UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF OCEAN ENERGY MANAGEMENT
GULF OF MEXICO OCS REGION
NEW ORLEANS, LOUISIANA

SITE-SPECIFIC ENVIRONMENTAL ASSESSMENT

OF

DEVELOPMENT OPERATIONS COORDINATION DOCUMENT NO. R-5873

FOR

SHELL OFFSHORE INC.

August 29, 2013

RELATED ENVIRONMENTAL DOCUMENT

Environmental Impact Statement for Gulf of Mexico OCS Oil and Gas Lease Sales: 2012-2017; Western Planning Area Sales 229, 233, 238, 246, and 248; Central Planning Area Sales 227, 231, 235, 241, and 247 (OCS EIS/EA BOEM 2012-019)

FINDING OF NO SIGNIFICANT IMPACT (FONSI)

In accordance with the National Environmental Policy Act (NEPA), Council on Environmental Quality (CEQ) regulations at 40 C.F.R. Part 1501.3 and 1508.9, Department of the Interior (DOI) regulations implementing NEPA at 43 C.F.R. Part 46, and Bureau of Ocean Energy Management (BOEM) policy, BOEM prepared a Site-Specific Environmental Assessment (SEA), No. R-5873. This SEA analyzed the potential effects of Shell Offshore Inc.'s revised Development Operations Coordination Document (DOCD) for drilling operations on the Outer Continental Shelf (OCS) of the Gulf of Mexico (GOM). Our evaluation of the proposed action is complete and the BOEM has found no information to indicate that the proposed action will significantly affect the quality of the human environment within the meaning of Section 102(2)(c) of the NEPA. Therefore, the BOEM has determined that an Environmental Impact Statement (EIS) is not required and is issuing a Finding of No Significant Impact (FONSI).

Gregory Kozlowski /s/ — August 29, 2013
Unit 2 Supervisor, Environmental Operations Section — Date
Office of the Environment, GOM OCS Region

TABLE OF CONTENTS

Page

SITE-SPECIFIC ENVIRONMENTAL ASSESSMENT (SEA) PREPARED FOR SHELL OFFSHORE INC'S REVISED DEVELOPMENT OPERATIONS COORDINATION DOCUMENT; R-5873

1. OVERVIEW

The purpose of this Site-Specific Environmental Assessment (SEA) is to determine whether the proposed activities outlined in the revised Development Operations Coordination Document (DOCD), R-5873, initially submitted by Shell Offshore Inc. (Shell) on April 25, 2013 will significantly affect the quality of the human environment within the meaning of Section 102(2)(c) of the National Environmental Policy Act (NEPA) and whether an Environmental Impact Statement (EIS) must be prepared. Shell's revised DOCD proposes to explore for hydrocarbons by drilling and completing six wells, Well Numbers PI-1ST, P8, P7ST, and GG in Mississippi Canyon Block 809 and Well Numbers DD and EE in Mississippi Canyon Block 810, in the Central Planning Area (CPA). This SEA is tiered from the prior Multisale EIS: *Gulf of Mexico OCS Oil and Gas Lease Sales: 2012-2017; Western Planning Area Sales 229, 233, 238, 246, and 248; Central Planning Area Sales 227, 231, 235, 241, and 247; Final Environmental Impact Statement* (USDOI, BOEM, 2012). The Multisale EIS evaluated a broad spectrum of potential impacts resulting from drilling activities across the Central and Western Planning Areas of the Gulf of Mexico (GOM) Outer Continental Shelf (OCS).

"Tiering" process is provided for in the NEPA implementing regulations (40 C.F.R. Part 1502.20 and 1508.28) and is designed to reduce and simplify the size of subsequent environmental analyses of actions included within the broader program previously examined in NEPA compliance documents by eliminating discussions of impacts that would be repetitive to allow focus on those site-specific concerns and effects related to the specific action proposed. Document tiering in the Bureau of Ocean Energy Management (BOEM) is subject to additional guidance under Department of the Interior (DOI) regulations at 43 C.F.R. § 46.140 wherein the site-specific analysis must note which conditions and effects addressed in the programmatic document remain valid and which conditions and effects require additional review.

Although the analyses of drilling-related impacts prepared in the Multisale EIS are comprehensive, new information has become available with respect to the following:

- **Emission Impacts on Air Quality** – the DOCD contains project-specific emissions data not known during the preparation of the programmatic analyses;
- **Discharge Impacts on Offshore Water Quality – new environmental conditions now exist and the** DOCD contains project-specific discharge data not known during the preparation of the programmatic analyses;
- **Bottom Impacts on Deepwater Benthic Communities** – the DOCD contains project-specific information not known during the preparation of the programmatic analyses;
- **Noise/Vessel-Strike Impacts on Marine Mammals –** new environmental conditions now exist since the preparation of the programmatic analyses;
- **Noise/Vessel-Strike Impacts on Sea Turtles –** new environmental conditions now exist since the preparation of the programmatic analyses;
- **Discharge Impacts/Disturbances to Fish and Fisheries –** new environmental conditions now exist since the preparation of the programmatic analyses; and
- **Bottom Impacts on Potential Archaeological Resources** – the DOCD contains project-specific information not known during the preparation of the programmatic analyses.

Therefore, Chapter 3 of this SEA focuses on how the new information, including a discussion of the known effects of the Macondo well blowout, spill, and remediation on the analyzed resources, relates to the routine, accidental, and cumulative environmental effects of this proposed action. Where applicable, relevant affected environment discussions and impact analyses from the Multisale EIS is summarized and utilized for this site-specific analyses, and are incorporated by reference into this SEA. Relevant mitigative measures identified in the EIS have been considered in the evaluation of the proposed action.

1.1. BACKGROUND

The BOEM and the Bureau of Safety and Environmental Enforcement (BSEE) are mandated to manage and oversee the exploration and development of OCS oil, gas, and mineral resources while ensuring safe operations and the protection of the human, marine, and coastal environments. The BOEM and the BSEE issue oil and gas leases and regulates exploration, development, production, and decommissioning. Prior to authorizing activities related to these phases, BOEM conducts the appropriate NEPA review. The BOEM's Office of Leasing and Plans (OLP) oversees the submittal of Exploration Plans (EPs) and DOCDs pursuant to 30 C.F.R. Part 550, Subpart B.

Lessees and operators submit EPs and DOCDs to provide BOEM with information needed to adequately evaluate the overall potential impacts on OCS resources prior to seeking any individual permit approvals, such as an application for permit to drill (APD). Most of the information in EPs and DOCDs is presented in basic statements, figures, lists, and tables that simply provide the necessary details on the proposed exploration, development, production, and/or transportation operations. One exception is the Environmental Impact Analyses (EIA) required in EPs under 30 C.F.R. § 550.227 and in DOCDs under 30 C.F.R. § 550.261; wherein, the operator provides environmental information and makes impact conclusions regarding their activities.

On April 20, 2010, while working on an exploratory well approximately 50 mi (80 km) offshore Louisiana, the semisubmersible drilling rig *Deepwater Horizon* experienced an explosion and fire, resulting in an uncontrolled release of oil and natural gas from the Macondo reservoir. Oil was dispersed into the water column, but heavier oil fractions and tarballs washed onto shorelines in varying concentrations. Natural gas dissolved into the water column or vented into the atmosphere. On July 15, 2010, the leaking well was capped and a relief well encountered and plugged the Macondo wellbore on September 19, 2010. Prior to capping/plugging the well, approximately 53,000-62,000 barrels (bbl) per day (2.23-2.60 million gallons) were released from the well, with an approximate total release of 4.9 million bbl of oil (206,000,000 gallons) over an 87-day period.

The Macondo Event has resulted in changes in environmental conditions over a large portion of the northern GOM. Some of the information found in recent EIAs has relied upon out-of-date and inaccurate data. For this reason, BOEM reviewed, but did not rely upon, any environmental information and/or assumptions provided by the operator in the EIA when conducting this analysis.

The scope of the effects on the environment in the GOM from the activities proposed in Shell's revised DOCD were fully discussed and analyzed in the Multisale EIS, and the specific locations, equipment, methodologies, and the duration of the proposed activities will result in impacts similar to those discussed in the EIS. However, there is new information from the Macondo Event in scientific literature that is peer-reviewed as well as new mitigation methodologies such as oil spill remediation that should be taken into account for the affected environment. This information was not previously available and could not be considered or analyzed during the preparation of the Multisale EIS. This SEA was prepared by BOEM to evaluate the activity-specific issues related to the applicant's proposed activities in addition to the new information.

1.2. PURPOSE OF AND NEED FOR THE PROPOSED ACTION

Shell has submitted a plan to conduct development activities on the Outer Continental Shelf. The purpose of the proposed action is to drill and complete six wells on the OCS, which would help satisfy the Nation's need for energy.

The need for this action is established by BOEM's responsibility under the Outer Continental Shelf Lands Act (OCSLA) to make OCS lands available for expeditious and orderly development, subject to environmental safeguards, in a manner that is consistent with the maintenance of competition and other national needs. Section 25 of OCSLA (43 U.S.C. § 1350) requires oil and gas lessees seeking to conduct development activities to first obtain approval from the Secretary who has delegated the authority to grant such approval to the BOEM.

In response to the proposed action in Shell's plan, BOEM is required by OCSLA to approve, approve with modifications, or deny the plan within 120 days. (*See* 43 U.S.C. § 1350(h)(1)). The criteria that

BOEM will apply in reaching a decision to approve, approve with modifications, or deny the plan within 120 days and the scope of its discretion are provided by Section 25 of OCSLA and detailed in the implementing regulations (30 C.F.R. Part 550, Subpart B). Authorizing the proposed action as outlined in the revised DOCD, R-5873, allows Shell to pursue its rights under the lease and to conduct development drilling activities.

1.3. DESCRIPTION OF THE PROPOSED ACTION

Shell's revised DOCD proposes to explore for hydrocarbons by drilling and completing six wells, Well Numbers PI-1ST, P8, P7ST, and GG in Mississippi Canyon Block 809, Lease Number OCS-G 05868 and Well Numbers DD and EE in Mississippi Canyon Block 810, Lease Number OCS-G 09873 in the CPA. The proposed activities are located south of Venice, Louisiana, approximately 53 miles (mi) (85 kilometers (km)) from the nearest Louisiana shoreline and approximately 60 mi (97 km) from the site of the Macondo Well in Mississippi Canyon Block 252. The water depth at the proposed well sites ranges from 3,650 to 3,940 feet (ft) (1,113 to 1,201 meters (m)). Shell proposes using a dynamically positioned (DP) drillship, a mobile offshore drilling unit (MODU); to drill and complete these wells therefore, there are no anchors associated with the proposed operations. The projected duration of the proposed drilling and completing of six wells is 720 days (120 days per well) with a proposed start date of September 1, 2013 and end date of April 30, 2018. Supply and crewboat facilities to support the proposed action are located in Port Fourchon, Louisiana, approximately 107 mi (172 km) northwest of the project location. Port Fourchon will be used as the debarkation point for equipment, supplies, and crews supporting the proposed action. Air operations (helicopters) to support the proposed action are located in Amelia, Louisiana, approximately 156 mi (251 km) northwest of the project location. Shell does not expect any shore-based construction or expansion in association with this proposed action. The types of support vessels and their potential travel frequency during development drilling are described in their plan (Shell, 2013).

1.4. IMPACT-PRODUCING FACTORS

An impact-producing factor (IPF) is any activity or process resulting from an approved operation that causes impacts to the environment, such as an emission, effluent, or physical disturbance. The IPFs from the routine development activities proposed by the operator in this plan include: (1) waste and discharges from vessel operations and development activities; (2) air emissions from equipment and vessels; (3) noise from vessel and helicopter transportation and development activities, and (4) bottom disturbances from well completion activities. The routine IPFs are expected to occur during the operations conducted under the proposed action and are addressed in each of the site-specific analyses in Chapter 3 under "Routine Activities."

The analyses in Chapter 3 also consider IPFs that might result from an accidental event. The primary IPFs from potential accidents related to OCS drilling activities include: (1) vessel collisions with marine mammals and sea turtles; (2) oil spills and blowouts; (3) bottom disturbances from lost/jettisoned debris; and (4) helicopter collisions with coastal and/or marine birds. Unlike the IPFs associated with routine activities, the IPFs from accidental events are not expected because of the low probabilities of such events from occurring, existing/recently implemented safety measures and condition(s) of, approval, and an increased level of operator awareness observed since the Macondo Event. The accidental IPFs are detailed and addressed in each of the site-specific analyses under "Accidental Events."

The Multisale EIS considered the routine and accidental IPFs described above; however, additional information related to the oil spill/blowout IPF has been collected since the Macondo Event that was not available during the preparation of the programmatic analyses. Appendix A, Accidental Oil-Spill Discussion, introduces the new data and describes the circumstances that might result if an accidental spill were to occur. Additionally, the analyses of the "Accidental Events" incorporate information from Appendix B of the Multisale EIS, "Catastrophic Spill Event Analysis," to address the potential impacts to the environment in the unlikely event that a catastrophic spill similar to the Macondo Event was to occur.

Accidental Spill Concerns

Since spills are unplanned, unforeseeable events, BOEM is required to rely on past experiences to predict many factors regarding oil-spill risks. Based on experience and the operations proposed in Shell's plan, the potential sources of hydrocarbon spills from the proposed activity would include the following:

- A storage tank accident on the MODU;
- A transfer operation mishap between the supply vessel and the MODU;
- A leak resulting from damage to the fuel tanks on one of the supply or crew boats; and/or
- A blowout of a proposed well.

