, what is the scope of noise produced by equipment or construction). The second challenge, as with OCS oil and gas development, is understanding the effects of the more significant sound sources (i.e., pile driving during wind facility construction) and the biological significance of these impacts. The available scientific information has shown temporary and possibly permanent avoidance of marine mammals during construction of offshore wind facilities, primarily as a result of noise generated from pile driving during construction. Effects from noise during the operation of the wind facility have been shown to be nonexistent (Nedwell et al. 2007).

***Sea Turtles:*** Renewable energy project impacts would primarily be noise from pile-driving (e.g. wind turbine installation), alterations to the benthic communities by installation of structures, and increased risk of vessel strike as a result of increased vessel traffic associated with their installation and maintenance.

***Marine and Coastal Birds:*** The prospects for near-term wind energy developments off the mid-Atlantic coast of the United States has created concern about the interactions of wind turbines with marine and coastal birds. Moreover, millions of migratory birds traverse the US along flyways during spring and fall migrations. The challenge is to locate and operate wind energy facilities in such a way as to minimize bird mortality, especially since it is not possible to evaluate bird strikes by recovering carcasses. Studies of offshore wind farms in Europe have documented few bird fatalities and have shown that some species of birds are able to avoid wind turbines by diverting around the wind farm, flying low over the water within the wind farm during daylight, or by gaining altitude to fly above the wind farm at night (Desholm and Kahlert, 2005; Chamberlain et al., 2006). Lights on wind facilities may attract bird species, increasing their risk of collision. The MMS is currently funding an effort to evaluate technologies for observing bird interactions in an offshore environment.

The technology for harnessing ocean current and wave energy is still in the prototype stage. Wave and current energy arrays could pose a threat to seabirds in underwater pursuit of prey or diving into the water from heights in the attempt to capture prey swimming beneath them. For devices that extend well above the sea surface, collisions and attraction to lights may occur. The challenge is to determine how to locate and operate these devices so as to avoid or minimize impacts on marine birds.

### c. Information Needs

***Seafloor Habitats:*** A great deal of information exists that identifies significant seafloor habitats in much of the area of all OCS regions (some areas are not proposed for oil and gas activities). A part of the challenge in many areas will be to gather and synthesize existing information. Many studies targeting the characterization of seafloor habitats have been, and continue to be funded by MMS. There are some areas with limited information, and additional site-specific high-resolution mapping may be required to allow mitigation and avoidance of sensitive benthic habitats. This small-scale data can come from targeted studies and mapping efforts or surveys required from industry prior to permitting of any impacting activities.

***Coastal Habitats:*** While there is a large information base that provides a general understanding of coastal habitats, much of the information resides with many different Federal and State agencies. In some places, efforts are underway to synthesize this information and present it in a geospatial information format (map). However, these efforts do not always reflect the most recent conditions of coastal shorelines, where severe weather conditions and changes in sea level may be altering the area.

Offshore alternative energy projects remove energy from the environment (i.e. wind or wave energy) and so have the potential to reduce currents and alter sediment transportation. Currents and sediment transportation patterns can change the type of habitat and organisms that are found in an area. This is a fundamental knowledge gap that will affect any coastal habitat for every alternative energy project nationwide.

***Marine Fish Resources:*** There is adequate baseline information for marine fish resources, however, there are information gaps for specific regions as discussed in the following sections.

***Marine Mammals*:** Overall, there is an adequate baseline of information for understanding the general presence and life history traits of marine mammals throughout the OCS, or at least for predicting areas of likely presence and absence, and the range of potential impacts from OCS energy activities. Information is better for some species (e.g., nearshore movements of baleen whales, bottlenose dolphins and manatees) while data on other species is varied (e.g., offshore distribution of baleen whales, Arctic species). Effects for some activities are well-understood (e.g., contaminants and marine debris, vessel strikes) while less known for others (e.g., anthropogenic noise, climate change).

Some general information gaps remain and apply to marine mammals regardless of their species or geographic location. These include increasing our understanding on: (1) specific life history traits and critical habitat areas for some key marine mammal species (i.e., important feeding, mating and nursing behaviors and habitat for baleen whales, ESA-listed species, polar bears); (2) potential effects from noise-producing activities; (3) potential non-acoustic effects from renewable energy technologies (e.g., potential entanglement with anchoring array, large footprint of some facilities and potential effects to migration); (4) cumulative effects of multiple activities; and (5) effectiveness of the current mitigation and monitoring strategy for reducing or eliminating impacts. For more information on priority research needs on the sound issue, see the Joint Subcommittee on Ocean Science & Technology report, "Addressing the Effects of Human-Generated Sound on Marine Life: An Integrated Research Plan for U.S. Federal Agencies."

***Sea Turtles:*** Little is known about the effect of noise on sea turtles in the marine environment. In particular, their basic auditory system and hearing mechanisms or the role of sound in their life cycle are not well understood. However, it is believed that sea turtles are likely low frequency specialists. The biological importance of behavioral responses to construction noise (e.g., effects on energetics, survival, reproduction, population status) is unknown, and there is little information regarding short-term or long-term effects of behavioral reactions on sea turtle populations.

***Marine and Coastal Birds:*** Coastal birds, shorebirds, gulls and terns are found along all coasts of the United States as winter residents, summer breeders, and/or as migrants. Breeders nest along beaches and in vegetation in the sand dunes just behind the beaches. All of them forage along the coastline at the water's edge, in the intertidal zone, or in shallow waters near shore. Terns are known to sometimes forage several miles offshore, but there is sparse information on how far offshore these species can be found. Moreover, little is known about the flight directions, flight heights, or flight trajectories (ascending and descending) of these coastal birds either during migration or daily foraging activities. Such information is critical to understanding the potential for exposure to offshore wind energy developments and to analysis of collision risk.

The existing information on seasonal distribution and abundance of marine birds is also sparse, generally outdated, and of limited value. The FWS conducted some aircraft surveys of seabirds off the Atlantic Coast of the United States in the 1980's. However, changes in ocean currents, temperatures, and sea levels cause general and seasonal changes in the distribution and abundance of the prey species upon which marine birds depend, and therefore change the distribution and abundance of marine birds. Thus current information on marine bird distribution and abundance is always needed.

Existing information about marine bird distributions and abundance is largely from three sources – boat surveys, aircraft surveys, and "ships of opportunity." Boat surveys are generally limited to nearshore waters and narrow in geographic scope. Aircraft surveys offshore have been limited, and although useful for detection of aggregations of marine birds, the sampling methodology contains potentially significant errors of unknown magnitude in abundance estimates. "Ships of opportunity," in which bird observers are allowed aboard NOAA vessels, sample very limited area and do not allow analysis of seasonal and geographic variation in bird abundance and distribution.

## 2. Atlantic OCS Region

### a. Key Challenges for Oil and Gas Development

***Seafloor Habitats:*** Key challenges for new energy development along the U.S. Atlantic Margin include a synthesis of the accumulation of datasets from a variety of sources ranging from surveys by Federal Agencies such as the Navy (Department of the Navy 2008), USGS, and NOAA, and datasets produced by universities that regularly do offshore work in the region such as the University of New Hampshire, Woods Hole Oceanographic Institution, Virginia Institute of Marine Science, and Rutgers. The Navy has extensive marine assessment report documents covering operating areas of southeastern Florida, the mid-Atlantic, and the north Atlantic. Much of the slope along the Atlantic margin (water depths deeper that 1,000-1,500 m) has recently been surveyed using multibeam as part of studies carried out for Law of the Sea investigations.

***Coastal Habitats:*** The key challenge in the Atlantic Region is the lack of existing onshore infrastructure capable of supporting the offshore activity. The choice of site for onshore support bases, pipeline placements, waste disposal areas as well as construction of new channels and channel maintenance that may be required for OCS offshore access will be key in avoiding wetland damage. Most of the east coast, except portions of South Carolina and Georgia, are either developed (i.e., cities, towns, coastal communities, vacation communities) or are State or federally protected shorelines (i.e. parks or refuges) limiting locations for pipeline corridors.

***Marine Fish Resources:*** Key challenges relative to Atlantic Region fisheries are to prevent oil spills, minimize space-use conflicts, and avoid habitat alteration. Spawning and nursery grounds for fish resources along the Atlantic coast are located in both inshore and offshore areas. Most Atlantic fishing grounds are known, managed, and monitored. Seismic surveys and oil and gas development are occurring off the eastern Canadian coast. When, and if, surveys occur on the U.S. OCS, it will be important to monitor impacts on fisheries.

***Marine Mammals:*** As discussed previously, the primary challenge for OCS energy activities to coexist with marine mammals is the issue of anthropogenic sound. In addition, vessel strikes can result in injury or death and are a significant source of mortality for the highly endangered North Atlantic right whale and the endangered West Indian manatee (although vessel strikes with manatees generally occur closer to the coast). Studies document that the greatest number of incidents occur within the North American east coast, mainly with large whales. The majority of vessels involved are large, fast moving vessels such as container ships, tankers or military vessels, and collisions with vessels that are moving at slower speeds (less than 14 knots), such as those used in construction of OCS facilities, are less likely to strike marine life.

***Sea Turtles:*** The key challenges are the same as discussed for all regions in the Section E.1.a.

***Marine and Coastal Birds:*** The key challenges are the same as discussed for all regions in Section E.1.a.

### b. Key Challenges for Renewable Energy

***Benthic Habitats:*** Key challenges for renewable energy are similar to those for oil and gas activities (see above), but many of the renewable energy installations may be close to the coast. Much of the previous MMS assessments for oil and gas focused on the continental shelf further offshore, and there will now be a need to map and understand the nearshore seafloor geology in some areas. Installation of renewable energy devices in shallow or deep water may require high-resolution mapping to identify sensitive benthic biological resources. Ground truthing could be required in situations where device placement locations are limited. Wind farm structures would add new substrate to any locale where they were established, creating additional habitat from the seabed to the sea surface.

***Coastal Habitats***: The key challenges for renewable energy development for coastal habitats involve determining suitable locations for transmission cables to be installed.

***Marine Fish Resources:*** Key challenges relative to Atlantic region fisheries are to minimize space-use conflicts, estimate artificial reef effects, avoid habitat alteration, reduce noise from pile driving, and moderate effects from electromagnetic fields, if any.

***Marine Mammals:*** As discussed previously, the acoustic effects from the installation of facilities is a key challenge. In addition, more information is needed on potential non-acoustic effects from renewable energy technologies (i.e., potential entanglement with anchoring array, large footprint of some facilities and potential effects to migration).

***Sea Turtles:*** The key challenges are the same as discussed for all regions in the Section E.1.b.

***Marine and Coastal Birds:*** The key challenges are the same as discussed for all regions in Section E.1.b.

### c. Information Needs

***Benthic Habitats:*** There is a need to identify and synthesize existing geologic and benthic information as described above. However, most of the continental margin remains unmapped using modern techniques. New mapping is likely required in some areas to provide high-resolution information on complex benthic habitat and geologic processes in critical areas of interest to both nearshore and offshore energy programs.

A systematic survey of the geology of the Nation's submerged lands in areas of prime wind energy potential would facilitate energy development. Much of the area along the Atlantic margin meets the criteria for prime wind potential - water depths less than 30 m, high wind speed, and near areas of high electric consumption (see Figure II-7, section II). New mapping studies would be beneficial in some areas to aid industry in site selection and identify cable routes needed to bring energy ashore. Wind potential and local needs are driving forces that determine site selection that would reduce the overall geographic range of any needed surveys. The role of future operators to conduct surveys on renewable energy leases would also be a consideration for fulfilling this information gap.

Some high-diversity benthic habitats investigated, such as deepwater canyons with associated coral and other hard bottom benthic communities, have not been assessed since the last OCS studies in the 1970's. Revisiting these areas with modern mapping and underwater observation systems would improve estimates of the distribution of these important habitats and of the abundance of animals that inhabit them.

***Coastal Habitats:*** While a significant amount of information for shoreline and nearshore habitats exists, this information is scattered among various State and Federal Agencies. There is a need to synthesize this information and to incorporate it into a standardized database.

***Marine Fish Resources:*** For the Atlantic Region, the most noteworthy gap related to fisheries is that regarding potential space-use conflicts for commercial fishing, especially for the mid-Atlantic Region. Information does exist (Johnson et al. 2008) and any gaps can be met by working closely with stakeholder groups, including industry, at the time of specific projects.

***Marine Mammals:*** In addition to the general information needs discussed for marine mammals in Section E.1.c., more Atlantic-specific data gaps include: (1) baleen whale presence and movement in the offshore areas (existing information focuses largely on near shore areas); (2) areas of resident baleen whales; and (3) North Atlantic right whale movements during winter months.

***Sea Turtles:*** The information gaps are the same for all OCS regions and are discussed in Section E.1.c.

***Marine and Coastal Birds:*** In addition to the general information gaps discussed in Section E.1.c, there is a need to understand the risk to birds from offshore wind development. The existing data is limited as to the extent of usage of areas by birds (and bats) making it difficult to evaluate the risk of interactions with wind turbines.

## 3. Gulf of Mexico OCS Region

### a. Key Challenges for Oil and Gas Development

***Benthic Habitats:*** The only challenge for environmentally sound development in the proposed new areas of the eastern Gulf would be the availability of 3-D seismic survey coverage in unexplored areas. This information would be used during biological reviews for the potential presence of chemosynthetic communities or hard bottom areas that could support coral or other high density communities. Neither of these habitat types are expected anywhere away from the steep face of the Florida Escarpment that would be avoided for operations reasons regardless. Existing requirements have proven very effective for the protection of sensitive biological habitats in deepwater.

***Coastal Habitats:*** The key challenge in the Gulf of Mexico is wetland loss in coastal Louisiana. Utilization of existing onshore support, staging, construction and waste disposal bases as well as navigation channels should be given high priority in order to reduce wetland impacts. In addition, a greater understanding is needed of the timing and magnitude of land loss processes (i.e., subsidence, sea-level rise, storms) and how OCS processes influence land loss in Louisiana.

***Marine Fish Resources:*** Key challenges relative to Gulf of Mexico fisheries are to prevent oil spills, reduce degradation of inshore water quality, and avoid loss of Gulf wetlands, marshes, and estuaries. Spawning and nursery grounds for fish resources are located primarily inshore, but exist throughout OCS waters.

***Marine Mammals:*** The biggest current challenge for OCS energy activities in the Gulf of Mexico to coexist with marine mammals is the issue of anthropogenic sound (i.e., noise generated from commercial shipping, offshore energy activities, and other human activities). However, unlike other areas of the OCS, baleen whales (the species group believed to be most affected by OCS energy-produced anthropogenic sound) are rarely seen in the Gulf and therefore not of concern. Further, pinnipeds are not found in the Gulf, and manatees tend to be found primarily in nearshore environments. In addition, MMS has conducted extensive research on sperm whales, which has significantly increased our understanding of the distribution and abundance of this ESA-listed species and our understanding that this population reacts very little to OCS seismic noise.

***Sea Turtles:*** The key challenges are the same as discussed for all regions in Section E.1.a.

***Marine and Coastal Birds:*** The key challenges are the same as discussed for all regions in Section E.1.a.

### b. Key Challenges for Renewable Energy

***Seafloor Habitats:*** The key challenges are the same as discussed for all regions in Section E.1.b.

***Coastal Habitats***: The key challenges are the same as discussed for all regions in Section E.1.b.

***Marine Fish Resources:*** The renewable energy industry has expressed limited interest in developing the Gulf of Mexico for energy using methods or structures other than those used to develop fossil fuels. It appears unlikely that leasing for renewable energy will occur in the near-term in the Gulf.

***Marine Mammals:*** As discussed previously, the biggest current challenge for OCS energy activities to coexist with marine mammals is the issue of anthropogenic sound, how to better understand its potential for impacts to marine mammals, and how to most effectively mitigate to minimize or eliminate the potential for these effects. In addition, more information is needed on potential non-acoustic effects from renewable energy technologies (i.e., entanglement with anchoring array, large footprint of some facilities, vessel collisions).

***Sea Turtles:*** The key challenges are the same as discussed for all regions in Section E.1.b.

***Marine and Coastal Birds:*** Most of the migratory birds that overwinter in the neotropics and breed in eastern North America either fly directly across the Gulf or move around the edge of the Gulf Coast. Particularly during the spring migration, exhausted birds may be at risk from collisions with offshore wind structures as they make landfall.

### c. Information Needs

***Benthic Habitats:*** The only information gap for deep eastern Gulf areas would be a continuation of coverage of 3-D seismic surveys into new areas as mentioned above. This remote sensing data would be used to avoid any potential for impacting chemosynthetic communities or hard bottom habitats, although none would be expected away from the Florida Escarpment. The costs of these surveys are funded by companies employed by or speculating for future development by oil and gas companies.

***Coastal Habitats:*** One important data gap in the GOM, especially Louisiana, is information relating OCS vessel traffic to wetland loss. It is well-known that the creation of canals throughout the Louisiana coastal zone provides a conduit for saltwater intrusion into relatively low-saline coastal habitats, and that the ensuing salinity increases can stress plant communities and contribute to coastal land loss. The resolution of this issue requires quantification of OCS vessel traffic and a clear understanding of salt transport dynamics in existing navigation canals, including the degree to which these canals facilitate salt flux into adjacent wetland habitats. The MMS is working with USGS to continuously update coastal habitat information, in addition to current land loss information, to better assess OCS impacts on coastal habitats.

***Marine Fish Resources:*** The oil and gas industry has a long history in the Gulf of Mexico and modern fishing and oil and gas industries developed together over decades. For the Gulf region, the most noteworthy gap related to fisheries is that regarding offshore spawning locations of fish resources. The Gulf is one of only two areas where OCS oil and gas structures exist. The MMS is uniquely positioned and should continue to work with commercial and recreational fishing stakeholders to monitor the interface and interaction of fish resources and the fishing industry and offshore oil and gas.