Potential Spills from Vessels/Transfer Operations

As indicated above, offshore spills from Shell's proposed action are possible if an accident were to damage a storage tank onboard the drilling rig, the crewboats, offshore support vessels, or the fuel supply vessel. Historically, accidents of this nature have resulted from unintentional vessel collisions and transfer incidents during the offloading of diesel fuel to the drilling rig. Shell plans to use a DP drillship MODU equipped with a surface BOP attached to the well to conduct the proposed activities. There are several tanks onboard the MODU that store fuel and lubricants necessary for the rig's operation. A worst-case discharge scenario from a rupture and spill from the largest main tank of fuel oil on the proposed MODU would be 5,767 bbl with the total fuel oil capacity on the proposed MODU at 28,456 bbl. Additionally, the crew boat proposed to support the drilling operations has an estimated capacity of 8,000 gallons (190 bbl), the offshore support vessel has an estimated capacity of 120,000 gallons (2,857 bbl), and the fuel supply vessel has an estimated capacity of 100,000 gallons (2,380 bbl). The helicopter proposed to support activities has an estimated capacity of 764 gallons (18.2 bbl).

Potential Spills from a Loss of Well Control/Blowout

Losses of well control (also known as blowouts) can occur during exploratory drilling, developmental drilling, completion, production, or workover operations. Blowouts occur when improperly balanced well pressures result in the sudden, uncontrolled releases of fluids or gas from a wellbore or wellhead. Historically, since 1971, most OCS blowouts have resulted in the release of gas; blowouts resulting in the release of oil have been rare. As described in Chapter 1.1 above, the most recent blowout was related to the Macondo Event, which resulted in the release of both gas and oil. Though not proposed or expected, Shell has estimated that a worst-case discharge (WCD) scenario from a blowout of a well under this proposed action could be 201,000 BOPD of 28° American Petroleum Institute (API) gravity crude and 249 MMCF/day of natural gas. In accordance enhanced agency oversight, BOEM verified the operator's calculations used to determine the WCD volume.

In the unlikely event that a blowout was to occur, one of the primary processes that could stop the uncontrolled flow is a process called "bridging off." Bridging is a phenomenon that occurs when severe pressure differentials are imposed at the well/reservoir interface and the formation around the wellbore collapses and seals the well. Shell indicated within their plan that a mechanical failure/collapse of the borehole in a blowout scenario is influenced by several factors including in-situ stress, rock strength, and fluid velocities at the sand face. Given the substantial fluid velocities inherent in the WCD, and the scenario as defined where the formation is not supported by a cased and cemented wellbore, it is probable that the borehole will fail/collapse/bridge over within the span of a few days, significantly reducing the outflow rates. However, this WCD scenario does not include any bridging or consideration of solids production with the oil and gas (Shell, 2013).

Outside of bridging, the main tool for recovery and re-establishment of well control after a blowout event is a blowout preventer (BOP) attached to the well. Most BOP systems allow activation of selected components with the intent to sever the drill pipe and seal off the well bore. As per Shell's plan, the DP drillship that Shell plans to use to drill the wells is equipped with a surface BOP attached to the well (Shell, 2013). Other well control process/goals for blowout prevention and intervention and those processes/goals are listed in detail in their plan (Shell, 2013).

If the BOP fails, there are other options available to control the blowout that include capping/shut-in, capping/diverting, surface stinger, vertical intervention, offset kill, and relief wells. Of these methods, a relief well is often considered most important, and may be required immediately (even if it is not the first choice), since it is typically considered the ultimate solution for well control. The amount of time required to drill a relief well may depend upon the complexity of the intervention, the location of a suitable rig, the operations that may be required to release the rig, and any problems mobilizing personnel/equipment. For this project, Shell indicated that it has six drilling rig under contract to drill a relief well if needed. Shell estimates that it would take approximately 14 days to safely secure the well that the rig is working on up to the point the rig departs location, and an additional 4 days transit to mobilize to the relief well site depending on distance to the site. The relief well will take approximately 90 days to drill down to the last casing string above the blowout zone, plus approximately 28 days for precision ranging activity to intersect the blowout well bore with a total duration of 136 days. Additional details related to the proposed action can be found in Shell's plan (Shell, 2013) and general information on other intervention methodologies and recovery tools can be found in Appendix A.

Estimated Spill Occurrence Rates

Data from past OCS spills are used to estimate future potential OCS spills. The BOEM has estimated spill rates for spills from the following sources: facilities/platforms, pipelines, and drilling activities. Spill rates for facilities and pipelines have been developed for several time periods, and an analysis of trends for spills is presented in *Update of Occurrence Rates for Offshore Oil Spills* (Anderson et al., 2012). Spill rates for the most recent period analyzed, 1996-2010, are presented here. Data for this period should reflect more modern spill-prevention requirements than was required prior to 1996. When comparing the most recent 15-years data (1996-2010) to the last 15-years data in the previous analysis (1985-1996 data; Anderson and LaBelle, 2000), spill rates increased from 0.13 to 0.25 spills per Bbbl for spills ≥1,000 bbl and increased from 0.05 to 0.13 spills per Bbbl for spills ≥10,000 bbl (Anderson et al., 2012). These rates are still relatively low and include a spill from Hurricane Rita (2005) and the Macondo well spill in 2010.

An estimate of spill risk from Shell's proposed activities was calculated using the drilling spill rate for the entire OCS and the estimated number of wells to be drilled. The resulting value, 0.00042 or 0.042 percent, is used to address the risk of a spill >1,000 bbl occurring during the proposed action. When examining only wells in deep water (in water depths ≥200 m; 656 ft), data from 1996-2010 suggest the chance of a major spill from a deepwater well under current regulations and practices is 1 in about 2,939. Prior to the Macondo Event, two of the largest spills resulting from blowouts on the GOM OCS occurred in 1970, releasing 65,000 and 53,000 bbl of oil, respectively. Since 1970, there have been a total of 14 losses of well-control events that have resulted in >50 bbl of oil or condensate being spilled Additional details on estimating accidental spill occurrence rates can be found in Appendix A.

In addition to the extremely low probability noted above, there are several new factors that were not taken into consideration in the historical/statistical evaluation. The BOEM and the BSEE (formerly BOEMRE) recently promulgated new regulations, Notices to Lessees, and enhanced safety practices that will help improve the safety of OCS drilling operations addresses improvement with both well bore integrity and well control equipment and procedures. All of these post-Macondo regulatory changes are explained in the Multisale EIS (USDOI, BOEM, 2012, Section 1.3.1.1) and is incorporated by reference.

Ultimately, when one considers the historical data, the low estimated spill risk (0.042%), the recent response and containment improvements, BOEM and BSEE's enhanced oversight, and industry's heightened safety awareness since the Macondo Event, it is reasonable to conclude that an accidental spill event is not very likely to occur.

Spill Response Requirements

Agency regulations require that all owners and operators of oil handling, storage, or transportation facilities located seaward of the coastline submit an Oil-Spill Response Plan (OSRP) before they can use a facility. The BSEE has issued BSEE NTL 2012-N06 (Guidance to Owners and Operators of Offshore Facilities Seaward of the Coast Line Concerning Regional Oil Spill Response Plans), which informs operators of OSRP requirements and that they have adequate resources available to protect the environment from spills from their facilities. The Environmental Protection and Response Plan within the OSRP outlines the availability of spill containment and cleanup equipment and trained personnel necessary to ensure that a full-response can be deployed during an oil-spill emergency. All the proposed activities and facilities in this plan will be covered by the Regional Oil Spill Response Plan (OSRP) filed by Shell Offshore Inc. (0689) in accordance with 30 CFR 550 and 30 CFR 254. Shell's OSRP was approved by BSEE on April 11, 2013.

Catastrophic Spill Event Analysis

Appendix B of the Multisale EIS, "Catastrophic Spill Event Analysis," is a region-wide evaluation that identifies the most likely and most significant impacts from a high-volume blowout and oil spill that continues for an extended period of time. The scenario and impacts discussed in Appendix B are similar to that of a spill similar to the Macondo Event and are not associated with IPFs anticipated to result from routine activities or even more reasonably-feasible, accidental events that could occur during the proposed action.

The analysis utilizes two general analysis approaches. The first approach consists of a bounding analysis for each individual resource category (e.g., marine mammals, sea turtles, etc.), selecting a different set of factors and scenarios for each resource affected by a worst-case analysis. The second approach selects a single set of key circumstances that, in combination, result in catastrophic consequences. By combining the two approaches, relying on a generalized scenario while identifying site-specific severity factors for individual resources, this analysis allows for the scientific investigation of a range of possible, although not necessarily probable, consequences of a catastrophic blowout and oil spill in the GOM.

To analyze a hypothetical catastrophic event in an area such as the GOM, several assumptions and generalizations were made. Additionally, the life cycle of a catastrophic blowout and spill is divided into four geographic areas and/or time periods, some of which may overlap:

- Phase 1: Initial event (Section 2)
- Phase 2: Offshore spill (Section 3)
- Phase 3: Onshore contact (Section 4)
- Phase 4: Post-spill, long-term recovery (Section 5)

All four phases of a catastrophic oil spill is addressed and for each phase, the scenario is described, factors that could produce environmental impacts are listed, and the most likely and most significant impacts are discussed. The conclusions made in the Catastrophic Spill Event Analysis are addressed in the SEA's impact analyses (Chapters 3.2 to 3.8).

2. ALTERNATIVES CONSIDERED

2.1. NO ACTION ALTERNATIVE

Alternative 1 – If selected, the operator would not undertake the proposed activities. If the proposed activities are not undertaken, all environmental impacts, including additional routine, accidental, or cumulative impacts to the environmental and cultural resources described in the Multisale EIS and this SEA would not occur.

2.2. THE PROPOSED ACTION AS SUBMITTED

Alternative 2 – *Preferred Alternative* – If selected, the operator would undertake the proposed activities as requested in their plan. This alternative assumes that the operator will conduct their operations in accordance with their lease stipulations, the OCSLA and all applicable regulations (as per 30 C.F.R. § 550.101(a)), and guidance provided in all appropriate NTLs (as per 30 C.F.R. § 550.103). However, no additional, site-specific condition(s) of approval would be required by the BOEM.

2.3. SUMMARY AND COMPARISON OF THE ALTERNATIVES

If selected, Alternative 1, the no action alternative, would result in the operator not exercising its rights under the lease and conducting their proposed activities. Alternative 1 would not result in any impacts to the environmental resources analyzed in Chapter 3; however, the lessee would not develop the oil and gas resources of its lease for the benefit of the U.S. economy. Alternative 2 is the preferred alternative because it meets the objectives of the purpose and need and will allow the proposed action to be conducted safely and with the necessary conditions to limit or negate potential environmental impacts.

2.4. ALTERNATIVES CONSIDERED BUT NOT ANALYZED

Several other alternatives were considered and reviewed during the preparation of this SEA and coordination of the resource reviews. Ultimately, a viable alternative is required to be a logical option for carrying out the proposed action, ensure that the purpose and need can be met, and be feasible under the regulatory directives of the OCSLA and all other applicable guidance. The table below lists the alternatives that were considered but dismissed and not analyzed further along with the rationale for the decision:

Alternatives Considered but Not Analyzed

Dismissed Alternative	Alternative Detail	Reason Not Analyzed
Daytime Drilling Only	The alternative would restrict all drilling operations to the hours between legal sunrise and sunset to take advantage of the increased lighting in an effort to improve safety.	This alternative does not consider that adequate lighting is available on vessels and MODUs, existing safety protocol, and that the premature stopping of some drilling/well operations prior to critical junctures could lead to highly-problematic and unsafe situations.
Drilling from an Anchored MODU Only	The alternative would only allow the proposed activities from an anchored semisubmersible to reduce air quality impacts from the increased emissions released from dynamically-positioned (DP) MODUs.	This alternative does not consider the limited availability of conventionally-moored MODUs in the GOM or the negligible air quality concerns for temporary operations taking place a great distance from shore.
Incorporation of "Seasonal" Drilling Windows	The alternative would be based upon observed 'seasonal" migrations or behavioral patterns exhibited by marine protected species (MPS) and would restrict the proposed drilling operations for several weeks/months each year.	This alternative would have to rely upon incomplete seasonal data as most migratory MPS are not found in the Western GOM and it would not be able to account for year-round equipment and personnel contracting.

3. DESCRIPTION OF THE AFFECTED ENVIRONMENT AND ENVIRONMENTAL IMPACTS

3.1. INTRODUCTION

The discussion below will: (1) briefly describe/summarize the pertinent affected resources; (2) discuss whether proposed activities and their IPFs would have significant impacts to the human environment of the GOM; and (3) identify significant impacts, if any, that would require further NEPA analysis in an EIS. The description of the affected environment and impact analysis are presented together in this section for each resource. For the impact analysis, resource-specific significance criteria were developed for each category of the affected environment. The criteria reflect consideration of both the context and intensity of the impact at issue (see 40 C.F.R. § 1508.27). For the sake of this document, the criteria for impacts to environmental resources are classified into one of the three following levels:

- Significant Impact (including those that could be mitigated to non-significance);
- Adverse but Not Significant Impact; or
- Negligible Impact.

Preliminary screening for this assessment was based on a review of this relevant literature; previous SEAs, the Multisale EIS, and statistics/data pertinent to historic and projected activities. The BOEM initially considered the following resources for impact analysis:

- marine mammals (including Endangered Species Act (ESA) listed species and strategic stocks);
- sea turtles (all are ESA listed species);
- fishes (including listed species and ichthyoplankton);
- commercial and recreational fisheries;
- coastal and marine birds (including ESA listed species);
- benthic communities (including deepwater benthic communities, live bottoms, and topographic features);
- archaeological resources;
- military uses;
- recreational and commercial diving;
- socioeconomic conditions (including employment, marine transportation, and infrastructure);
- geology/sediments; and
- air and water quality.

The impact analyses focus on a broad group of oil and gas activities and resources with the potential for non-negligible impacts. Routine, accidental, and cumulative impacts from development activities similar to those proposed by Shell are analyzed in the Multisale EIS that considered the proposed activities as well as impacts to resources relevant to the proposal. The level of impacts associated with each interaction was analyzed and described in the EIS and is incorporated by reference.