***Marine Mammals:*** Overall, there is a solid baseline of information for understanding marine mammal presence and life history traits in the GOM and the range of potential impacts from OCS energy and other activities. In the GOM, information is extensive on sperm whales (see SWSS) and the general distribution of marine mammals (see GulfCet), while data on some species is limited (e.g., offshore distribution of beaked whales) but not considered critical. As in other areas of the OCS, effects for some GOM activities are well-understood (e.g., contaminants and marine debris, vessel strikes) while less known for others (e.g., anthropogenic noise, climate change).

In addition to the general marine mammal information needs outlined in Section E.1.c above, the remaining areas of research focus for the Gulf include: (1) identification of sperm whale prey species and effects of anthropogenic sound on these species (2) quantifying the presence of manatees in coastal waters in Texas, Louisiana, Mississippi, and Alabama; and (3) testing reactions of sperm whales (e.g., eastern GOM population) that have not yet been exposed to seismic airguns and comparing these results to SWSS, which studied a group of sperm whales likely already habituated to airgun noise.

***Sea Turtles:*** The information gaps are the same for all OCS regions and are discussed in Section E.1.c.

***Marine and Coastal Birds:*** In addition to the general information gaps discussed in Section E.1.c, there is a need to understand the risk of birds from offshore wind development. The existing data is limited as to the extent of usage of areas by birds (and bats) making it difficult to evaluate the risk of interactions with wind turbines.

## 4. Pacific OCS Region

### a. Key Challenges for Oil and Gas Development

***Benthic Habitats:*** The key challenge for new leasing in the Pacific is to obtain high-resolution seafloor and benthic habitat maps in all areas where energy activities could occur where necessary. Avoidance of important benthic habitat types, when present, would require fine-scale mapping and evaluation. Considerable information is available for some areas. Other areas have little available survey or mapping data. Activities proposed for any specific area may require more detailed coverage. In areas where detailed information may be needed for a specific energy-related project, common remote sensing methodologies used in other areas can easily obtain missing information with regard to benthic habitats. Information needs will be limited by the future potential use of each area, e.g., Washington and Oregon will not be offered for oil and gas leasing in the current proposed program.

***Coastal Habitats:*** The key challenges are the same as discussed for all regions in Section E.1.a.

***Marine Fish Resources:*** Key challenges relative to Pacific Region fisheries are to maximize production from existing infrastructure, prevent oil spills, and further define the value of existing offshore platforms as habitat for overfished species.

***Marine Mammals:*** As discussed previously, the biggest current challenge for OCS energy activities to coexist with marine mammals is the issue of anthropogenic sound, how to better understand its potential for impacts to marine mammals, and how to most effectively mitigate to minimize or eliminate the potential for these effects. In addition, effects from and rapid response to accidental oil spills is a key challenge given the presence of sea otters, seals and sea lions.

***Sea Turtles:*** The key challenges are the same as discussed for all regions in Section E.1.a.

***Marine and Coastal Birds:*** The key challenges are the same as discussed for all regions in Section E.1.a.

### b. Key Challenges for Renewable Energy

***Benthic Habitats:*** Challenges for renewable energy would are similar to those for oil and gas development. The installation of any renewable energy device would also require fine-scale information about the benthic habitats affected.

***Coastal Habitats:*** Offshore renewable energy projects remove energy from the environment (i.e., wave energy) and have the potential to reduce currents and alter sediment transportation. Currents and sediment transportation patterns can change the type of habitat and organisms that are found in an area. The extent of energy reduction and change to a particular habitat, however, may be mitigated through proper siting of a project.

***Marine Fish Resources:*** Renewable energy development may be proposed from Washington State to southern California. Key challenges for the Pacific Region fisheries are to minimize space-use conflicts, estimate artificial reef effects, avoid habitat alteration, reduce noise from pile driving, and moderate effects from EMF, if any.

***Marine Mammals:*** As discussed previously, the biggest current challenge for OCS energy activities to coexist with marine mammals is the issue of anthropogenic sound, how to understand better its potential for impacts to marine mammals, and how to mitigate most effectively to minimize or eliminate the potential for these effects. In addition, more information is needed on potential non-acoustic effects from renewable energy technologies, specifically wave technologies (i.e., potential entanglement with anchoring array, large footprint of some facilities, and potential effects to migration, and vessel collisions). Larger wave energy developments may affect migratory pathways or result in entanglement in cables.

***Sea Turtles:*** The key challenges are the same as discussed for all regions in Section E.1.b.

***Marine and Coastal Birds:*** The key challenges are the same as discussed for all regions in Section E.1.b.

### c. Information Needs

***Benthic Habitats:*** The principal information gap for a complete evaluation of benthic habitats and their communities would be updated high-resolution mapping and ground truthing of survey data in specific areas under consideration.

***Coastal Habitats:*** The information gaps are the same as discussed for all regions in Section E.1.c.

***Marine Fish Resources:*** For the Pacific Region, the most noteworthy gap related to fisheries is that regarding siting and potential space-use conflicts for commercial fishing, especially for northern California, Oregon, and Washington. However, information does exist, and any gaps can be met by working closely with stakeholder groups, including industry, at the time of specific projects. Offshore space-use conflicts in southern California have been addressed since 1983 by the Joint Oil Fisheries Liaison Office. This office was created through a cooperative effort of the fishing industry and the oil and gas industry and is financially supported by the energy industry. The MMS has several ongoing studies to determine the habitat value of Pacific offshore oil and gas platforms.

***Marine Mammals:*** In the Pacific, there is adequate information on some species (e.g., nearshore movements of baleen whales, sea otters, seals and sea lions) while data on other species is limited (e.g., offshore distribution of baleen whales, range expansion of southern sea otters). Effects for some activities are well understood (e.g., contaminants and marine debris, vessel strikes) while less known for others (e.g., anthropogenic noise, climate change).

In addition to the general marine mammal information needs outlined in Section E.1.c above, more specific focus is needed in the Pacific on: (1) a literature review of existing information on marine mammal presence in northern California, Oregon, and Washington in order to develop recommendations for additional studies; (2) effectiveness of mitigation designed to avoid vessel strikes and prevent and respond to spilled oil, given the nearshore nature of many marine mammal species in the Pacific and the vulnerability of otters and pinnipeds to spilled oil; and (3) further study of the potential range expansion of the ESA-listed southern sea otter in southern California.

***Sea Turtles:*** The information gaps are the same as discussed for all regions in Section E.1.c.

***Marine and Coastal Birds:*** The information gaps are the same as discussed for all regions in Section E.1.c.

## 5. Alaska OCS Region

### a. Key Challenges for Oil and Gas Development

***Seafloor Habitats:*** The key challenge is the limited information available concerning seafloor habitats in the Beaufort, Chukchi, and Bering Sea. Some habitats such as the Boulder Patch have been well studied and are isolated and considered important and vulnerable. The presence of hard substrate is very rare in general. However, the potential for other areas similar to the

Boulder Patch must be considered, and the absence of significant benthic habitat demonstrated by adequate surveys of potential development areas. The MMS is currently funding a study in the Chukchi Sea to expand the baseline information of seafloor habitats.

***Coastal Habitats:*** The Alaskan coastal environment is remote, creating a challenge for rapid oil spill response. The primary opportunities for protection involve accurately identifying the sensitive resources so they can be avoided by proper site selection and routing of support services. Route planning for support transportation, piping, and waste containment and disposal must be initiated based on knowledge of the area to be affected so as to avoid the most sensitive areas or minimize impacts to the area.

***Marine Fish Resources***: Key challenges for Alaska region fisheries with regard to offshore oil development is to preserve the important fisheries, prevent oil spills, minimize space-use conflicts, and avoid habitat alteration. The North Pacific Fisheries Management Council has put a moratoria on commercial fisheries in the Arctic. There is limited information on the detrimental effects of oil on fisheries in the Arctic and ice-bound areas. The MMS should continue to fund studies on oil spill response in ice-covered waters.

***Marine Mammals:*** As discussed previously, the biggest current challenge for OCS energy activities to coexist with marine mammals is the issue of anthropogenic sound, how to better understand its potential for impacts to marine mammals, and how to most effectively mitigate to minimize or eliminate the potential for these effects. In addition, effects from and rapid response to accidental oil spills is a key challenge given the presence of sea otters, seals, sea lions, and polar bears in Alaskan waters.

***Sea Turtles:*** The key challenges are the same as discussed for all regions in Section E.1.a.

***Marine and Coastal Birds:*** The key challenges are the same as discussed for all regions in Section E.1.a.

### b. Key Challenges for Renewable Energy

Renewable energy development is not being considered on the OCS for Alaska in the near future.

### c. Information Needs

***Seafloor Habitats:*** Other than general need for small-scale survey information for any new seafloor habitat area, there is one additional consideration related to undescribed features. There have been citations noted that large "pockmarks" had been found on the seafloor along the northern Chukchi Sea slope and in the eastern Beaufort Sea nearshore shelf (MacDonald et al., 2005; Paull et al., 2007). Similar pockmarks around methane seeps have been found on the U.S. mid-Atlantic shelf (Newman et al., 2008); and pockmarks with methane seeps and special biological communities have been found at the Gulf of Mexico shelf break (Kennicutt et al., 1985). The relationship of the Chukchi pockmarks to methane seeps, whether they support biological communities and whether there are any such features in areas under consideration for development, is unknown.