The EIS provides a comprehensive characterization of biological and socioeconomic resources that may be adversely affected by oil and gas exploration and development activities. For this SEA, the BOEM evaluated the potential impacts resulting from the operator's proposed activities that were not considered in the EIS. For the reasons set forth on page 1, this section concentrates on the potential impacts of the proposed action on the following affected resources:

- air quality;
- offshore water quality;
- deepwater benthic biologically sensitive resources;
- marine mammals (including Threatened/Endangered and Nonendangered Species);
- sea turtles (all are ESA listed species);
- fisheries and essential fish habitat (EFH); and
- archaeological resources.

Other environmental and socioeconomic conditions, identified in the initial list of resources considered for impact analysis above, such as military uses, were considered and the potential impacts that could occur from activities, such as the proposed activities, were fully addressed in the Multisale EIS and deemed negligible (40 C.F.R. § 1508.27) and are not discussed in this SEA. Space-use conflicts with any recreational or commercial fishing vessels, as well as recreational and/or commercial diving operations, are minimal, if any, because of the proposed activities, the water depth (>3,650 ft (>1,113 m)), and the distance to shore (53 mi (85 km)). Coastal and marine birds were not further analyzed due to the distance from shore and the temporary nature of the proposed activities. Topographic and pinnacle features were not further analyzed due to the distance from the proposed activities to the nearest topographic and/or pinnacle features (>35 and 80 mi (>56 and 129 km) respectively). No socioeconomic effects were further analyzed due to the type, the temporary nature, and employment size, of the proposed activity. There is no expansion or modification of support bases proposed as a result of this activity. Additionally, support vessel operations are comparable to that described and analyzed in the Multisale EIS for similar activities. The potential impacts of a low-probability, Catastrophic Oil-Spill event, such as the Macondo Event (see below) to the environmental resources and socioeconomic conditions listed above are fully addressed in the Catastrophic Spill Event Analysis (Appendix B of the Multisale EIS) and a respective resource summary of that analysis is provided in each impact review below.

Macondo Well Blowout, Spill, and Remediation

Chapter 1.1 of this SEA provides a summary of the basic facts of the spill. With respect to spill remediation the following information was made available by the *Deepwater Horizon* Unified Command (DHUC) (2010):

- More than 6,050 response vessels and approximately 47,849 personnel responded to protect the shoreline and wildlife and to cleanup vital coastlines;
- At the surface, approximately 34.7 million gallons (827,251 bbl) of oily water were recovered and an estimated 11.14 million gallons (265,450 bbl) of oil burned;
- Approximately 1.84 million gallons (43,809 bbl) of dispersant were applied (1.07 million gallons [25,476 bbl] on the surface and 771,000 gallons [18,357 bbl] subsea);
- More than 3.33 million feet (1,003 km) of containment boom and 9.7 million feet (2,469 km) of sorbent boom were deployed;
- Approximately 641 mi (1,032 km) of Gulf Coast shoreline was oiled, including approximately 368 mi (592 km) in Louisiana, 112 mi (180 km) in Mississippi, 73 mi (117 km) in Alabama, and 88 mi (142 km) in Florida.

According to the National Marine Fisheries Service (NMFS), approximately 80,228 square miles (mi^2) (207,790 square kilometers [km^2]) of Federal waters were closed to commercial and recreational fishing, approximately 33 percent of the GOM Federal waters (USDOC, NMFS, 2010).

Macondo Impacts Incorporated into SEA Analyses

The BOEM, in conjunction with the well operator and other Federal and State agencies, continues to monitor and evaluate both the short-term and long-term impacts of the accidental spill. There is ongoing research to assess the impacts to resources from the Macondo well blowout, spill, and remediation efforts. For many resources, the data are still being collected and analyzed through the National Resource Damage Assessment (NRDA) process. The BOEM continues to seek data and research results from the NRDA process and the scientific community. Results of this research are forthcoming, and BOEM subject matter experts (SMEs) are continuing to update their analyses as this information becomes available.

Chapter 3 of this document describes the environmental and archaeological resources and the potential routine, accidental, and cumulative impacts of the proposed action on the resources that could be affected by the proposed activities. These descriptions present environmental resources as they are now, thus providing new baseline information that is informed by the Macondo Event for analyses of potential impacts from the proposed activities.

3.2. AIR QUALITY

3.2.1. Affected Environment

The complete description of the air quality in the GOM region is set forth in in Chapters 4.1.1.1 and 4.2.1.1 of the Multisale EIS, and is incorporated by reference. The following information is a summary of the description incorporated from the Multisale EIS. Mississippi Canyon Blocks 809 and 810 are located west of 87.5° W. longitude and hence, falls under BOEM's jurisdiction for enforcement of the Clean Air Act (CAA). The air over the OCS water is not classified, but it is presumed to be better than the National Ambient Air Quality Standards (NAAQS) for all criteria pollutants (USDOI, MMS, 1997). Shell's proposed activities in Mississippi Canyon Blocks 809 and 810 are located approximately 53 mi (85 km) from the nearest coastline, south of Plaquemines Parish, Louisiana, an area that is in attainment of the NAAQS for carbon monoxide, nitrogen oxides, sulphur oxides, ozone, and particulate matter and that, for Prevention of Significant Deterioration (PSD) purposes, is classified as a Class II Area.

Influences to onshore air quality are dependent upon meteorological conditions and air pollution emitted from operational activities. The pertinent meteorological conditions regarding air quality are the wind speed and direction, the atmospheric stability, and the mixing height (which govern the dispersion and transport of emissions). The typical, large-scale wind flow for the northern GOM is driven by the clockwise circulation around the Bermuda High, resulting in a prevailing southeasterly to southerly wind flow, which is conducive to transporting air pollution emissions toward shore. However, superimposed upon this large-scale circulation are smaller scale wind-flow patterns, such as the land/sea breeze phenomenon. In addition, there are other large-scale weather features that occur periodically, namely tropical cyclones, and mid-latitude frontal systems. Because of the routine occurrence of these various conditions, the winds blow from all directions in the area of concern (Florida A&M University, 1988).

3.2.2. Impact Analysis

A detailed impact analysis of the routine, accidental, and cumulative impacts of the proposed activities on air quality can be found in Chapters 4.1.1.1.2 and 4.2.1.1.2 (routine), 4.1.1.1.3 and 4.2.1.1.3 (accidental) and 4.1.1.1.4 and 4.2.1.1.4 (cumulative) of the Multisale EIS and is incorporated by reference. The following information is a summary of the impact analyses.

3.2.2.1. Alternative 1

If selected, Alternative 1, the no action alternative, would result in the operator not undertaking the proposed activities as described in the plan. Therefore, the IPFs to air quality would not occur. For example, there would be no VOC emissions that would result in potential localized degradation of air quality.

3.2.2.2. Alternative 2

If selected, Alternative 2, the proposed action, would result in the operator undertaking the proposed activities, as requested and conditioned in the plan. As described in the analyses below, impacts to air quality from the proposed action are expected to be short-term, localized, and not lead to significant impacts.

Routine Activities

Air quality would be affected in the immediate vicinity of the proposed operations, service vessels, and aircraft. The impact from emissions for the proposed activities described in this revised DOCD will not exceed BOEM's exemption levels per 30 C.F.R. § 550.303(d), which would exempt the operator from additional air quality modeling. The proposed activities are not expected to significantly affect onshore air quality, due to the distance from shore and the distance from the area of the proposed action to any PSD Class I air quality area, such as the Breton National Wildlife Refuge.

Accidental Events

Should a spill of oil occur, the volatile organic compounds (VOCs), which would escape to the atmosphere from a surface slick, are precursors to photochemically produced ozone. A spike in VOCs could contribute to a corresponding spike in ozone, especially if the release were to occur on a hot sunny day in a NO_2-rich environment. The corresponding onshore area is in attainment for ozone. Due to the distance from shore, the proposed activities are not expected to have any impacts to onshore air quality, including nonattainment areas. If a fire occurs, prior to containment, particulate and combustible emissions will be released in addition to the VOCs. Emissions of pollutants into the atmosphere from routine activities associated with the proposed activities are projected to have minimal impacts to onshore air quality because of the prevailing atmospheric conditions, emission heights, emission rates, and the distance of these emissions from onshore.

Despite the Macondo Event, historical trends in the GOM (see Chapter 1.4) indicate that catastrophic spill events are not likely to occur as a result of drilling and completion activities associated with the proposed action. In the event of a catastrophic spill similar to the Macondo Event, the Catastrophic Spill Analysis in Appendix B of the Multisale EIS discusses the most likely and most significant impacts to air quality as it relates to the four phases of a major spill/blowout:

1) **Initial Event** (Section 2.2.1.1.; Page B-4);
2) **Offshore Spill** (Section 3.2.1.1; Page B-15);
3) **Onshore Contact** (Section 4.2.1.1; Page B-30); and
4) **Post-Spill, Long-Term Recovery** (Section 5.2.1.1.; Page B-40).

As the Catastrophic Spill Analysis concludes, the potential impacts from a catastrophic spill could include air quality impacts that would require extensive recovery times.

Conclusion

The air quality in the immediate vicinity of the proposed activities would be affected by the short-term projected emissions, but the 53 mi (85 km) distance between the area of the proposed action and the shoreline results in substantial dilution factors for point-source emissions from the proposed action so that onshore air quality impacts would be well below levels considered to be significant. Therefore, because of the short duration of the proposed activities and the distance from shore, no substantial long-term impacts on air quality would be expected from the proposed activities. The potential impacts from a catastrophic spill as described and analyzed in Appendix B of the Multisale EIS could include air quality impacts that would require extensive recovery times.

Cumulative Impacts

Cumulative impacts on air quality within the offshore area would come primarily from non-OCS oil/gas activities in the Gulf as well as sources on land such as generated outside the OCS and include emissions from industrial plants, power generation, and urban transportation. The location of the proposed action is far removed from coastal populations or industrial activity. The proposed activities are located approximately 53 mi (85 km) from shore, and would not affect the overall quality of air over the Louisiana coast because of the temporary nature of the proposed activity and the distance to shore. Most of the Gulf's coastal areas, except for Southeast Texas, are currently designated as "attainment" for all the NAAQS regulated pollutants (USEPA, 2003).

No substantive cumulative impacts on air quality are expected as a result of the proposed activities when added to the impacts of past, present, or reasonably foreseeable oil and gas development in the area, as well as other activities in the area.

3.3. OFFSHORE WATER QUALITY

3.3.1. Affected Environment

The description of water quality in offshore waters of the GOM is set forth in Chapters 4.1.1.2 and 4.2.1.2 of the Multisale EIS and is incorporated by reference. The following information is a summary of the description incorporated from the EIS with additional updates added if available.

The water offshore of the Gulf's coasts can be divided into two regions: the continental shelf and slope (<1,000 ft; 305 m) and deep water (>1,000 ft; 305 m). Waters on the continental shelf and slope are heavily influenced by the Mississippi and Atchafalaya Rivers, the primary sources of freshwater, sediment, nutrients, and pollutants from a huge drainage basin encompassing 55 percent of the continental U.S. (Murray, 1998). Lower salinities are characteristic nearshore where freshwater from the rivers mix with Gulf waters. The presence or extent of a nepheloid layer at the sea bottom affects water quality on the shelf and slope. Deep waters east of the Mississippi River are affected by the Loop Current and associated warm-core (anti-cyclonic) eddies that consist of clear, low-nutrient water (Muller-Karger et al., 2001). However, cold-core cyclonic eddies (counter-clockwise rotating) also form at the edge of the Loop Current and are associated with upwelling and nutrient-rich, high-productivity waters.

Dissolved oxygen enters the upper waters (~100-200 m; 328-656 ft) of the GOM through the atmosphere and photosynthesis (Jochens et al., 2005). In deep waters, dissolved oxygen is introduced through the transport and mixing of oxygen-rich watermasses into the GOM from the Caribbean Sea through the Yucatan Channel (Jochens et al., 2005). The GOM does not have watermass formation to replenish the deep oxygen concentrations (Jochens et al., 2005). Thus, the deep circulation of the GOM and its related mixing are the mechanisms that replenish the deep oxygen (Jochens et al., 2005). Oxidation of organic matter is the major oxygen sink in the GOM (Jochens et al., 2005). The GOM has an oxygen minimum zone, which is generally located from 300 to 700 m (984 to 2,297 ft) (Jochens et al., 2005).

Though the largest zone of hypoxia in the United States is the zone on the Louisiana-Texas shelf, separate zones of hypoxia have been discovered in other shelf regions such as a recent dead zone that stretched from the Chandeleur Sound off Louisiana's coast to Alabama's Dauphin Island and possibly beyond (McConnaughey, 2012).

Compared with the Eastern and Western Gulf, the Central Gulf generally has higher levels of total organic carbon and hydrocarbons in sediment, particularly those from terrestrial sources (Gallaway and Kennicutt, 1988). Hydrocarbons in sediments have been determined to influence biological communities of the Gulf slope, even when present in trace amounts (Gallaway and Kennicutt, 1988).

Natural hydrocarbon seepage is considered to be the predominant source of petroleum in Gulf waters (NRC, 2003). The National Research Council (NRC) estimated an annual input of oil from seeps to be approximately 980,000 bbl/yr for the entire Gulf (NRC, 2003). In addition to hydrocarbon seeps, other fluids leak from the underlying sediments into the bottom water along the slope. These fluids have been identified to have three origins: (1) seawater trapped during the settling of sediments; (2) brine from dissolution of underlying salt diapirs; and (3) deep-seated formation waters (Fu and Aharon, 1998; Aharon et al., 2001).

Produced water (formation water) is the largest waste stream by volume from the oil and gas industry that enters Gulf waters. Produced water is commonly treated to separate free oil and is either injected back into the reservoir or discharged overboard according to NPDES permit limits. The NRC has estimated the quantity of oil in produced water entering the Gulf per year to be 473,000 bbl (NRC, 2003).

Deepwater sediments, with the exception of barium concentrations in the vicinity of previous drilling, do not appear to contain elevated levels of metal contaminants (USDOI, MMS, 1997 and 2000). Reported total hydrocarbons, including biogenic (e.g., from biological sources) hydrocarbons, in sediments collected from the Gulf slope range from 5 to 86 nanograms/gram (Kennicutt et al., 1987).