***Coastal Habitats***: The best methods of avoiding and mitigating impacts in this region depend on accurately identifying the wetland habitat and understanding its response to OCS activities in the area. While existing sources of data on wetland habitats are useful, they are not updated frequently enough to capture rapidly changing environmental conditions. In addition, the spatial and temporal resolution of existing data sets is not adequate in some cases. Most datasets could be greatly improved through additional ground-truthing efforts. Our understanding of plant communities in some areas under consideration for activities needs to be improved. These gaps in wetland identification are mainly in the Arctic.

***Marine Fish Resources:*** For Alaska, the most significant gaps related to fisheries are those regarding space-use conflicts for commercial fishing and subsistence fishing for coastal communities in both the North Aleutians and the Arctic. The MMS has several ongoing studies that specifically address these issues. Developing a better scientific and socio-economic understanding will lead to better documentation of effects, less controversy regarding risks, increased stakeholder involvement, direct information from the citizens, increased certainty underlying policies and regulatory decisions, and effective mitigation efforts.

***Marine Mammals:*** In general, there are pockets of good information for species found in Alaskan waters and areas where little information is known. Many of the information needs tend to focus on ESA-listed species and their population status, the effects of climate change induced range expansions (e.g., humpback whales in the Beaufort Sea) or range depletions (e.g., polar bears and other species dependent on Arctic ice). Further, there are several species under review for ESA listing, including the Pacific walrus, bearded seals, ringed seals, and spotted seals.

In addition to the general marine mammal information needs outlined in Section E.1.c above, there are information gaps which still remain for Alaska, including increasing our understanding of: (1) ongoing changes in distribution and behavior related to climate change; (2) habitat use patterns for key species (e.g., baleen whales, Pacific walrus, ice seals, and polar bears) and areas (e.g., Chukchi and Bering Seas) and identifying important feeding areas; and (3) improvements to oil spill response capabilities in icy waters.

***Sea Turtles:*** The information gaps are the same as discussed for all regions in Section E.1.c.

***Marine and Coastal Birds:*** The information gaps are the same as discussed for all regions in Section E.1.c.

# IV. INFORMATION DATA GAPS

As we move into an era of renewable energy in some areas and the continued development of more traditional energy sources in others, our information base is not always complete. Additional geographically-based, targeted research will be required in some areas and for some disciplines. The prospects for future energy development vary depending on the location and nature of the resource, ecosystem characteristics of the affected environment, and many socioeconomic and cultural factors. All of these elements must be considered as information availability and data gaps are assessed. Development scenarios differ by area, and so too does the need for detailed site-specific mapping, environmental characterization, and impact assessment. In some cases, simply avoiding an area or sensitive habitat may be appropriate. In other cases, the potential for a conflict between a development activity and a vulnerable species, for example, may be managed with information on the species' seasonal occurrence and migration pathways and by appropriately scheduling or altering the development activity.

Thus, the data and information gaps identified in this report must be viewed in terms of a broad range of decisions – over broad geographic areas - that will need to be made in the future. Note too, that data gaps identified in this report will be supplemented with input from stakeholders at the Federal, state and community level as regional and project-level decision making proceeds. It is likely that increased knowledge over time will improve our ability to define the data and information gaps as well, particularly as existing data are identified, compiled, and synthesized. As is sometimes the case, there is sufficient data, it just needs to be turned into useable information. These decisions will depend on the nature of the proposed activity, its timing, extent, location, environmental effects, and proposed mitigations. Ultimately, informed decision makers must weigh the overall costs and benefits of specific proposed activities as they impact our society at local, regional, and national levels.

## Renewable Energy Resources

Quantifying the potential offshore renewable energy resource is reasonably straightforward, and great strides are being taken to map the offshore wind, wave, and tidal resources. However, there is a high degree of uncertainty in estimating the actual extractable or developable amount of energy given the many uncertainties in societal preferences, technological developments, environmental sensitivities, transmission capacity, grid connection availability, and potential space-use conflicts in the ocean environment. Even as coastal States look to aggressively develop readily-available offshore wind resources in the North Atlantic, there is a need to better understand where the best resource is located and how to most appropriately develop that resource. Thus, several States have begun to initiate comprehensive environmental studies and ocean mapping and management plans to identify the most appropriate areas for future development.

Offshore renewable energy technologies are still developing: particularly for wave, tidal, and current power; there is a need for standardized protocols and criteria in technical evaluation and design; resource assessment methods for wave, tidal and current energy are less developed compared to wind energy; resource assessments are incomplete; and the actual amount of developable energy is dependent upon a host of factors that need to be examined more closely.

## Oil and Gas Resource Evaluation

Seismic surveys are the primary method of exploring for oil and gas. Most of the seismic data acquired in the potential new lease areas are more than 25 years old and may not be adequate for detailed prospect mapping or for lease sale bid formulation and evaluation, especially in geologically complex areas. New seismic and related data will likely be required for some areas (especially in the Atlantic Outer Continental Shelf (OCS) area and Eastern Gulf of Mexico) and is typically used by the oil and gas industry as part of their pre-leasing evaluation. Prior to acquisition of seismic data, environmental analyses may be required to better inform decisions.

## Sensitive Environmental Areas and Resources

Understanding how renewable energy technologies will affect the marine environment is a key component in determining appropriate siting and effective regulation. The MMS is continuing to work with stakeholders on various siting issues and is committed to balancing our nation's energy needs while protecting the marine environment and ensuring human safety. Launching demonstration projects in coastal waters will help to fill knowledge gaps. Likewise, establishing monitoring protocols for early projects while assessing the ecological risks associated with different technology types will help regulators understand the impacts that accompany commercial deployment. Forming partnerships through research and development programs could also provide long term fundamental technology leadership, funding, and the facilities needed to accelerate innovation and spur industry growth.

Overall, an adequate baseline of information exists to address the environmental effects of the OCS oil and gas program and the renewable energy program in support of leasing decisions. A key challenge in many areas will be to gather and synthesize existing information. In addition, new information is continually being gathered by MMS, the United States Geological Survey, and others. Once specific areas are identified for development, additional information may be needed for some biological resources. Some of the key information needs follow.

**Seafloor Habitats:** There are some areas with limited information, and additional site-specific high-resolution mapping may be required to allow mitigation and avoidance of sensitive biological habitats such as coral reefs.

**Coastal Habitats:** While there is a large information base that provides a general understanding of coastal habitats, these efforts do not always reflect the most recent conditions of coastal shorelines, where severe weather conditions and changes in sea level may be altering the area.

**Marine Fish Resources:** The key information need related to fisheries is that regarding potential space-use conflicts for commercial fishing, which requires identification of important fishing grounds.

**Marine Mammals:** Key information needs include increasing our understanding of: (1) specific life history traits and critical habitat areas for some key marine mammal species (i.e., important feeding, mating and nursing behaviors and habitat for baleen whales and Endangered Species Act-listed species); (2) potential effects from noise-producing activities; and (3) potential non-acoustic effects from renewable energy technologies (e.g., potential entanglement with anchoring array, large footprint of some facilities and potential effects on migration).

**Sea Turtles:** Little is known about the effect of noise on sea turtles in the marine environment. In particular, their basic auditory system and hearing mechanisms or the role of sound in their life cycle are not well understood.

**Marine and Coastal Birds:** The existing information on seasonal distribution and abundance of marine birds is sparse. Such information is critical to understanding the potential for exposure to offshore wind energy developments and to analysis of collision risk.

## Concluding Remarks

Our National energy demands have steadily increased over the past 50 years, and fossil fuels have consistently remained the primary form of energy production, followed by nuclear and renewable energy sources. While we continue to rely heavily on oil for transportation and generate a majority of our electricity from coal, renewable energy sources will play an increasingly important role as we look for ways to address environmental, economic, and energy security. The energy resources of the OCS, and specifically renewable energy sources, are particularly attractive options with significant resources located in close proximity to coastal population centers.

The experience, knowledge, and tools exist to ensure that all sources of offshore energy are developed in a comprehensive and environmentally sound manner. By obtaining stakeholder input (locally and nationally); compiling existing information and acquiring new data where needed; conducting objective analyses using monitoring data to manage adaptively; and applying the necessary mitigations and safeguards along the way, we can achieve our national energy, economic, and environmental goals.

# Appendix A.
# Acronyms and List of Terms Used

# Appendix A. Acronyms and List of Terms Used

## Acronyms

| | |
|---|---|
| 2-D | two dimensional common depth point seismic information |
| 3-D | three dimensional common depth point seismic information |
| 4-D | four dimensional seismic data |
| ac | acres |
| AC | alternating current |
| ADFG | Alaska Department of Fish and Game |
| AEAU | Alternative Energy and Alternate Use |
| AEP | Alternative Energy Program |
| AWEA | American Wind Energy Association |
| bbl | barrel |
| Bbo | billion barrels of oil |
| BBOE | billion barrels of oil equivalent |
| Bcf | billion cubic feet of gas |
| BLM | U.S. Bureau of Land Management |
| BMP | Best Management Practices |
| BOE | barrels of oil equivalent |
| CAA | Clean Air Act |
| CDP | Common Depth Point |
| CFR | Code of Federal Regulations |
| COET | Center for Ocean Energy Technology |
| COOGER | California Offshore Oil and Gas Energy Resources |
| COST | Continental Offshore Stratigraphic Test |
| CZMA | Coastal Zone Management Act |
| DC | direct current |
| DCF | discounted cash flow |
| DGH | Indian Government Directorate General of Hydrocarbons |
| DOE | U.S. Department of Energy |
| DOI | U.S. Department of the Interior |
| E&D | exploration and development |
| EA | Environmental Assessment |
| EFH | essential fish habitat |
| EIA | Energy Information Administration |
| EIS | Environmental Impact Statement |
| EMEC | European Marine Energy Center |
| EMF | electromagnetic fields |
| EMP | Energy Master Plan |
| EPA | U.S. Environmental Protection Agency |
| EPAct | Energy Policy Act of 2005 |
| EPRI | Electric Power Research Institute |
| ESA | Endangered Species Act |
| ESI | Environmental Sensitivity Index |
| ESP | Environmental Studies Program |
| EUR | estimated ultimate recovery |
| FAU | Florida Atlantic University |
| FERC | Federal Energy Regulatory Commission |
| Ft | feet |
| FWS | U.S. Fish and Wildlife Service |
| G&G | geological and geophysical |
| GIS | geographic information system |
| GOM | Gulf of Mexico |
| GSOE | Garden State Offshore Energy LLC |
| GW | gigawatt |
| IEA | International Energy Administration |
| JIP | Joint Industry Project |
| JSOST | Joint Subcommittee on Ocean Science & Technology |
| km | kilometer |
| km/h | kilometer per hour |
| kV | kilovolt |
| kW | kilowatt |
| LIPA | Long Island Power Authority |
| LIOWP | Long Island Offshore Wind Park |
| m | meters |
| mi | mile m/s meters per second |
| MBTA | Marine Bird Treaty Act |
| Mcf | thousand cubic feet of gas |
| mi | miles |
| MMbo | million barrels of oil |
| MMBOE | million barrels of oil equivalent |

| | |
|---|---|
| Mph | miles per hour |
| MOA | Memorandum of Agreement |
| MW | megawatt |
| mW | milliwatt |
| MMPA | Marine Mammal Protection Act |
| MMS | Minerals Management Service |
| nm | nautical miles |
| NAAQS | National Ambient Air Quality Standards |
| NEPA | National Environmental Policy Act |
| NJ BPU | New Jersey Board of Public Utilities |
| NMFS | National Marine Fisheries Service |
| NOAA | National Oceanic and Atmospheric Administration |
| NPV | net present value |
| NRC | National Research Council |
| NREL | National Renewable Energy Laboratory |
| NSF | National Science Foundation |
| OCS | Outer Continental Shelf |
| OCSLA | Outer Continental Shelf Lands Act |
| OMB | United State Office of Management and Budget |
| OPT | Ocean Power Technology |
| OSRA | Oil-Spill Risk Analysis |
| OSU | Oregon State University |
| PEIS | Programmatic Environmental Impact Statement |
| PPA | Power Purchase Agreement |
| PTC | production tax credit |
| R&D | research and development |
| RFP | Request for Proposal |
| ROD | Record of Decision |
| RPS | renewable portfolio standard |
| SAMP | Special Ocean Area Management Plan |
| SWSS | Sperm Whale Seismic Survey |
| TA&R | Technology Assessment and Research |
| Tcf | trillion cubic feet |
| TCFE | trillion cubic feet of gas equivalent |
| TOC | total organic carbon |
| TW | terawatt |
| TWh/y | terawatt hours per year |
| U.S.C. | United States Code |
| USCG | U.S. Coast Guard |
| USCOP | U.S. Commission on Ocean Policy |
| USGS | U.S. Geological Survey |
| UERR | undiscovered economically recoverable resources |
| UTRR | undiscovered technically recoverable resources |
| WEC | wave energy conversion |
| WTG | wind turbine generator |

# List of Terms Used

**Cumulative production:** The sum of all produced volumes of oil and gas prior to a specified point in time.

**Estimated Ultimate Recovery (EUR):** All hydrocarbon resources within known fields that can be profitably produced using current technology under existing economic conditions. The EUR is the sum of cumulative production plus proved reserves plus unproved reserves plus reserve appreciation.

**Nacelle:** The body/shell/casing of a propeller-type wind turbine, covering the gearbox, generator, blade hub, and other parts.

**Pool:** A discovered or undiscovered accumulation of hydrocarbons, typically within a single stratigraphic interval.

**Play:** A group of pools that share a common history of hydrocarbon generation, migration, reservoir development, and entrapment.

**Probability***:* A means of expressing an outcome on a numerical scale that ranges from impossibility to absolute certainty; the chance that a specified event will occur.

**Prospect:** A geologic feature having the potential for trapping and accumulating hydrocarbons; a pool or potential field.

**Proved reserves:** The quantities of hydrocarbons estimated with reasonable certainty to be commercially recoverable from known accumulations under current economic conditions, operating methods, and government regulations. Current economic conditions include prices and costs prevailing at the time of the estimate. Estimates of proved reserves do not include reserve appreciation.

**Reserves:** The quantities of hydrocarbon resources anticipated to be recovered from known accumulations from a given date forward. All reserve estimates involve some degree of uncertainty.

**Reserves appreciation:** The observed incremental increase through time in the estimates of reserves (proved and unproved) of an oil and/or natural gas field as a consequence of extension, revision, improved recovery, and the addition of new reservoirs.

**Resources:** Concentrations in the earth's crust of naturally occurring liquid or gaseous hydrocarbons that can conceivably be discovered and recovered.

**Total endowment:** All technically recoverable hydrocarbon resources of an area. Estimates of total endowment equal undiscovered technically recoverable resources plus the EUR.

**Undiscovered resources:** Resources postulated, on the basis of geologic knowledge and theory, to exist outside of known fields or accumulations.

**Undiscovered technically recoverable resources (UTRR):** Oil and Gas that may be produced as a consequence of natural pressure, artificial lift, pressure maintenance, or other secondary recovery methods, but without any consideration of economic viability. They are primarily located outside of known fields.

**Undiscovered economically recoverable resources (UERR):** The portion of the undiscovered technically recoverable resources that is economically recoverable under imposed economic and technologic conditions.

**Unproved reserves:** Quantities of hydrocarbon resources that are assessed based upon geologic and engineering information similar to that used in developing estimates of proved reserves, but technical, contractual, economic, or regulatory uncertainty precludes such reserves being classified as proved.

# Appendix B.
# Overview of Assessment Methodology

# Appendix B. Overview of Assessment Methodology

The assessment of hydrocarbon resources is a statistical analysis of geologic data. The principal procedural components of the assessment process consist of petroleum geological analysis, play definition and analysis, and resource estimation. Petroleum geological analysis is the basis for all other components of the assessment. Play definition and analysis involves identifying and quantifying the necessary elements for the estimation of resources in geologic plays in a form that can be used for statistical resource estimation. The resource-estimation process uses a set of computer programs developed for the statistical analysis of play data. The results of that statistical analysis are estimates of the undiscovered technically recoverable resources (UTRR) of geologic plays.

The resource estimates are further subjected to a separate statistical analysis that incorporated economic and engineering parameters to estimate the undiscovered economically recoverable resources (UERR) for the assessment areas. For those areas with existing production, cumulative production and estimates of discovered resources are added to estimates of undiscovered conventionally recoverable resources to obtain a measure of the total resource endowment.

A major strength of this method is that there is a strong relationship between information derived from oil and gas exploration activities and the geologic model developed by the assessment team. An extensive effort was involved in developing play models, delineating the geographic limits of each play, and compiling data on critical geologic and reservoir engineering parameters. These parameters are crucial input in the determination of the total quantities of recoverable resources in each play.

Due to the inherent uncertainties associated with an assessment of undiscovered resources, probabilistic techniques are employed and the results reported as a range of values corresponding to different probabilities of occurrence. For plays in frontier areas with sparse data, analogs are developed using subjective probabilities to cover the range of uncertainties. Most plays in the Alaska, Atlantic and some in the Pacific Outer Continental Shelf (OCS) are assessed this way. For mature areas with significant amounts of data, such as the Gulf of Mexico (GOM) and southern California, plays are analyzed using a method based on statistical parameters of discovered pools and historical trends.