Mississippi Canyon Blocks 809 and 810 are entirely in deep water, for which more limited information is available on water quality as compared to coastal or inland waters. However, several studies have addressed offshore water and sediment quality in deep waters. Water at depths >1,400 m (4,593 ft) is relatively homogeneous with respect to temperature, salinity, and oxygen (Nowlin, 1972; Pequegnat, 1983; Gallaway et al., 1988; Jochens et al., 2005). Limited analyses of trace metals and hydrocarbons for the water column and sediments exist (Trefry, 1981; Gallaway et al., 1988). Continental Shelf Associates, Inc. (CSA) completed an Agency-funded field study of four drilling sites located in water depths of 1,033-1,125 m (3,389-3,691 ft) (CSA, 2006). Chemical impacts of drilling were detected at all four sites. Impacts noted within the near-field zone included elevated barium, SBF, total organic carbon (TOC) concentrations, and low sediment oxygen levels. At one relatively pristine location, mean concentrations of sediment barium increased by ~30-fold at near-field stations following drilling operations (from 0.108% to 3.32%). As well, mean concentrations of sediment mercury and total polycyclic aromatic hydrocarbons (PAHs) increased in the near-field from 71 to 90 nanograms/gram and 232 to 279 nanograms/gram, respectively. At this site, sediment cadmium concentrations did not change significantly following drilling operations.

The condition of offshore waters in the central GOM was altered by the *Deepwater Horizon* (DWH) drilling rig blowout event and associated oil spill. The Government estimated that approximately 4.9 million barrels of oil were released during the event (Oil Spill Commission, 2011a), and 1.84 million gallons of dispersant were used subsea at the wellhead and on the surface (Oil Spill Commission, 2011b). As well, the corresponding emission of methane from the wellhead during the event was estimated between 9.14×10^9 and 1.25×10^{10} moles (Kessler et al., 2011). Independent analysis of chemical measurements derived an average environmental release rate for hydrocarbons of $(10.1 \pm 2.0) \times 10^6$ kg/d which confirmed the official average leak rate of $(10.2 \pm 1.0) \times 10^6$ kg/d (Ryerson et al., 2012). Studies indicate that the oil contained approximately 3.9 percent PAHs by weight which results in an estimated release of 2.1×10^{10} g of PAHs (Reddy et al., 2011; Reddy, Official Communication, 2012).

In shelf waters, surface water oiling stretched from a maximum westward extent at roughly the Louisiana-Texas border to an eastward extent around Apalachicola, Florida (Oil Spill Commission, 2011a, Figure 7.1). Surface oiling was also observed stretching southward from the spill site, farther over deep waters, as oil was advected by cyclones at the northern edge of the Loop Current (e.g., Oil Spill Commission, 2011a). To date, oil from the DWH event has not been identified as having entered the Loop Current. A subsurface oil and gas plume was discovered in deep waters between ~1,100 and 1,300 m (3,609 and 4,265 ft) (e.g., Diercks et al., 2010). Based on in-situ fluorescence and oxygen measurements (likely indicators of oil concentration and biodegradation, respectively), the subsurface plume traveled to the northeast of the wellhead and much farther to the southwest, reaching as far west as approximately -93.0° (e.g., Kessler et al., 2011; see supporting online material).

Offshore water quality would not only be impacted by the oil, gas, and their respective components but also to some degree from cleanup and mitigation efforts. Increased vessel traffic, hydromodification, and the addition of dispersants, methanol, and water-based drilling mud to the marine environment in an effort to contain, mitigate, or clean up the oil may also tax the environment to some degree. Fortunately, over time, natural processes can physically, chemically, and biologically degrade oil (NRC, 2003). The physical processes involved include evaporation, emulsification and dissolution; the primary chemical and biological degradation processes include photooxidation and biodegradation (i.e., microbial oxidation). The oil from the DWH event as well as remediation and degradation processes are discussed in greater detail in the multi-sale EIS.

The DWH response conducted extensive water and sediment sampling (OSAT, 2010) which is discussed in greater detail in multi-sale EIS for the CPA. After August 3, 2010, no shelf water samples or shelf sediment samples exceeded the benchmark. Approximately 4,000 water and sediment samples from the deepwater zone were analyzed in the OSAT report. In the deepwater zone, there was a total of 70 exceedances of aquatic life benchmarks for PAH's in water and 7 exceedances in sediment. Chronic exceedances in water samples in deepwater potentially associated with Mississippi Canyon Block 252 oil were constrained to within approximately 70 km (43 mi) of the wellhead and to approximately two depths (the near-surface and the subsurface between ~1,100 and 1,300 m [~3,609 and 4,265 ft]). Quantitative results indicate that deposits of drilling mud-entrained oil remained near the wellhead. Seven sediment samples within 3 km (2 mi) of the wellhead collected since August 3, 2010, exceeded aquatic life benchmarks for PAH's, with oil concentrations of 2,000-5,000 ppm.

The amounts of dispersant sprayed at the surface and injected at the wellhead were 1,072,514 gallons and 771,272 gallons, respectively (USDHS, USCG, 2010). The fate of this dispersant remains under study. As part of the DWH response, the OSAT (2010) report analyzed results from water and sediment samples analyzed for dispersant-related chemicals and those results are discussed in more detail in the multi-sale EIS for the CPA. The dispersant-related chemical measured predominantly in the deepwater zone was DPnB (dipropylene glycol n-butyl ether), with a benchmark for DPnB in water of 1,000 μg/L (1 ppm). Of the 4,114 total water samples that were analyzed for dispersants in deepwater, 353 samples contained measurable amounts of DPnB. The range in detected DPnB concentrations was 0.0170-113.4 μg/L (mean 4.3 μg/L), with all samples significantly below the chronic screening level. Peaks in DPnB detects were observed in two distinct layers, at the surface and in the subsurface (1,100-1,300 m; 3,609-4,265 ft) similar to distributions of exceedances of the aquatic life benchmark for PAH's. Of 440 shelf water samples analyzed only half of the samples had any detection of dispersant related chemicals and there were no exceedances of dispersant-related benchmarks for individual compounds.

Dissolved oxygen levels are a concern with any release of a carbon source, such as oil and natural gas, and became a particular concern during the DWH event since dispersants were used in deep waters for the first time. In areas where plumes of dispersed oil were previously found, dissolved oxygen levels decreased by about 20 percent from long-term average values in the GOM; however, scientists reported that these levels stabilized and were not low enough to be considered hypoxic (USDOC, NOAA, 2010). The drop in oxygen, which did not continue over time, has been attributed to microbial degradation of hydrocarbons (Camilli et al., 2010; Hazen et al., 2010; Valentine et al., 2010).

It is currently impossible to estimate precisely the long-term impacts that the spill from the DWH event will have on offshore water quality. The DWH event and resulting spill occurred in offshore waters and was of considerable magnitude. Various monitoring efforts and environmental studies are underway. Although response efforts decreased the fraction of oil remaining in Gulf waters and reduced the amount of oil contacting the coastline, oil still remains in the offshore environment, albeit at levels that were considered not actionable by USCG (OSAT, 2010). As such, there is incomplete or unavailable information that may be relevant to reasonably foreseeable impacts on offshore water quality. This information includes data and analyses that may be forthcoming after the DWH event and is continuing to be collected and developed through the NRDA process. These data collection and research projects may be years from completion. Few data or conclusions have been released to the public to date. Regardless of the costs involved, it is not within BOEM's ability to obtain this information from the NRDA process within the timeline of this EIS. In light of this incomplete and unavailable information, BOEM subject-matter experts have used credible scientific information that is available and applied it using scientifically accepted methodology. Given the data samples that are available regarding water quality and sediments after the DWH event, as described above, BOEM believes that this incomplete or unavailable information is not essential to a reasoned choice among alternatives.

3.3.2. Impact Analysis

A detailed impact analysis of the routine, accidental, and cumulative impacts of the proposed activities on offshore water quality can be found in Chapters 4.1.1.2.2.2 and 4.2.1.2.2.2 (routine), 4.1.1.2.2.3 and 4.2.1.2.2.3 (accidental), and 4.1.1.2.2.4 and 4.2.1.2.2.4 (cumulative) of the Multisale EIS, and is incorporated by reference. The IPFs associated with the proposed activities in Mississippi Canyon Blocks 809 and 810 are that could affect marine water quality include: (1) turbidity from bottom disturbances from well/rig siting activities; (2) discharges during the drilling of the well(s); and (3) accidental spills of crude oil, diesel fuel, chemicals, or other materials from vessels/blowouts in marine waters. As explained below, due to the type and the temporary nature of the proposed activities, no substantive impacts would be expected.

3.3.2.1. Alternative 1

If selected, Alternative 1, the no action alternative, would result in the operator not undertaking the proposed activities as described in the plan. Therefore, the IPFs to offshore water quality would not occur. There would be no turbidity issues related to well siting activities that would result in potential localized degradation of water quality, no discharges during the drilling of the wells and no accidental spills of crude oil, diesel fuel, chemicals, or other materials from vessels/blowouts in marine waters.

3.3.2.2. Alternative 2

If selected, Alternative 2, the proposed action, would result in the operator undertaking the proposed activities as requested and conditioned in the plan. As described in the analyses below, impacts to water quality from the proposed action, as submitted by the operator, are expected to be short-term, localized and not lead to significant impacts.

Routine Operations

The water depth at the proposed well sites range from 3,650 to 3,940 ft (1,113 to 1,201 m). These deep marine waters and environments would not be directly affected by the proposed activities. Minor localized sediment disturbance and increased turbidity near the sea bottom would occur near the actual well sites. These disturbances would not adversely affect offshore water quality because the area of potential disturbance is relatively small and the effects would be temporary. Elevated turbidity would be a short-term, localized, and reversible condition once the disturbance ceases.

The USEPA regulates discharges associated with offshore oil and gas exploration, development, and production activities on the outer continental shelf (OCS) under the Clean Water Act's (CWA) National Pollutant Discharge Elimination System (NPDES) program. Regulated wastes include drilling fluids, drill cuttings, deck drainage, produced water, produced sand, well treatment fluids, well completion fluids, well workover fluids, sanitary wastes, domestic wastes, and miscellaneous wastes (USEPA, 2009a). The USEPA's NPDES general permit for the Western GOM, Region 6, (GMG290000, which authorizes discharges to surface water during drilling and production) was reissued and went into effect on October 1, 2012 (USEPA, 2012). The USEPA Region 4's NPDES general permit (GEG460000) for offshore oil and gas activities in Federal waters in the eastern portion of the OCS of the GOM (off of the coast of Mississippi and eastward) similarly covers the same wastes and was issued on March 15, 2010 (USEPA, 2010). Overboard discharges and wastes intended from the project are shown in the wastes and discharge tables provided in the plan and the types and rates would be in accordance with NPDES General Permit (Shell, 2013). The wastes destined for onshore disposal or recycling pose no potential significant impacts to affected resources unless spilled. Sanitary and domestic waste would be produced on the MODU as well as the support vessels; however, these discharges would be treated to meet USEPA discharge requirements. Water would be impacted by the introduction of suspended solids and biochemical oxygen demand (BOD) matter.

Accidental Events

The BOEM has determined, based on historical trends in the GOM (see Chapter 1.4 and Appendix A) that blowouts are not likely to occur as a result of drilling and completion activities associated with the proposed action. In 2012, BOEM looked at the occurrences of blowouts during a 15 year period. From 1996-2010, 46 blowouts occurred during drilling operations (both exploration and development) at a rate of one blowout for every 300 wells drilled. As in Izon et al. (2007), blowouts that occurred during workover, production, or completion operations and blowouts that occurred during sulfur well drilling are not included. Spills that occur from the proposed drilling activity would be few (if any) and small in size (<1,000 bbl) (see Chapter 1.4, Appendix A, and Anderson et al., 2012). Spilled oil originating from the project is not expected to be ≥1,000 bbl and if such a spill occurred, it is expected to be substantially recovered and/or weathered while still at sea.

A surface slick from a blowout begins to weather as soon as it forms, depending on a number of factors, particularly the characteristics of the released oil and oceanographic conditions. Some of the subsurface oil may disperse within the water column. A variety of physical, chemical, and biological processes act to disperse and degrade the slick once oil enters the ocean. These include spreading, evaporation of the more volatile constituents, dissolution into the water column, emulsification of small droplets, agglomeration sinking, microbial modification, photochemical modification, and biological ingestion and excretion. Some oil from the slick would be mixed into the water and dispersed by wind and waves. The quality of marine waters on the surface or in a rising subsurface plume from a blowout would be temporarily affected by the solubility of hydrocarbon components and by small, dispersed oil droplets that do not rise to the surface due to current activity or that are mixed downward by surface turbulence. Dispersion by currents and microbial degradation remove the oil from the water column and eventually dilute the constituents to background levels.

In the event of a catastrophic spill similar to the Macondo Event, the Catastrophic Spill Analysis in Appendix B of the Multisale EIS discusses the most likely and most significant impacts to offshore water quality as it relates to three of the four phases of a major spill/blowout:

1) **Initial Event** (Section 2.2.1.2.; Page B-5);
2) **Offshore Spill** (Section 3.2.1.2; Page B-16);
3) **Onshore Contact** (offshore water quality not included in this discussion); and
4) **Post-Spill, Long-Term Recovery** (Section 5.2.1.2.; Page B-40).

The potential impacts from a catastrophic spill could result in both temporary and long term offshore water quality degradation that would require extensive recovery times. However, despite the Macondo Event, historical trends in the GOM (see Chapter 1.4 and Appendix A) indicate that catastrophic spill events are not likely to occur as a result of drilling and completion activities associated with the proposed action.

Conclusion

No significant long-term impacts on offshore water quality would be expected from the proposed action because of the type of and temporary nature of the proposed activity. Near-bottom water quality would be affected by increased turbidity and disturbed substrates during the period of well siting activities. Any effects from the elevated turbidity would be short term, localized, and reversible.