**1. Probabilistic Nature of Resource Assessment:** There are numerous uncertainties regarding the geologic framework and petroleum geologic characteristics of a given area and the location and volume of its undiscovered oil and gas resources. These include uncertainty regarding the presence and quality of petroleum source rocks, reservoir rocks, and traps; the timing of hydrocarbon generation, migration, and entrapment; and the location, number, and size of accumulations. The value and uncertainty regarding these petroleum geologic factors can be qualitatively expressed (e.g., “there is a high probability that the quality of petroleum source rocks is good”). However, in order to develop volumetric resource estimates, the value and uncertainty regarding some factors must be quantitatively expressed (e.g., “there is a 95-percent probability that reservoir rocks will have porosities of 10 percent or more”). Each of these factors—and the volumetric resource estimate derived from them—is expressed as a range of values with each value having a corresponding probability. The following definitions are provided to ensure proper understanding of the probabilistic nature of this assessment and the resource estimates presented in this report.

Probability (chance) is the predicted likelihood that an event, condition, or entity exists; it is expressed in terms of success (the chance of existence) or risk (the chance of nonexistence). Petroleum geologic probability is the chance that an event (e.g., generation of hydrocarbons), property (permeability of reservoir rocks), or condition (presence of traps) necessary for the accumulation of hydrocarbons exists.

A probability distribution is a range of predicted values with corresponding probabilities of occurrence. The estimates of UTRR are developed as cumulative probability distributions, in which a specified volume or more of resources corresponds to a probability of occurrence. These estimates are reported as a range of values from each cumulative probability distribution, which includes a low estimate corresponding to the 95th-percentile value of the distribution (i.e., the chance of existence of the estimated volume or greater is 19 in 20), a mean estimate corresponding to the statistical average of all values in the distribution, and a high estimate corresponding to the 5th-percentile value of the distribution (i.e., the chance of existence of the estimated volume or greater is 1 in 20). The low, mean, and high estimates of undiscovered resources that are presented in this report correspond to these specific probabilistic criteria.

Oil and natural gas deposits on the OCS are hidden from view under hundreds or thousands of feet of water and thousands of feet of the earth's crust. Seismic surveying to reveal possible accumulations and exploratory drilling are the basic investments that are made in the search for oil and gas. Actual deposits can only be discovered through drilling costly exploratory wells. Exploration investment more often than not fails to yield discoveries of oil and gas, and when prospects are identified, on closer evaluation, some do not warrant further investment with exploratory drilling. Many prospects that are drilled turn out to contain no oil and gas; others are found to contain oil or gas, but are not economically producible because of the size and character of the deposit. Estimating resource potential is not an exact science, and different technical experts and companies could have widely different views on appropriate methodologies and the interpretation of data. While the Government has a greater amount of basic geological and geophysical (G&G) data on unleased OCS oil and natural gas prospects as do private companies, interpretations of those data and perceptions of an area's hydrocarbon potential will vary. Both groups, however, will evaluate the resource potential by explicitly incorporating risk and uncertainty into the resource assessments to account for the absence of a strong relationship between the geologic variables and the presence of specific amounts of hydrocarbon resources, as well as the lack of geologic information for many of the OCS areas.`

The Government assessments of oil and gas resource potential rely on risk-based methodologies to statistically reflect different chances for drilling success for different areas. Frontier areas such as parts of the Eastern GOM and other offshore areas where leasing has not occurred for twenty or more years offer the potential of larger field-size discoveries. Yet, uncertainty is greater with investments in these areas. The Minerals Management Service

(MMS) resource assessment models explicitly account for differences in geologic risk among oil and gas provinces and planning areas. As a result, the risk-based estimates in frontier areas ordinarily will have been seen as far too conservative if later exploration demonstrates that the area is hydrocarbon-prone (and will have overstated resources in those areas that ultimately prove unsuccessful). To the extent the Government relies upon understated, or overstated, resource estimates in determining programmatic "balancing" decisions pursuant to the Outer Continental Shelf Lands Act requirements, this could introduce some bias into program decisions. The MMS attempts to mitigate this problem by conducting periodic assessments that incorporate new data and information from drilling and seismic surveys, both from within the assessed area and from geologically analogous provinces located outside of the assessed area.

**2. Petroleum Geologic Analysis:** The first component of the assessment process involves analysis of the G&G data to identify areas of hydrocarbon potential and to ascertain the areal and stratigraphic extent of potential petroleum source rocks, reservoir rocks, and traps within these areas. The information obtained through this process is the basis for the definition of geologic plays and for the quantification of parameters in the play definition and analysis component.

Published and proprietary reports and information are compiled to better understand the depositional and tectonic history of each province and assessment area, to identify the areas of hydrocarbon potential, and to better establish the petroleum geologic framework on which the plays would be defined. The scope of these reports ranges from studies of the regional geology and tectonics of an area to detailed geochemical and well-log analyses from exploratory wells and coreholes. Exploratory well information and interpretations of seismic-reflection profiles are the basis for identifying stratigraphic intervals within the assessment areas. Paleontological and lithological analyses are used to determine the age and environment of deposition of stratigraphic units.

Potential petroleum generative sources are identified through the use of published and proprietary geochemical studies and MMS proprietary data from exploratory and development drilling. Hydrocarbon indications from exploratory and production wells along with analyses of well data are used to identify potential petroleum source rocks and to estimate source-rock properties. Geophysical well information are used along with interpretations of seismic-reflection profiles to estimate generative areas within those source-rock units.

Potential hydrocarbon reservoirs and possible migration pathways from source to reservoir are identified primarily through the use of exploratory well data and interpretations of seismic-reflection profiles. Reservoir-rock properties and the presence of trapping mechanisms are estimated by using information from well-log analysis and from analogous stratigraphic units in producing areas. Geophysical interpretations of seismic-reflection profiles are used to infer migration pathways and to estimate the extent of stratigraphic intervals in which reservoir-quality rocks are expected.

Identification of potential structural traps (prospects) is based primarily on MMS interpretation and subsurface mapping of proprietary seismic-reflection data. Where feasible and appropriate, the interpretations are modified to incorporate new data and ideas. In some areas, interpretations are based on sparse seismic-reflection data, and although those interpretations could be used to identify depositional and structural trends, they could not be used to identify individual prospects. In such cases, and for assessment areas which are outside of areas with existing data or interpretations, estimates of the number and areal size of prospects are based on interpretations from geologically analogous areas.

**3. Play Definition and Analysis:** The MMS uses a play-based approach (White and Gehman, 1979; White, 1988; 1992) for estimating resources. Play definition involves the identification, delineation, and qualitative description of a body of rocks that potentially contains geologically related hydrocarbon accumulations. A play is a group of hydrocarbon accumulations that share a common history of hydrocarbon generation, accumulation, and entrapment. A corollary to this definition is that a group of hydrocarbon accumulations within a properly defined play can be considered as a single entity for statistical evaluation.

Play analysis involves the quantitative description of parameters relating to the volumetric hydrocarbon potential of the play. The presence of necessary conditions for the generation, migration, and entrapment of hydrocarbons is unknown, but probabilities for their existence and quantification can be estimated, and these can then be used in the resource-estimation process to develop probability distributions for quantities of hydrocarbon resources. Play analysis provides the necessary quantitative information in the form of play-specific probability distributions; these distributions reflect the uncertainty of the parameters and are used as the basis for the statistical resource-estimation process.

Each play may be characterized by parameters that, in combination, describe the volumetric resource potential of the play, assuming that the play does contain hydrocarbon accumulations. A range of values is assigned to each parameter, based on information obtained through the petroleum geological analysis component.

Probability analysis (often called risk analysis) is performed on individual components that are necessary for success of a play or prospect—adequate hydrocarbon fill, presence and favorable quality of reservoir rock, and presence of trapping conditions. The probabilities (chances) of success of the individual components are combined to yield the probability of success for the play as a whole (play chance) and the probability of success for individual prospects within the play (conditional prospect chance). The combination of these factors yields the probability that all necessary conditions are present together at an individual prospect, assuming that the play is successful.

**4. Resource Estimation:** Prospect sizes within plays with sufficient data coverage, discovered field sizes within mature basins (those with extensive exploration and production histories), and many other geologic properties have distributions that approximate a statistical pattern called lognormality. The MMS's assessment of the volume of UTRR is based on the assumption that, within a properly defined play, the size distribution of the entire population of accumulations (which consists of both discovered and undiscovered accumulations) will also be lognormal. This means that in a play with discoveries, the undiscovered accumulations will, in combination with those discoveries, describe a lognormal distribution. Also, in a play with no discoveries, the undiscovered accumulations alone will describe a lognormal distribution.

For plays in frontier areas with sparse data, analogs are developed using subjective probabilities to cover the range of uncertainties. Most plays in the Alaska, Atlantic and some in the Pacific OCS are assessed this way. Measured prospect sizes (e.g., from seismic prospect mapping) and other parameters are used to estimate pool sizes. If data is sufficient for detailed mapping, the areal sizes of mapped prospects in the play approximate a lognormal distribution. In many assessment areas, prospect mapping is incomplete, so the uncertainty is greater. For plays in such areas, the areal size distribution of the mapped prospects is extrapolated to develop distributions for the areal size and number of prospects in the entire play. Other parameters (e.g., net pay and recovery factors) are similarly estimated. These estimates are statistically combined to derive a ranked pool-size distribution for the play. The resource volumes of the pools in the play are aggregated to derive play resources. Results of the probability analysis (described in the 3. Play Definition and Analysis) are used to reduce the distribution of prospects (possible pools) to a distribution of pools (containing resources). Monte Carlo methodology is used to statistically combine the various parameters to derive probability distributions for the volume of UTRR in the play.