Impacts on offshore water quality from the operational discharges that would be expected to result from the proposed action are negligible because of; 1) existing USEPA regulations cited above, 2) water depth, 3) distance of the project from the coast, 4) weathering, and 5) dilution factors. Spilled oil originating from the project is not expected to be ≥1,000 bbl and if such a spill occurred, it is expected to be substantially recovered/weathered while still at sea (see Chapter 1.4 and Appendix A). Operator-initiated activities to contain and clean up an oil spill would begin as soon as possible after an event. Small quantities of unrecovered oil would weather and largely biodegrade within two weeks.

Cumulative Impacts

Exploration, development, and production activities contribute to cumulative water quality degradation in offshore waters. Spills of oil, diesel fuel, and other materials may occur from vessels transporting crude oil and petroleum products; from vessels involved in commercial fishing, freight or passenger transport; and from OCS operations. Well blowouts can disturb the bottom, increase turbidity, and put oil into the sea. Should a blowout occur, involving an oil spill ≥1,000 bbl, localized, short-term changes in water quality would be expected and cumulative impacts would be negligible. Activities that would contribute to cumulative impacts, for example bottom area disturbances resulting from other, like dredging, are not expected due to water depths in the area of the proposed action.

Therefore, no significant cumulative impacts on offshore water quality would be expected as a result of the proposed activities when added to the impacts of past, present, or reasonably foreseeable oil and gas development; as well as other activities in the area.

3.4. DEEPWATER BENTHIC COMMUNITIES

3.4.1. Chemosynthetic and Nonchemosynthetic Deepwater Benthic Communities

Chemosynthetic and nonchemosynthetic deepwater benthic communities are found in water depths of 984 ft (300 m) and greater (BOEM, USDOI, 2012).

3.4.1.1. Affected Environment

A description of chemosynthetic deepwater benthic communities in the Gulf of Mexico region can be found Chapter 4.1.1.8.1 and 4.2.1.9.1 of the Multisale EIS, and a description of the nonchemosynthetic deepwater benthic communities can be found in Chapters 4.1.1.9.1 and 4.2.1.10.1 of the same document. The following information is a summary of the descriptions in the EIS, and it is incorporated by reference into this SEA.

The continental slope in the GOM extends from the edge of the continental shelf at a depth of about 656 ft (200 m) to a water depth of approximately 9,840 ft (3,000 m) (USDOI, BOEM, 2012). The vast majority of the GOM has a soft, muddy bottom in which burrowing infauna are the most abundant invertebrates. Mississippi Canyon Blocks 809 and 810 fall into this category. The water depth at the proposed well sites range from 3,650 to 3,940 ft (1,113 to 1,201 m).

A remarkable assemblage of invertebrates are found in association with hydrocarbon seeps in the GOM. Chemosynthetic communities occur at or near hydrocarbon seeps and are defined as persistent, largely sessile assemblages of marine organisms dependent upon symbiotic chemosynthetic bacteria as their primary food source (MacDonald, 1992). Invertebrate taxa in these communities include tube worms and bivalves, among others. These bacteria live within specialized cells in these invertebrate organisms and are supplied with oxygen and chemosynthetic compounds by the host via specialized blood chemistry (Fisher, 1990). Chemosynthetic bacteria, which live both on bacterial mats and in symbiosis with chemosynthetic invertebrates, use a carbon source independent of photosynthesis and the sun-dependent photosynthetic food chain that supports most all other life on the planet. The chemosynthetic invertebrate host of symbiotic bacteria, in turn, lives off the organic products subsequently released by the bacteria and may even feed on the bacteria themselves. Chemosynthetic communities begin with chemosynthetic bacterial mats that consume methanes and sulfides; their respiration results in the precipitation of calcium carbonate, forming a hard substrate. Chemosynthetic invertebrates can then become established on the carbonate substrate. These invertebrates form additional structure upon the seafloor, increasing the complexity of the habitat and supporting a variety of nonchemosynthetic invertebrates and fishes.

Nonchemosynthetic communities may also occur at or near hydrocarbon seeps and are defined by a dominance of ahermatypic coral and can be associated with chemosynthetic communities. Chemosynthetic bacterial mats at hydrocarbon and sulfide seep sites produce chemical reactions that result in the precipitation of hard carbonate substrate, as discussed above. Such hard substrate underlies deep coral habitats in the deep Gulf of Mexico. The deepwater coral communities can form and thrive on the hard substrate of chemosynthetic invertebrate habitat on the periphery away from the immediate effects of the seep and even replace chemosynthetic communities after the hydrocarbon seep subsides. These unique coral communities are distinctive and provide three-dimensional habitat similar to reefs for a range of fish and invertebrates. Hard-bottom habitats in deep water include nonchemosynthetic invertebrate communities dominated by the thicket-forming hard coral, *Lophelia pertusa*, with other corals such as the bamboo coral (*Keratoisis flexibilis*) and hidden white coral (*Madrepora oculata*).

Numerous other invertebrates are also associated with these benthic habitats (Sulak et al., 2008; Cordes et al., 2008; Fisher et al., 2007; Schroeder et al., 2005). The coral community forms additional structure upon the seafloor, increasing the complexity of the habitat and supporting a variety of invertebrates and fishes.

Hydrocarbon seep communities in the GOM have been reported to occur at water depths greater than 300 m (984 ft) (USDOI, BOEM, 2012). There are currently 66 blocks that have one or more high-density deepwater benthic community that consists of chemosynthetic organisms, deepwater corals, or both. An MMS study, *Investigations of Chemosynthetic Communities on the Lower Continental Slope of the Gulf of Mexico*, performed exploration surveys specifically targeting water depths below 3,280 ft (1,000 m) (Brooks et al., 2009). This study confirmed the presence of 12 additional chemosynthetic communities not previously known in these water depths. What was initially thought to be relatively rare occurrences of chemosynthetic communities is now known to be far more common and regularly associated with primary geophysical signatures of the seabed, including faulting with conduits for hydrocarbons to migrate to the surface from deeper depths and precipitation of carbonate deposits on the seafloor.

In order to map areas of probable habitat for deepwater benthic communities scientists at BOEM have analyzed decades of 3-D seismic data to classify seafloor returns exhibiting anomalously high or low reflectivity. The areas of high reflectivity represent patches of anomalous seafloor returns that likely indicate patches of hard seafloor that would provide substrate for deepwater benthic communities. Currently, there are over 16,000 patches represented in the database. Most of these hard bottoms are created by the precipitation of calcium carbonate substrate by chemosynthetic bacterial activity. Investigations have revealed that most of these patches of substrate support patches of chemosynthetic megafaunal communities and/or live bottom reef communities. This database of high positive reflectivity anomalies reveals that chemosynthetic and coral communities are much more common in the deepwater GOM than previously known (USDOI, BOEM, 2012).

3.4.1.2. Impact Analysis

A detailed impact analysis of the routine, accidental, and cumulative impacts of the proposed activities on chemosynthetic communities can be found in Chapters 4.1.1.8.2 and 4.2.1.9.2 (routine), 4.1.1.8.3 and 4.2.1.9.3 (accidental), and 4.1.1.8.4 and 4.2.1.9.4 (cumulative) of the Multisale EIS and for nonchemosynthetic communities in Chapters 4.1.1.9.2 and 4.2.1.10.2 (routine), 4.1.1.9.3 and 4.2.1.10.3 (accidental), and 4.1.1.9.4 and 4.2.1.10.4 (cumulative) of the same document. The following information is a summary of the impact analyses in the EIS, and it is incorporated by reference into this SEA. The potential impacts on chemosynthetic and nonchemosynthetic benthic communities expected to inhabit the area of the proposed action are discussed in this section.

Any hard substrate communities located in deep water would be particularly sensitive to impacts from OCS activities, such as bottom disturbances and increased turbidity. Such impacts to these sensitive habitats could permanently prevent recolonization with similar organisms requiring hard substrate. The IPFs associated with the proposed activities in Mississippi Canyon Blocks 809 and 810 that could affect deepwater benthic communities include physical impacts from: (1) well siting activities; (2) drilling discharges, including primarily cuttings with associated drilling muds; and (3) possible seafloor blowouts during well drilling.

3.4.1.2.1. Alternative 1

If selected, Alternative 1, the no action alternative, would result in the operator not undertaking the proposed activities as described in the plan. Therefore, the impact- producing factors on chemosynthetic and nonchemosynthetic deepwater benthic communities would not occur. For example, there would be no well placement activities that could result in physical damage to the chemosynthetic and nonchemosynthetic deepwater benthic communities or their substrates, no drilling discharges that could result in burial of the organisms, or no damage from contact with oil from blowouts/spills.

3.4.1.2.2. Alternative 2

If selected, Alternative 2, the proposed action, would result in the operator undertaking the proposed activities as requested and conditioned in the plan. Examples of potential impacts on chemosynthetic and nonchemosynthetic deepwater benthic communities include, but are not limited to, damage from well emplacement and drilling discharges, possible sedimentation in the case of a seafloor blowout, and potential oil contamination from a blowout. Because the operator is required to follow all existing lease stipulations as well as the applicable regulations as clarified by NTLs (the operator reaffirmed compliance in its plan as cited above), conditions outlined in the following analyses related to NTL No. 2009-G40 will result in negating or lessening the probability of a significant impact to deepwater benthic communities.

Routine Operations

The NTL No. 2009-G40, (Deepwater Benthic Communities) provides guidance related to the BOEM's regulations implementing a policy of avoidance of dense deepwater benthic communities or areas that have a high potential for supporting these community types, as interpreted from geophysical records. According to NTL 2009-G40 all plans submitted for deepwater (984 ft, 300 m or greater) will be reviewed for the presence of deepwater benthic communities that may be affected by the proposed activity. Wells must be located a distance of at least 2,000 ft from possible and known deepwater benthic communities to prevent cuttings from smothering the communities and any seafloor disturbance (anchors, anchor chains, rig emplacement, pipeline emplacement) must be at least 250 ft from a possible or known deepwater benthic community. Lessees intending to explore or develop in water depths >984 ft (300 m) are required to provide information about geophysical surveys of the area of proposed activities and to evaluate the data for indications of conditions that may support chemosynthetic and nonchemosynthetic communities.

Well Emplacement: Emplacement or siting the well and associated subsea equipment can cause disturbances with lethal effects such as: (1) crushing; (2) burial or disruption the organisms; and (3) increased turbidity from sediment that is resuspended as a result of the operations which could interfere with filter-feeding organisms. The site-specific deepwater benthic communities review conducted for the proposed drilling determined that there were no potential high-density chemosynthetic and nonchemosynthetic communities or sites that could support such communities within 2,000 ft (610 m) from the proposed well sites.

Turbidity and Sedimentation: Routine surface discharges of drilling cuttings have been documented to reach the seafloor in water depths greater than 1,310 ft (400 m); however, significant accumulation thickness will be limited to a relatively close distance from the surface discharge point. A study looked at both exploration and production facility drilling discharges in water depths of 3,280 ft (1,000 m) and reported detectable accumulations at distances as far as 0.6 mi (1 km) (CSA, 2006). Realistically, splays of discharges only move in limited directions depending on prevailing currents; a good estimate would be 1/3 of the circumference of a circle with a radius of 3,280 ft (1,000 m) or 260 acres (105 hectares). Routine surface discharges of drilling cuttings would not result in a significant impact on the benthic communities because the duration and areal extent of the proposed activities would be limited and recolonization of benthic communities would be facilitated from nearby surrounding areas because numerous widespread pelagic larvae can settle on sediment where mortality to deepwater benthic organisms may reduce crowding and open up space for colonization. Impacts to hard-bottom communities are expected to be avoided by the compliance with BOEM regulations and guidance described in NTL 2009-G40, because BOEM does not approve the placement of wells or other OCS activity near these communities within the setback distances in the NTL. However, there is no known or potential high-density chemosynthetic and nonchemosynthetic communities within 2,000 ft (610 m) from the proposed well sites.

Accidental Events

A blowout at the seafloor occurs when excess pressure in the wellbore exceeds the capacity (drilling apparatus' pressure control capacity) to contain the well. A blowout could create a crater on the sea bottom and resuspend and disperse large quantities of bottom sediments within a 985 ft (300 m) radius of the blowout site, burying both infaunal (living in the sediment) and epifaunal (living on sediment) organisms and interfering with sessile invertebrates that rely on filter-feeding organs. Rapid burial by accumulations of sediment >1 ft (>30 cm) in thickness is likely to be lethal for all benthic organisms based on analysis of escape trace fossils from the geologic record (Frey, 1975; Basan et al., 1978; Eckdale et al., 1984). Burial by thinner accumulations of sediment (or cuttings) may be lethal to some sessile (attached or immotile) invertebrates and survivable by motile organisms. Similar to impacts from drill cuttings, impacts from a blowout would be limited because the duration and areal extent [within a radius of 985 ft (300 m)] and recolonization of communities would be facilitated from nearby surrounding areas because numerous widespread pelagic larvae can settle on sediment where mortality to chemosynthetic organisms may reduce crowding and will open up space for colonization. Shell's proposed activities are not to be placed near sensitive high-density chemosynthetic communities because BOEM is prohibited under its regulations, from approving the placement of any wells near these communities. Consequently, sensitive high-density chemosynthetic communities would not be affected by sediments.

Oil released by a seafloor blowout could have potential negative effects on chemosynthetic nonchemosynthetic deepwater benthic communities. However, there are two reasons why substantive impacts are very unlikely: (1) the surface areas of possible communities is very small compared with the surrounding soft bottoms so they present relatively small, widely dispersed targets for contact by an oil spill; and (2) the likelihood of any size blowout is very small. Impacts from a potential blowout similar to the Macondo Event are examined in the Catastrophic Spill Analysis located in Appendix B of the Multisale EIS.