For mature areas with significant amounts of data, such as the GOM and southern California, plays are analyzed using a method based on statistical parameters of discovered pools and historical trends. Where there are sufficient data, mapped prospect areas approximate lognormality. Fields (discoveries) within mature basins generally also have size distributions which are lognormal. The discovered accumulations in a play, when combined with the undiscovered accumulations, will approximate a lognormal distribution. The discovered pools, along with the requirement for approximate lognormality, determine a minimum number of pools in the play; however, lognormal distributions can be defined for a larger number of pools. Therefore, additional information (e.g., prospect mapping) and subjective judgment are employed in order to estimate the total number of pools within the constraints of the data. After development of such a distribution for a play, the undiscovered pools are sampled using Monte Carlo methodology to estimate the total volume of undiscovered resources in the play.

The probability distributions for the volume of UTRR in individual plays are statistically aggregated to the field, province, and regional levels. A separate economic analysis is performed on the field-level aggregated UTRR results.

The economic analysis is the second phase in the assessment of each petroleum province, following the assessment of the geologic characteristics and UTRR. The geologic model generates an inventory of pools in each play, which for the economic analysis is sampled repeatedly to select pools for the simulations in the economic model. For each modeling trial, a set of hypothetical pools ("simulation pools") are collected using a probability sampling system that replicates the discovery of pools in the province. Engineering parameters relating to development are sampled from an array of variables and assigned to each simulation pool. The collection of pools undergoes a simulation to model the costs and scheduling associated with discovery, development, and production. A discounted cash flow (DCF) analysis is performed for each pool. Pools with positive net present value (NPV) are counted as economic resources for that trial, and those with negative NPV are set to zero resources. The sampling, engineering simulation, and DCF analysis are then repeated. Typically, a full modeling run consists of 10,000 trials with different sets of pools in each trial. These results are known as the Undiscovered Economically Recovered Resources or UERR.

After the modeling run is completed, statistics are aggregated for successful (profitable pools) and unsuccessful (not discovered or negative NPV) simulations. Economic volumes of oil and gas, including associated substances (solution gas in oil, condensate liquids in gas) are compiled and probability levels are calculated. The reported volumes are considered as "risked" because unsuccessful trials are included in the statistics.

The modeling runs are repeated at fixed dollar per barrel ($/bbl) price increments between low starting and high ending oil prices to produce a spectrum of results under changing economic conditions. The results are compiled on a "price-supply" graph that illustrates the relationship between economically recoverable resources (dependent variable) and commodity prices (independent variable). The results of the economic assessment are strongly influenced by the preceding geologic assessment, as most of the engineering variables are tied to geologic characteristics. For example: deeper reservoirs have higher well costs; thicker reservoirs have higher well flow rates. Unfavorable geology is accentuated by the economic analysis—not improved by it. This means that provinces with unfavorable geology are likely to have minimal economically recoverable resources.

The UERR's for the 2006 assessment were generated using an oil price range of $8/bbl to $80/bbl. This analysis was updated for the Draft Proposed Outer Continental Shelf (OCS) Oil and Gas Leasing Program 2010-2015 in January 2009 (MMS, 2009). For the updated analysis oil prices of $60/bbl, $110/bbl, and $160/bbl were used, and MMS's economic model was updated to incorporate a relationship between oil price and development costs. Capturing observed variations in oil and gas exploration and development costs across a wide range of oil prices improved the MMS confidence in estimating UERR's.

This fundamental relationship was not modeled in previous MMS economic assessments. A cost-price "elasticity factor" is defined based on internal analyses that found that a statistically significant relationship exists between crude oil price and an index of upstream capital cost. These analyses are applied to all cost components. Another important factor affecting the UERR reported in the updated analysis was a revised estimate of the natural gas heat content (BTU) equivalency factor. That factor, which was 0.90 in 2005, has decreased to 0.60 in 2008, thus lowering the economic value of gas relative to oil. For example, an oil price of $60/bbl in the 2006 assessment was associated with a $9.07 per thousand cubic feet of gas (Mcf), while the same oil price is associated with a natural gas price of $6.41 per Mcf in 2008.

# Appendix C.
# UTRR by Planning Area

# Appendix C. UTRR by Planning Area

This appendix summarizes the planning area level technically recoverable oil and gas resources for the U.S. Outer Continental Shelf (OCS) (see Figure C-1). The OCS comprises that portion of the submerged seabed whose mineral estate is subject to Federal jurisdiction. Planning areas are administrative subdivisions of the OCS used in the Department of Interior's offshore oil and gas leasing program. Planning area boundaries were redefined in 2006, and therefore the planning area level results of this study are not directly comparable with previous Minerals Management Service resource assessments. The 2006 assessment represents a comprehensive appraisal that considered relevant data and information available as of January 1, 2003, incorporated advances in petroleum exploration and development technologies, and employed new methods of resource assessment.

This assessment provides estimates of the undiscovered, recoverable oil and natural gas resources located outside of known oil and gas fields on the OCS. Estimates of undiscoverable technically recoverable resources are presented in Table C-1. Estimates are presented at the F95 and F5 percentile levels, as well as the mean. This range of estimates corresponds to a 95-percent probability (a 19 in 20 chance) and a 5-percent probability (a 1 in 20 chance) of there being more than those amounts present, respectively. The 95- and 5-percent probabilities are considered reasonable minimum and maximum values, and the mean is the average or expected value.


Figure C-1. Federal OCS Planning Areas

Table C-1. Undiscovered Technically Recoverable Resources of the OCS

| Region / Planning Area | Undiscovered Technically Recoverable Oil and Gas Resources (UTRR) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Oil (Bbo) | | | Gas (Tcfg) | | | BOE (Bbo) | | |
| | F95 | Mean | F5 | F95 | Mean | F5 | F95 | Mean | F5 |
| Alaska OCS* | 8.66 | 26.61 | 55.14 | 48.28 | 132.06 | 279.62 | 17.25 | 50.11 | 104.89 |
| Chukchi Sea | 2.32 | 15.38 | 40.08 | 10.32 | 76.77 | 209.53 | 4.15 | 29.04 | 77.36 |
| Beaufort Sea | 0.41 | 8.22 | 23.24 | 0.65 | 27.64 | 72.18 | 0.53 | 13.14 | 36.08 |
| Hope Basin | 0.00 | 0.15 | 0.60 | 0.00 | 3.77 | 14.98 | 0.00 | 0.82 | 3.27 |
| Navarin Basin | 0.00 | 0.13 | 0.62 | 0.00 | 1.22 | 5.80 | 0.00 | 0.35 | 1.65 |
| North Aleutian Basin | 0.02 | 0.75 | 2.50 | 0.40 | 8.62 | 23.28 | 0.09 | 2.29 | 6.65 |
| St. George Basin | 0.00 | 0.21 | 0.79 | 0.00 | 2.80 | 11.15 | 0.00 | 0.71 | 2.77 |
| Norton Basin | 0.00 | 0.06 | 0.24 | 0.00 | 3.06 | 13.27 | 0.00 | 0.60 | 2.61 |
| Cook Inlet | 0.06 | 1.01 | 2.85 | 0.03 | 1.20 | 3.48 | 0.06 | 1.23 | 3.47 |
| Gulf of Alaska | 0.00 | 0.63 | 2.04 | 0.00 | 4.65 | 16.00 | 0.00 | 1.45 | 4.89 |
| Shumagin | 0.00 | 0.01 | 0.05 | 0.00 | 0.49 | 2.04 | 0.00 | 0.10 | 0.42 |
| Kodiak | 0.00 | 0.05 | 0.20 | 0.00 | 1.84 | 7.62 | 0.00 | 0.38 | 1.55 |
| *The Aleutian Arc, Aleutian Basin, Bowers Basin, and St. Matthew-Hall Planning Areas in the Alaska OCS Region were not evaluated in this study as their petroleum potential is negligible. | | | | | | | | | |
| Atlantic OCS | 1.12 | 3.82 | 7.57 | 14.30 | 36.99 | 66.46 | 3.67 | 10.40 | 19.39 |
| North Atlantic | 0.57 | 1.91 | 3.80 | 7.18 | 17.99 | 32.17 | 1.85 | 5.12 | 9.52 |
| Mid-Atlantic | 0.43 | 1.50 | 2.96 | 5.44 | 15.13 | 27.53 | 1.39 | 4.19 | 7.85 |
| South Atlantic | 0.13 | 0.41 | 0.81 | 1.67 | 3.86 | 6.76 | 0.43 | 1.10 | 2.01 |
| Gulf of Mexico OCS | 41.21 | 44.92 | 49.11 | 218.83 | 232.54 | 249.08 | 80.15 | 86.30 | 93.43 |
| Western Gulf of Mexico | 9.80 | 10.70 | 11.80 | 62.65 | 66.25 | 70.17 | 20.95 | 22.49 | 24.28 |
| Central Gulf of Mexico | 28.41 | 30.32 | 32.77 | 134.49 | 144.77 | 156.56 | 52.33 | 56.08 | 60.62 |
| Eastern Gulf of Mexico | 2.76 | 3.88 | 5.51 | 18.06 | 21.51 | 25.98 | 5.97 | 7.71 | 10.13 |
| Straits of Florida | 0.01 | 0.02 | 0.03 | 0.01 | 0.02 | 0.02 | 0.01 | 0.02 | 0.04 |
| Pacific OCS | 7.55 | 10.53 | 13.94 | 13.28 | 18.29 | 24.12 | 9.91 | 13.79 | 18.24 |
| Washington/Oregon | 0.00 | 0.40 | 0.94 | 0.03 | 2.28 | 4.89 | 0.01 | 0.81 | 1.81 |
| Northern California | 1.08 | 2.08 | 3.55 | 2.30 | 3.58 | 5.17 | 1.49 | 2.71 | 4.47 |
| Central California | 1.17 | 2.31 | 3.76 | 1.10 | 2.41 | 4.06 | 1.37 | 2.74 | 4.49 |
| Southern California | 3.51 | 5.74 | 8.53 | 6.41 | 10.03 | 14.69 | 4.65 | 7.52 | 11.14 |
| Total U.S. OCS | 66.60 | 85.88 | 115.13 | 326.40 | 419.88 | 565.87 | 124.68 | 160.60 | 215.82 |