Oil treated with dispersant on the sea surface or at depth could contact chemosynthetic or nonchemosynthetic deepwater benthic communities beyond the immediate area of the proposed activity. Currently there is limited information on toxicity of oil to deepwater benthic organisms. Data on the general toxicity of oil to organisms suggests that if oil contacted deepwater benthic communities, potential toxic effects would range from no discernible effect (for well-dispersed oil undergoing biodegradation) to lack of growth, to interruption of reproductive cycles, to loss of gamete viability, to tissue damage, and to death of affected organisms, depending on the amount and duration of contamination. The site-specific deepwater benthic communities review conducted for the proposed drilling determined that there were no potential high-density chemosynthetic and nonchemosynthetic communities or sites that could support such communities within 2,000 ft (610 m) from the proposed well sites.

Because chemosynthetic organisms frequently live near hydrocarbon seeps, they are tolerant of low levels of hydrocarbon exposure. For example, in 2002, a BOEM study stated that "three of our [chemosynthetic community] sites are clearly anomalous in terms of [high] oil concentration" (MacDonald, 2002). Such organisms may be more tolerant to exposure to oil than other invertebrates associated with chemosynthetic communities, particularly the crustaceans, and would likely be less susceptible to damage from oil exposure. Recolonization of severely damaged or destroyed communities could take years to decades because the organisms are long-lived with relatively low reproductive rates (i.e., they are ecologically k-selected).

Oil that makes its way to the seafloor could contact deepwater benthic communities beyond the immediate area of the drilling activity. There have been no experiments and thus, no information regarding the response of deepwater corals to oil exposure. Experiments with shallow water tropical corals indicate that corals have a high tolerance to oil exposure (Shigenaka, 2001). Though deepwater corals live in a different environment, their general physiology is similar to shallow water tropical corals and, therefore, similar response to oiling can be expected. The mucus layers on coral resist penetration of oil and slough off the contaminant. Longer exposure times and areas of tissue where oil adheres to the coral in shallow waters are more likely to result in tissue damage and death of polyps. Corals with branching growth forms appear to be more susceptible to damage from oil exposure (Shigenaka, 2001). The most common deepwater coral, *Lophelia pertusa*, is a branching species indicating possible susceptibility to oil damage. Tests with shallow tropical gorgonians indicate relatively low toxic effects to the coral, suggesting deepwater gorgonians may have a similar response. Deepwater coral response to exposure to oil would vary, depending on the level of exposure. Exposure to widely dispersed oil adhering to organic detritus and partially degraded by bacteria may be expected to result in little effect; such oil was undetectable on the seafloor following the Ixtoc spill (ERCO, 1982). Direct contact with plumes of relatively fresh dispersed oil in the vicinity of the incident could cause death of affected coral polyps, because concentrated oil has the ability to penetrate their exoskeletons and impair photosynthesis carried out in symbiotic algae that the polyps rely upon for oxygen and food (Cook and Knap, 1983). Median levels of exposure to dispersed oil in a partly degraded condition may result in effects similar to those of shallow tropical corals, with often no discernable effects other than temporary contraction and some sloughing. The health of corals may be degraded by the necessary expenditure of energy as the corals respond to oiling. Communities exposed to more concentrated oil may experience detrimental effects including death of affected organisms, tissue damage, lack of growth, interruption of reproductive cycles, and loss of gametes (Peters et al., 1981; Reimer, 1975; Loya and Rinkevich, 1979;

Rinkevich and Loya, 1977; Cohen et al., 1977; Guzman and Holst, 1993). Many invertebrates associated with deepwater coral communities, particularly the crustaceans, would likely be more susceptible to damage from oil exposure (Dean and Jewett, 2001; Gómez Gesteria and Dauvin, 2000). Recolonization of severely damaged or destroyed communities could take years to decades (MEC, 1995; Rinkevich and Loya, 1977; CSA and GERG, 2001; MRRI, 1984; Montagna and Holmberg, 2000).

Despite the Macondo Event, historical trends in the GOM (see Chapter 1.4) indicate that catastrophic spill events are not likely to occur as a result of the activities associated with the proposed action. In the event of a catastrophic spill similar to the Macondo Event, the Catastrophic Spill Analysis in Appendix B of the Multisale EIS discusses the most likely and most significant impacts to deepwater benthic habitats as it relates to three of the four phases of a major spill/blowout:

1) **Initial Event** (Section 2.2.2.5.; Page B-7);
2) **Offshore Spill** (Section 3.2.2.7; Page B-23);
3) **Onshore Contact** (deepwater benthic communities not included in this discussion); and
4) **Post-Spill, Long-Term Recovery** (Section 5.2.2.8; Page B-44).

The potential impacts from a catastrophic spill on deepwater benthic communities would be similar to aforementioned routine and accidental issues, and any substantive impact on deepwater benthic communities is very unlikely, due to the low probability of oil contacting the widely scattered, small targets represented by the communities.

Conclusion

Although high-density chemosynthetic and nonchemosynthetic community components could potentially occur in the vicinity of the proposed activities in Mississippi Canyon Blocks 809 and 810, the proposed activities are not expected to impact either known or probable areas of high-density chemosynthetic and nonchemosynthetic communities because based on BOEM's review of the survey data submitted with the operator's revised DOCD, there are no known or potential high-density chemosynthetic and nonchemosynthetic communities within 2,000 feet of the area of the proposed well sites. The operator proposes compliance with the regulations as clarified by NTL No. 2009-G40; therefore, the operations are not expected to significantly impact any chemosynthetic and nonchemosynthetic communities during routine activities. Significant impacts to chemosynthetic and nonchemosynthetic communities are not expected from accidental blowouts due to their low probability and the low probability of oil contacting such communities (representing very small, widely dispersed targets). Additionally, the distance from the well sites to the potential communities is such that impacts from discharges are expected to be negligible.

The potential impacts from a catastrophic spill on chemosynthetic and nonchemosynthetic communities would be similar to aforementioned routine and accidental issues, and any substantive impact to chemosynthetic communities is very unlikely, due to the low probability of oil contacting the widely scattered, small targets represented by the communities. The proposed activities are expected to have negligible impacts on the ecological function, biological productivity, or distribution of hard-bottom non-chemosynthetic communities. Bottom disturbances from the discharge of drilling cuttings and associated drilling muds would not be of sufficient size or duration to adversely affect these benthic community types to any significant or permanent degree. Minor and temporary impacts, such as interference with filter-feeding structures, could occur over areas inside an envelope estimated to be no more than about 260 acres (105 hectares). Routine discharges at the sea surface are not expected to adversely impact these community types because of the water depth in Mississippi Canyon Blocks 809 and 810. Bottom disturbances from a blowout during the drilling of the wells are not likely, based on the historical record of blowout events in the Gulf.

The recruitment of new organisms would take place from nearby areas, and organisms from undisturbed areas are free to migrate into disrupted areas after the disturbance ceases. Impacts to hard-bottom communities are expected to be avoided as a consequence of the compliance with existing BOEM regulations and adherence by the operator to NTL 2009-G40 for such communities; however there is no means to verify this without monitoring the situation over time. The same geophysical conditions associated with the potential presence of chemosynthetic communities also result in hard carbonate substrate. Hard bottoms are rare in the deep Gulf and there are no known hard-bottom areas near this block.

Cumulative Impacts

Impacts from routine activities would be local and short-term and unlikely to occur more than once to any area. Impacts resulting from a major blowout event could severely damage localized areas supporting chemosynthetic or nonchemosynthetic communities. However, the chance of such a blowout is very low and would only damage a deepwater benthic community that happens to be directly in the path of a subsea plume at the seafloor. Effects to the overall ecosystem of chemosynthetic or nonchemosynthetic communities in the GOM would be minimal. For the same reasons described above, even the most severe impacts, from a blowout, are not expected to significantly impact the overall chemosynthetic or nonchemosynthetic community.

Therefore, no significant cumulative impacts to deepwater benthic communities would be expected as a result of the proposed activities when added to the impacts of past, present, or reasonably foreseeable oil and gas development in the area as well as other activities in the area.

3.5. MARINE MAMMALS

3.5.1. Affected Environment

Twenty-one species of cetaceans occur in the GOM (Jefferson et al., 1992; Davis et al., 2000) and are identified in the NMFS GOM Stock Assessment Reports (SAR) (Waring et al., 2012) inclusive of one species of Sirenian. The GOM's marine mammals are represented by members of the taxonomic order Cetacea, which is divided into the suborders Mysticeti (i.e., baleen whales) and Odontoceti (i.e., toothed whales), as well as the order Sirenia, which includes the manatee and dugong.

Threatened or Endangered Marine Mammal Species

The life history, population dynamics, status, distribution, behavior, and habitat use of baleen and toothed whales can be found in Chapters 4.1.1.11 and 4.2.1.12 of the Multisale EIS, and is incorporated by reference, and also in the NMFS 2009 SAR (Waring et al., 2012). Five baleen cetaceans (the North Atlantic right, blue, fin, sei, and humpback whales), one toothed cetacean (the sperm whale), and one sirenian (the West Indian manatee) occur in the GOM and are listed as endangered under the Endangered Species Act (ESA). The sperm whale is common in oceanic waters of the northern GOM and appears to be a resident species, while the baleen whales are considered rare or extralimital in the GOM (Würsig et al., 2000). The National Marine Fisheries Service's (NMFS) annual Stock Assessment Report (SAR) for the GOM indicates that the northern right, blue, fin, sei, and humpback whales are rare in the GOM (Waring et al., 2012). The West Indian manatee (*Trichechus manatus*) typically inhabits only coastal marine, brackish, and freshwater areas. The distribution, feeding habits, habitat use, and population estimates of manatees can be found in Chapter 4.2.1.12.1 of the Multisale EIS.

Non-ESA-Listed Marine Mammal Species

One baleen cetacean (Bryde's whale) and 19 toothed cetaceans (including beaked whales and dolphins) occur in the GOM. None of these species are protected under the ESA however all marine mammals are protected under the Marine Mammal Protection Act (1972). There are two species of non-ESA-listed baleen whales that may occur in the GOM – the minke whale and the Bryde's whale. The minke whale is considered rare and is not included in the NMFS SAR for the GOM (Würsig et al., 2000; Waring et al., 2012). The Bryde's whale is considered uncommon but is the most frequently sighted baleen whale in the GOM (Würsig et al., 2000).

Non-ESA-listed toothed whales include all of the dolphin and small whale/"blackfish" species in the GOM and comprise 20 species. The *Kogia* species (pygmy and dwarf sperm whales) are small and cryptic whales that inhabit offshore waters. Very little is known of their life history. The beaked whales have been highly publicized in the last several years due to strandings and deaths attributed to military sonar. Beaked whales are not as small as *Kogia,* but they are just as cryptic and difficult to survey. As with *Kogia*, very little is known about beaked whales (Waring et al., 2012).

Additional information on non-ESA-listed marine mammal species of the GOM is provided in Chapter 4.2.1.12.1 of the Multisale EIS, and in the NMFS 2009 SAR (Waring et al., 2012) and is incorporated by reference into this SEA.

3.5.2. Impact Analysis

A detailed impact analysis of the routine, accidental, and cumulative impacts of the proposed development activities on marine mammals can be found in Chapters 4.1.1.11.2 and 4.2.1.12.2 (routine), 4.1.1.11.3 and 4.2.1.12.3 (accidental), and 4.1.1.11.4 and 4.2.1.12.4 (cumulative) of the Multisale EIS, and is incorporated by reference. The IPFs associated with the proposed activities in Mississippi Canyon Blocks 809 and 810 that could affect marine mammals include: (1) vessel noise and collisions; (2) marine debris; (3) water-quality degradation from drilling rig effluents; (4) oil spills and spill-response activities; and (5) drilling noise. These IPFs are the same for nonthreatened and nonendangered marine mammal species as well as those listed under the Endangered Species Act of 1973 (ESA).

3.5.2.1. Alternative 1

If selected, Alternative 1, the no action alternative, would result in the operator not undertaking the proposed activities as described in the plan. Therefore, the IPFs to marine mammals would not occur. These factors include vessel/drilling noise that would result in behavioral change, masking, or non-auditory effects to marine mammals, no long-term or permanent displacement of the animals from preferred habitats, and no destruction or adverse modification of any habitats. Because there would be no support vessel traffic related to the drilling operation, there would be no risk of collisions with marine mammals, and there would be no water degradation as a result of the proposed activities.

3.5.2.2. Alternative 2

If selected, Alternative 2, the proposed action, would result in the operator undertaking the proposed activities as requested and conditioned in the plan. The operator has proposed adherence with the guidance provided under BSEE NTL No. 2012-G01 (Marine Trash and Debris Awareness and Elimination) and Joint NTL No. 2012-G01 (Vessel Strike Avoidance and Injured/Dead Protected Species Reporting) (Shell, 2013). Compliance with the regulations as clarified in these NTLs should negate or lessen the chance of significant impacts to marine mammals under this alternative.

Routine Operations

Vessel Noise and Collisions

The proposed activities are expected to require several roundtrip supply-vessel and crew-vessel trips per week. Deep-diving whales may be more vulnerable to vessel strikes given the longer surface period required to recover from extended deep dives. Given NMFS has determined vessel strikes to be a discountable concern for sperm whales (USDOC, NMFS, 2007), a deep-diving species, the faster diving marine mammal species with less surface recovery time would be expected to have even less risk of vessel strikes. Although manatees have been killed by vessel strikes (e.g., Schiro et al., 1998), they are rare in the deepwater GOM, and consequently, the proposed activity should pose little, if any, risk to them.

The dominant source of noise from vessels is from the propeller operation, and the intensity of this noise is largely related to ship size and speed. Vessel noise from the proposed action will produce low levels of noise, generally in the 150 to 170 dB re 1 μPa-m at frequencies below 1,000 Hz. Vessel noise is transitory and generally does not propagate at great distances from the vessel. As a result, the NMFS 2007 ESA Biological Opinion concluded that the effects to sperm whales from vessel noise are discountable (USDOC, NMFS, 2007).

The noise and the shadow from helicopter overflights, take-offs, and landings can cause a startle response and can interrupt whales and dolphins while resting, feeding, breeding, or migrating (Richardson et al., 1995). The Federal Aviation Administration's Advisory Circular 91-36D (September 17, 2004) encourages pilots to maintain higher than minimum altitudes over noise-sensitive areas. Guidelines and regulations put in place by NOAA Fisheries under the authority of the Marine Mammal Protection Act include provisions specifying that helicopter pilots maintain an altitude of 1,000 ft (305 m) within 300 ft (91 m) of marine mammals. The proposed action is expected to have helicopter support with multiple transits between the MODU and airbase. Since these occurrences would be temporary and pass within seconds; therefore, marine mammals are not expected to be adversely affected by routine helicopter traffic operating at prescribed altitudes.

Atmospheric noise inputs, however, are negligible relative to other sources of noise that are propagated in water (e.g., vessel traffic and platform and drill rig operations). Noise from service-vessel traffic may elicit a startle and/or avoidance reaction from whales and dolphins or mask their sound reception. There is the possibility of short-term disruption of movement patterns and behavior, but such disruptions are unlikely to affect survival or productivity. The behavioral disruptions potentially caused by noise and the presence of service-vessel traffic will have negligible effects on cetacean populations in the northern GOM.

Drilling activities would produce sounds transmitted into the water at intensities and frequencies that could be heard by cetaceans. Noise from drilling could be intermittent, sudden, and at times could be high intensity as operations take place. Sound from a fixed, ongoing source like an operating drillship is continuous. However, the distinction between transient and continuous sounds is not absolute on a drillship as generators and pumps operate essentially continuously, but there are occasional transient bangs and clangs from various impacts during operations (Richardson et al. 1995). Drilling from semi-submersible vessels estimated frequencies are broadband from 80-4000 Hz with an estimated source level (SL) of 154 dB re 1µPa at 1 m. Tones of 60 Hz has SLs of 149 dB, 181 Hz was 137 dB, and 301 Hz was 136 dB (Greene, 1986). The potential effects that water-transmitted noise have on marine mammals include disturbance (subtle changes in behavior, interruption of previous activities, or short- or long-term displacement), masking of sounds (calls from conspecifics, reverberations from own calls, and other natural sounds such as surf or predators), physiological stress, and hearing impairment. Individual marine mammals exposed to recurring disturbance could be negatively affected. Malme et al. (1986) observed the behavior of feeding gray whales in the Bering sea during four experimental playbacks of drilling sounds (50 to 315 Hz; 21- min overall duration and 10% duty cycle; source levels 156 to 162 dB re: 1 µPa-m). In two cases for received levels (RLs) 100 to 110 dB re: 1 µPa, there was no observed behavioral reaction. Avoidance behavior was observed in two cases where RLs were 110 to 120 dB re: 1 µPa. These source levels are all below NMFS' current 160 dB level B harassment threshold under the MMPA.

The source levels from drilling are relatively low (154 dB and below, as cited by Greene, 1986 in Richardson et al. 1995), below the level B (behavioral) harassment threshold of 160 dB (set by NMFS). According to Southall et al. (2007), for behavioral responses to nonpulses (such as drill noise), data indicate considerable variability in received levels associated with behavioral responses. Contextual variables (such as novelty of the sound to the marine mammal and operation features of the sound source) appear to have been at least as important as exposure level in predicting response type and magnitude. While there is some data from the Arctic on baleen whales, there is little data on the behavioral responses of marine mammals in the GOM from the sound of drilling. Southall et al (2007) summarized the existing research, stating that the probability of avoidance and other behavioral affects increases when received levels increase from 120 to 160 dB. Marine mammals may exhibit some avoidance behaviors, but their behavioral or physiological responses to noise associated with the proposed project, however, are unlikely to have population-level impacts to marine mammals in the northern GOM.

Marine Debris

Many types of plastic materials end up as solid waste during drilling and production operations. Some of this material is accidentally lost overboard where cetaceans could consume it or become entangled in it. The incidental ingestion of marine debris and entanglement could adversely affect marine mammals. The operator has proposed adherence with the guidance provided under BSEE NTL No. 2012-G01 (Marine Trash and Debris Awareness and Elimination) which appreciably reduces the likelihood of marine mammals encountering marine debris from the proposed activity (Shell, 2013).

Water Degradation

Most operational discharges are diluted and dispersed when released in offshore areas and are considered to have sublethal effects (NRC, 1983; API, 1989; Kennicutt, 1995; Kennicutt et al., 1996). Any potential impacts from drilling fluids would be indirect, either as a result of impacts to prey species or possibly through ingestion via the food chain (Neff et al., 1989). Marine mammals generally are thought to be inefficient assimilators of petroleum compounds within prey (Neff, 1990).

Accidental Events

Oil Spills and Response Activities

The oil from an oil spill can adversely affect cetaceans by causing soft tissue irritation, fouling of baleen plates, respiratory stress from inhalation of toxic fumes, food reduction or contamination, direct ingestion of oil and/or tar, and temporary displacement from preferred habitats. The long-term impacts to marine mammal populations are poorly understood but could include decreased survival and lowered reproductive success. The range of toxicity and degree of sensitivity to oil hydrocarbons and the effects of cleanup activities on cetaceans are unknown. One assumption concerning the use of dispersants is that chemical dispersion of oil will considerably reduce the impacts to seabirds and aquatic mammals, primarily by reducing their exposure to petroleum hydrocarbons (French-McCay 2004; NRC, 2005). Chemical dispersant application during an oil spill may lower the amount of oil to which a bird or aquatic mammal is exposed while increasing the potential loss of the insulative properties of feathers or fur through the reduction of surface tension at the feather/fur-water interface (NRC, 2005).

Impacts from the dispersants are unknown but may have similar irritants to tissues and sensitive membranes as they are known to have had on seabirds and sea turtles (NRC, 2005). There have been no experimental studies and only a handful of observations suggesting that oil has harmed any manatees (St. Aubin and Lounsbury, 1990). Types of impacts to manatees and dugongs from contact with oil include (1) asphyxiation due to inhalation of hydrocarbons, (2) acute poisoning due to contact with fresh oil, (3) lowering of tolerance to other stress due to the incorporation of sublethal amounts of petroleum components into body tissues, (4) nutritional stress through damage to food sources, and (5) inflammation or infection and difficulty eating due to oil sticking to the sensory hairs around their mouths (Preen, 1989, in Sadiq and McCain, 1993, AMSA, 2003). For a population whose environment is already under great pressure, even a localized incident could be significant (St. Aubin and Lounsbury, 1990). Spilled oil might affect the quality or availability of aquatic vegetation, including seagrasses, upon which manatees feed.

In the event of catastrophic spill similar to the Macondo Event, the Catastrophic Spill Analysis in Appendix B of the Multisale EIS discusses the most likely and most significant impacts to marine mammals as it relates to the four phases of a major spill/blowout:

1) **Initial Event** (Section 2.2.2.3.; Page B-6);
2) **Offshore Spill** (Section 3.2.2.3; Page B-18);
3) **Onshore Contact** (Section 4.2.2.3; Page B-32); and
4) **Post-Spill, Long-Term Recovery** (Section 5.2.2.3; Page B-41).

In the event of a catastrophic spill similar to the Macondo Event, any substantive impact to marine mammals is very unlikely because the potential impacts from a catastrophic spill would be similar to aforementioned routine and accidental issues. However, despite the Macondo Event, historical trends in the GOM (see Chapter 1.4) indicate that catastrophic spill events are not likely to occur as a result of drilling and completion activities associated with the proposed action.

Conclusion

The sections above discuss the potential range of effects to marine mammals from the proposed activity and any of these effects has the potential individually or cumulatively to result in impacts to marine mammal species commonly found in the GOM and proposed action area. However, BOEM finds that the potential for such effects from the proposed action are unlikely to rise to significant levels for the following reasons:

- Mysticetes, as low-frequency hearing specialists, are the species groups most likely to be susceptible to impacts from nonpulse sound (intermittent or continuous) given that their hearing ranges overlap most closely with the noise frequencies produced from drilling (Southall et al., 2007). However, all mysticete species that may occur in the GOM (i.e., North Atlantic right, blue, fin, sei, humpback, minke and Bryde's whales) are considered either "extralimital," "rare," or "uncommon" within the GOM (Wursig et al., 2000; Waring et al., 2012). Given the small geographic scope of the proposed action, the presence of these species within the action area is unlikely.

- The remaining marine mammal species in the GOM (e.g., sperm whales, dwarf or pygmy sperm whales, and dolphins) are considered mid-frequency hearing specialists with hearing ranges that slightly overlap with sound frequencies produced from drilling noise (Southall et al., 2007). It is expected that there will be some overlap in the frequencies of the drill source and the hearing thresholds of the marine mammals present in the GOM. Greene (1986) estimated the broadband frequencies of semi-submersible drill vessels to be from 80-4000 Hz with an estimated SL of 154 dB re 1µPa at 1 m. Tones of 60 Hz had source levels of 149 dB, 181 Hz was 137 dB, and 301 Hz was 136 dB. Wartzok and Ketten (1999) stated that bottlenose dolphins have hearing thresholds ranging from less than 5 kHz to over 100 kHz, Ridgway and Carder (2001) found, through auditory brainstem analysis, that pygmy sperm whales have thresholds from 90 to 150 kHz. Gordon et al. (1996) found that a stranded sperm whale had lower hearing limits at around 100 Hz while Ridgway and Carder (2001) found that a sperm whale calf had best hearing sensitivity between 5 and 20 kHz. Since there is some overlap in the sound levels produced and hearing thresholds of marine mammals, there is potential for the drilling noise produced to cause auditory and non-auditory effects, PTS, TTS, behavioral changes, or masking but it is expected to be limited.
- The NMFS sets the 180-dB root-mean-squared (rms) isopleth where on-set of auditory injury or mortality (level A harassment) to cetaceans may occur. Southall et al. (2007) suggests this level should rather be at 230 dB rms for a nonpulsed sound, such as drilling noise. Richardson et al (1995) cited Greene (1986) and stated drilling from semi-submersible vessels have estimated broadband frequencies from 80-4000 Hz with an estimated source level of 154 dB re 1microPa at 1 m. Tones of 60 Hz have source levels of 149 dB, while 181 Hz have source levels of 137 dB, and 301 Hz have source levels of 136 dB. These source levels all fall below the 180 dB level A harassment isopleths.
- The operator proposes adherence with the guidance provided under BSEE NTL No. 2012-G01, "Marine Trash and Debris Awareness and Elimination," which appreciably reduces the likelihood of marine mammals encountering marine debris from the proposed activity (Shell, 2013).

The geographic scope of the proposed action is small in relation to the ranges of marine mammals in the GOM. The proposed activities are not expected to cause long-term or permanent displacement of the animals from preferred habitats, nor will they result in the destruction or adverse modification of any habitats. In conclusion, the scope, timing, and transitory nature of the proposed action and the condition(s) of approval and monitoring requirements in place, the noise related to the proposed action is not expected to result in PTS, TTS, behavioral change, masking, or non-auditory effects to marine mammals in the GOM that would rise to the level of significance.

Cumulative Impact Analysis

The proposed action may cumulatively affect protected cetaceans when viewed in light of the Macondo Event and associated cleanup activities. Marine mammals could be impacted by oil and gas leasing, exploration, development and production activities including the degradation of water quality resulting from operational discharges, vessel traffic, noise generated by platforms, semisubmersibles, helicopters and vessels, seismic surveys, explosive structure removals, oil spills, oil-spill-response activities, loss of debris from service vessels and OCS structures, commercial fishing, capture and removal, and pathogens. The cumulative impact on marine mammals is expected to result in a number of chronic and sporadic sublethal effects (i.e., behavioral effects and nonfatal exposure to or intake of OCS-related contaminants or discarded debris) that may stress and/or weaken individuals of a local group or population and predispose them to infection from natural or anthropogenic sources (Harvey and Dahlheim, 1994).

Few deaths are expected from chance vessel collisions, ingestion of plastic material, commercial fishing, and pathogens. Disturbance (noise from vessel traffic and drilling operations, etc.) and/or exposure to sublethal levels of toxins and anthropogenic contaminants may stress animals, weaken their immune systems, and make them more vulnerable to parasites and diseases that normally would not be fatal (Harvey and Dahlheim, 1994). The net result of any disturbance will depend upon the size and percentage of the population likely to be affected, the ecological importance of the disturbed area, the environmental and biological parameters that influence an animal's sensitivity to disturbance and stress, or the accommodation time in response to prolonged disturbance (Geraci and St. Aubin, 1980).

The effects of the proposed action, when viewed in light of the effects associated with other relevant activities, may impact marine mammals in the GOM. However, the operator is required to follow all existing lease stipulations and regulations as clarified by NTLs. The operator's reaffirmed compliance with Joint NTL No. 2012-G01 (Vessel-Strike Avoidance) and BSEE NTL 2012-G01 (Marine Trash and Debris), as well as the limited scope, timing, and geographic location of the proposed action, effects from the proposed activities on marine mammals will be negligible. Therefore, no significant cumulative impacts to marine mammals would be expected as a result of the proposed activities when added to the impacts of past, present, or reasonably foreseeable oil and gas development in the area as well as other activities in the area.

3.6. SEA TURTLES

3.6.1. Affected Environment

The life history, population dynamics, status, distribution, behavior, and habitat use of sea turtles can be found in Chapters 4.1.1.12 and 4.2.1.13 of the Multisale EIS, and is incorporated by reference. Of the extant species of sea turtles, five are known to inhabit the waters of the GOM (Pritchard, 1997): the leatherback, green, hawksbill, Kemp's ridley, and loggerhead. These five species are all highly migratory, and individual animals will migrate into nearshore waters as well as other areas of the North Atlantic Ocean, GOM, and Caribbean Sea. All five species of sea turtles found in the GOM have been federally listed as endangered or threatened since the 1970's. There is currently no critical habitat designated in the GOM.