(Bbo-billion barrels of oil; Tcf-trillion cubic feet of gas. F95 indicates a 95-percent chance of at least the amount listed; F5 indicates a 5-percent chance of at least the amount listed. Only mean values are additive. Some total mean values may not equal the sum of the component values due to independent rounding.)

# Appendix D.
# Acquisition of New Seismic Data in OCS Frontier Areas

# Appendix D. Acquisition of New Seismic Data in OCS Frontier Areas

## Summary

Estimated costs range from about $100 million to approximately $175 million for each frontier planning area to acquire a two-dimensional (2-D) seismic survey and a follow-up, focused three-dimensional (3-D) seismic survey. These costs include data acquisition, processing, and interpretation; ship mobilization and demobilization; and associated environmental costs. Actual survey costs could vary greatly depending upon the specific location chosen, the actual amount of data to be acquired, the location of the surveys, the availability of data acquisition vessels, data processing program design, and environmental compliance, etc.

The timeframe from the initiation of necessary environmental analyses to the completion of an updated resource assessment for one frontier planning area would probably be between 6 and 10 years. The Minerals Management Service (MMS) would also require, for each frontier planning area studied, an additional 2 full-time employees and $300,000 to manage the data acquisition program, interpret the data, and complete an assessment.

## Background

The MMS acquires seismic data from three principal sources: (1) prelease exploration permits, (2) lessee activities, and (3) publicly available data acquired via scientific research activities. The overwhelming majority of the geophysical data that MMS acquires are through prelease exploration permits. Generally, industry acquires data in areas where there are ongoing or planned activities, such as lease sales. Any party wishing to conduct geophysical exploration for mineral resources on the Outer Continental Shelf (OCS) over an area not leased by that party must obtain a permit from MMS. As a condition of the permit, MMS has the right to acquire a copy of such data at the cost of reproduction. In recent years, the average cost of seismic data MMS obtains through the permitting process represents about 1/500 to 1/600 of the market price.

Prelease seismic exploration data are acquired by seismic contractors either as a contract service for an oil company who retains ownership of the data or as a multi-client survey in which risk is shared among the seismic contractor, who retains data ownership, and the oil and gas companies that license the data from the contractor.

The MMS has acquired virtually all of the existing exploration seismic data in frontier OCS areas from prelease exploration permits. These datasets have been selectively augmented with relevant seismic data from Canada (Scotian Shelf), Bahamas, Cuba and various adjacent coastal State waters; MMS paid the market price for these international data sets.

## Discussion: Environmental Analyses

A National Environmental Policy Act (NEPA) analysis is required for all seismic activity. In frontier areas of the OCS, this analysis can be rather extensive.

- In addition, Section 7(a) of the Endangered Species Act (ESA) requires MMS to consult with the National Marine Fisheries Service (NMFS) on any Agency action (e.g., seismic survey permit) that may affect a listed species or designated critical habitat. Therefore, as a permitting Federal Agency, the MMS has a responsibility to consult with NMFS before permitting or conducting the proposed activity.

- Similarly, the Marine Mammal Protection Act (MMPA) requires a "small take authorization" be issued for any activity that may incidentally take a marine mammal.

- Under the Coastal Zone Management Act, a State with an approved coastal management program (CMP) can request consistency review of a license or permit, even if not listed in their approved program, by notifying the applicant, the Federal Agency, and the National Oceanic and Atmospheric Administration (NOAA) at the same time as its request to review (15 CFR 930.54). The MMS cannot issue the permit or conduct seismic activities until every "affected state" that reviews the proposal determines the activity consistent with its CMP or until consistency can be presumed due to non-responsiveness of a State.

- In some OCS areas, the Magnuson Stevens Fishery Conservation and Management Act requires MMS to consult with NMFS on any action that may result in adverse effects to essential fish habitat.

The MMS has not fully implemented the requirements of these environmental laws and regulations in all 26 planning areas. For example, rulemaking for programmatic NEPA, ESA, and MMPA coverage for Gulf of Mexico-wide seismic surveys is in progress, as is NEPA multi-year coverage for open-water seismic surveys in the Alaska Arctic (draft Environmental Impact Statement [EIS]). Environmental coverage is needed for the other Alaskan Planning Areas (including the North Aleutian Basin) and for all Atlantic Planning Areas. Additionally, the environmental coverage for the Pacific Planning Areas is outdated and may need updating. Timeframes required to implement these requirements could range up to several years. For example, a Notice of Intent to prepare a Programmatic EIS for the Atlantic was published in the Federal Register on January 21, 2009. If funding to support this EIS can be secured, it would take approximately 2 to 3 additional years to complete the environmental documentation to support decisions on seismic surveying in the Atlantic.

In addition, there are costs associated with environmental analysis. Such costs run about $300,000 for an Environmental Assessment (EA) and approximately $2 to $3 million for an EIS. As previously stated, the timeframe for these documents to be completed would run from months in the case of an EA to about 2 to 3 years in the case of an EIS.

## Discussion: Cost and Timing for Frontier Areas

The MMS considers approximately 23 of the 26 OCS planning areas to be frontier areas. Not every one of these areas is believed to hold significant promise for the presence of commercial quantities of oil and gas.

If the MMS were directed to acquire modern seismic data in frontier areas to supplement existing data, we would propose a two-phase approach. The first phase would be a reconnaissance 2-D seismic survey designed to supplement existing data. This survey would then be followed up by a carefully targeted modern 3-D seismic survey, which would serve to substantially reduce geologic risks and uncertainties, refine play concepts, and identify specific exploration targets. However, even with this new geophysical data, only through actual exploratory drilling will there be a definitive determination of a frontier area's actual hydrocarbon potential.

The MMS estimates that, for a typical frontier planning area, the average percentage having oil and gas potential would be approximately 25 percent, amounting to approximately 2,000 to 2,500 OCS blocks (9 square miles/block). The MMS would utilize a reconnaissance 2-D survey to cover that area. Assuming that 10-15 percent of the area covered by the 2-D survey is classified as being “high potential,” the next phase would be a focused 3-D survey covering that specific high potential area (between 200 and 375 OCS blocks).

Preliminary estimates of costs include acquisition and initial processing costs for a 2-D seismic survey, and for a follow-up, focused 3-D survey, as well as ship mobilization, demobilization, and interpretation of such data. Costs are about $1,000 per line-mile for acquisition and initial processing of 2-D data, and about $375,000 per OCS block for 3-D data. These estimated costs are based upon values provided by the International Association of Geophysical Contractors, and would be applied to each frontier planning area to be studied.

**2-D surveys** are measured in terms of the length of the line traversed, hence line-miles. A 2 x 2 mile survey is composed of a regular rectangular grid of lines, each of which is 2 miles apart. For our example, a 2 x 2 mile survey covering some 2,000 blocks would require approximately 18,000 line-miles of data to be acquired. The MMS estimates that it would take approximately 2 to 3 years to complete the 2-D survey, from acquisition through processing.

**3-D surveys** are measured in terms of surface area—either square miles or OCS blocks. The MMS estimates that it would take an additional 2 to 4 years to complete the 3-D survey, from acquisition through processing.

Based on the acquisition and processing costs listed above, as well as an estimate of $5-$6 million for mobilization, demobilization, interpretation, etc., the total estimated direct costs to acquire and process new data in a frontier planning area would range from about $100 million to $175 million. The total timeframe for completing 2-D and 3-D seismic work ranges from 4 to 7 years.

# Appendix E.  References

# Appendix E. References

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