In 2007, FWS and NMFS published 5-year status reviews for all federally listed sea turtles in the GOM (USDOC, NMFS and USDOI, FWS, 2007a-e). A 5-year review is an ESA-mandated process that is conducted to ensure that the listing classification of a species as either threatened or endangered is still accurate. Both agencies share jurisdiction for federally listed sea turtles and jointly conducted the reviews. After reviewing the best scientific and commercially available information and data, agencies determined that the current listing classification for the five sea turtle species remain unchanged.

3.6.2. Impact Analysis

A detailed impact analysis of the routine, accidental, and cumulative impacts of the proposed development activities on sea turtles can be found in Chapters 4.1.1.12.2 and 4.2.1.13.2 (routine), 4.1.1.12.3 and 4.2.1.13.3 (accidental) and 4.1.1.12.4 and 4.2.1.13.4 (cumulative) of the Multisale EIS, and is incorporated by reference. The diversity of a sea turtle's life history leaves it susceptible to many natural and human impacts, including impacts while it is on land, in the benthic environment, and in the pelagic environment. The IPFs associated with the proposed activities in Mississippi Canyon Blocks 809 and 810 that could affect sea turtles include: (1) vessel noise and collisions; (2) marine debris; (3) water-quality degradation from drilling rig effluents; (4) oil spills and spill-response activities; and (5) drilling noise.

3.6.2.1. Alternative 1

If selected, Alternative 1, the no action alternative, would result in the operator not undertaking the proposed activities as described in the plan. Therefore, the IPFs to sea turtles would not occur. For example, there would be no vessel noise or drilling noise that would result in behavioral change, masking, or non-auditory effects to sea turtles, no long-term or permanent displacement of the animals from preferred habitats, and no destruction or adverse modification of any habitats. Since there would be no vessel traffic related to the drilling operation, there would be no risk of collisions with sea turtles.

3.6.2.2. Alternative 2

If selected, Alternative 2, the proposed action, would result in the operator undertaking the proposed activities as requested and conditioned in the plan. The operator has proposed adherence with the guidance provided under BSEE NTL No. 2012-G01 (Marine Trash and Debris Awareness and Elimination) and Joint NTL No. 2012-G01 (Vessel Strike Avoidance and Injured/Dead Protected Species

Reporting) (Shell, 2013). Compliance with the regulations as clarified in these NTLs should negate or lessen the chance of significant impacts to sea turtles under this alternative.

Routine Operations

Vessel Noise and Collisions

The first IPF associated with the proposed action that could affect ESA-listed sea turtles is impacts from vessel noise and vessel collisions. The dominant source of noise from vessels is propeller operation, and the intensity of this noise is largely related to ship size and speed. Vessel noise from the proposed action would produce low levels of noise, generally in the 150 to 170 dB re 1 μPa-m at frequencies below 1,000 Hz. Vessel noise is transitory and generally does not propagate at great distances from the vessel. Also, available information indicates that sea turtles do not greatly utilize environmental sound. As a result, the NMFS 2007 Biological Opinion concluded that effects to sea turtles from vessel noise are discountable (USDOC, NMFS, 2007).

Drilling activities would produce sounds transmitted into the water that could be intermittent, sudden, and at times could be high intensity as operations take place. However, sea turtles are not expected to be impacted by this disturbance because the NMFS in their 2007 Biological Opinion determined that "drilling is not expected to produce amplitudes sufficient to cause hearing or behavioral effects to sea turtles or sperm whales; therefore, these effects are insignificant."

Sea turtles spend at least 3-6 percent of their time at the surface for respiration and perhaps as much as 26 percent of time at the surface for basking, feeding, orientation, and mating (Lutcavage et al., 1997). Data show that collisions with all types of commercial and recreational vessels are a cause of sea turtle mortality in the GOM (Lutcavage et al., 1997). Stranding data for the U.S. Gulf and Atlantic Coasts, Puerto Rico, and the U.S. Virgin Islands show that between 1986 and 1993 about 9 percent of living and dead stranded sea turtles had boat strike injuries (Lutcavage et al., 1997). Vessel-related injuries were noted in 13 percent of stranded turtles examined from the GOM and the Atlantic during 1993 (Teas, 1994), but this figure includes those that may have been struck by boats post-mortem. Large numbers of loggerheads and 5-50 Kemp's ridley turtles are estimated to be killed by vessel traffic per year in the U.S. (NRC, 1990; Lutcavage et al., 1997).

There have been no known documented sea turtle collisions with drilling and service vessels in the GOM; however, collisions with small or submerged sea turtles may go undetected. Based on sea turtle density estimates in the GOM, the encounter rates between sea turtles and vessels would be expected to be greater in water depths less than 200 m (USDOC, NMFS, 2007). To further minimize the potential for vessel strikes, BOEM issued Joint NTL No. 2012-G01, which clarifies 30 CFR § 550.282 and provides NMFS guidelines for monitoring procedures related to vessel strike avoidance measures for sea turtles and other protected species. With implementation of these measures and the avoidance of potential strikes from OCS vessels, the NMFS 2007 Biological Opinion concluded that the risk of collisions between oil/gas-related vessels (including those for G&G, drilling, production, decommissioning, and transport) and sea turtles is appreciably reduced, but strikes may still occur. The BOEM monitors for any takes that have occurred as a result of vessel strikes and also requires that any operator immediately report the striking of any animal (see 30 C.F.R. § 550.282 and Joint NTL No. 2012-G01).

To date, there have been no known reported strikes of sea turtles by drilling vessels. Given the scope, timing, and transitory nature of the proposed action and with this established condition(s) of approval, effects to sea turtles from drilling vessel collisions is expected to be negligible.

Marine Debris

Many types of plastic materials end up as solid waste during drilling and production operations. Some of this material is accidentally lost overboard where sea turtles could consume it or become entangled in it. The incidental ingestion of marine debris and entanglement could adversely affect sea turtles. As proposed in their plan, the operator proposes compliance with the guidelines provided in BSEE NTL No. 2012-G01 "Marine Trash and Debris Awareness and Elimination", which appreciably reduces the likelihood of sea turtles encountering marine debris from the proposed activity.

Water Degradation

Most operational discharges are diluted and dispersed when released in offshore areas and are considered to have sublethal effects (NRC, 1983; API, 1989; Kennicutt, 1995; Kennicutt et al., 1996).

Any potential impacts from drilling fluids would be indirect, either as a result of impacts to prey species or possibly through ingestion via the food chain (Neff et al., 1989). Impacts from water degradation are expected to be negligible due to the localized nature of the proposed activity and the wide-ranging habits of sea turtle species in the GOM.

Accidental Events

Oil Spills and Response Activities

The oil from an oil spill can adversely affect sea turtles by causing soft tissue irritation, respiratory stress from inhalation of toxic fumes, food reduction or contamination, direct ingestion of oil and/or tar, and temporary displacement from preferred habitats (Lutz and Lutcavage, 1989). The long-term impacts to sea turtle populations are poorly understood but could include decreased survival and lowered reproductive success. The range of toxicity and degree of sensitivity to oil hydrocarbons and the effects of cleanup activities on sea turtles are unknown. Impacts from the dispersants are unknown, but may have similar irritants to tissues and sensitive membranes as they are known to have had on seabirds and marine mammals (NRC, 2005).

In the event of a catastrophic spill similar to the Macondo Event, the Catastrophic Spill Analysis in Appendix B of the Multisale EIS discusses the most likely and most significant impacts to sea turtles as it relates to the four phases of a major spill/blowout:

1) **Initial Event** (Section 2.2.2.4.; Page B-7);
2) **Offshore Spill** (Section 3.2.2.4; Page B-19);
3) **Onshore Contact** (Section 4.2.2.4; Page B-33); and
4) **Post-Spill, Long-Term Recovery** (Section 5.2.2.4; Page B-41).

In the event of a catastrophic spill similar to the Macondo Event, any substantive impact to sea turtles is very unlikely because the potential impacts from a catastrophic spill would be similar to aforementioned routine and accidental issues. However, despite the Macondo Event, historical trends in the GOM (see Chapter 1.4) indicate that catastrophic spill events are not likely to occur as a result of drilling and completion activities associated with the proposed action.

Conclusion

The sections above discuss the potential range of effects to sea turtles from the proposed action, including: (1) vessel noise and collisions; (2) marine debris; (3) water-quality degradation from drilling rig effluents; (4) oil spills and spill-response activities; and (5) drilling noise. The potential effects of the proposed activity on sea turtles will not rise to the level of significance for the following reasons:

- The best available scientific information indicates that sea turtles do not greatly use sound in the environment for survival; therefore, disruptions in environmental sound would have little effect.
- The scope, timing, and transitory nature of the proposed action will produce limited amounts of drilling noise in the environment. As described, effects of vessel noise on sea turtles are considered "discountable" (USDOC, NMFS, 2007).
- Implementation of the regulations as clarified in BSEE NTL No. 2012-G01 "Marine Trash and Debris Awareness and Elimination", appreciably reduces the likelihood of sea turtles encountering marine debris from the proposed activity.

The risk of collisions between sea turtles and vessels associated with the proposed action exists but would not rise to the level of significance given:

- Under 30 CFR § 550.282 clarified by Joint NTL No. 2012-G01, BOEM provides guidelines for the monitoring programs designed to minimize the risk of vessel strikes to sea turtles and other protected species and the reporting of any observations of injured or dead protected species.
- The NMFS 2007 Biological Opinion determined that monitoring measures should appreciably reduce the potential for vessel strikes. The NMFS issued an Incidental Take Statement on sea turtle species; the Statement contains reasonable and prudent measures (RPMs) with implementing terms and conditions to help minimize take. As the operator has indicated that the vessel strike avoidance

guidance (Joint NTL No. 2012-G01) will be followed, there should be an appreciably reduced the numbers of sea turtles that may be incidentally taken from routine offshore vessel operations; however, the available information on the relationship between these species and OCS oil and gas activities indicates that sea turtles may be killed or injured by vessel strikes. Therefore, pursuant to Section 7(b)(4) of the ESA, NMFS anticipates incidental take and granted a limited number of Incidental Take Authorizations to BOEM for sea turtle mortalities by vessel strikes. The BOEM continues to monitor for any strikes to ensure this authority is not exceeded.

- The scope, timing, and transitory nature of the proposed action will result in limited opportunity for vessel strikes to sea turtles.

Cumulative Impact Analysis

Activities considered under the cumulative scenario, including the proposed action, may affect sea turtles. Sea turtles may be impacted by oil and gas leasing, exploration, development and production activities including the degradation of water quality resulting from operational discharges, vessel traffic, noise generated by platforms, drilling rigs, helicopters and vessels, seismic surveys, explosive structure removals, oil spills, oil-spill-response activities, loss of debris from service vessels and OCS structures, commercial fishing, capture and removal, and pathogens. The cumulative impact of these ongoing OCS activities on sea turtles is expected to result in a number of chronic and sporadic sublethal effects (i.e., behavioral effects and nonfatal exposure to or intake of OCS-related contaminants or discarded debris) and that may stress and/or weaken individuals of a local group or population and that may predispose them to infection from natural or anthropogenic sources.

Few deaths are expected from chance collisions with OCS service vessels, ingestion of plastic material, commercial fishing, and pathogens. Disturbance (noise from vessel traffic and drilling operations, etc.) and/or exposure to sublethal levels of toxins and anthropogenic contaminants may stress animals, weaken their immune systems, and make them more vulnerable to parasites and diseases that normally would not be fatal during their life cycle. The net result of any disturbance depends upon the size and percentage of the population likely to be affected, the ecological importance of the disturbed area, the environmental and biological parameters that influence an animal's sensitivity to disturbance and stress, or the accommodation time in response to prolonged disturbance (Geraci and St. Aubin, 1980). As discussed above, lease stipulations and regulations are in place to reduce vessel strike mortalities.

Incremental injury effects from the proposed action on sea turtles are expected to be negligible for drilling and vessel noise and minor for vessel collisions, but will not rise to the level of significance because of the limited scope, duration, and geographic area of the proposed drilling and vessel activities and the relevant regulatory requirements.

The effects of the proposed action, when viewed in light of the effects associated with other relevant activities, may affect sea turtles occurring in the GOM. With the enforcement of regulatory requirements for drilling and vessel operations and the scope of the proposed action, incremental effects from the proposed activities on sea turtles will be negligible (drilling and vessel noise) to minor (vessel strikes). The best available scientific information indicates that sea turtles do not greatly use sound in the environment for survival; therefore, disruptions in environmental sound would have little effect. Consequently, no significant cumulative impacts would be expected from the proposed activities or as the result of past, present, or reasonably foreseeable oil and gas leasing, exploration, development and production in the GOM.

3.7. FISH RESOURCES AND ESSENTIAL FISH HABITAT

3.7.1. Affected Environment

The life history, population dynamics, status, distribution, behavior, and habitat use of fish and essential fish habitat can be found in Chapters 4.1.1.15 and 4.2.1.18 of the Multisale EIS, and is incorporated by reference. Healthy fish resources and fishery stocks depend on essential fish habitat (EFH) waters and substrate necessary to fish for spawning, breeding, feeding, and growth to maturity. Due to the wide variation of habitat requirements for all life history stages for managed species, NOAA initially identified EFH throughout the GOM to include all coastal and marine waters and substrates from the shoreline to the seaward limit of the Exclusive Economic Zone (200 mi [322 km] from shore).

The GOM supports a wide variety of finfish, and most of the commercial finfish resources are linked either directly or indirectly to the estuaries that ring the GOM. The life history of estuarine-dependent species involves spawning on the continental shelf; the transportation of eggs, larvae, or juveniles back to the estuary nursery grounds; and the migration of the adults back to the sea for spawning. Movement of the adult estuarine-dependent species is essentially onshore-offshore with no extensive east-west migration. Darnell et al. (1983) observed that the density distribution of fish resources in the Gulf was highest nearshore off the central Gulf Coast. For all seasons, the greatest abundance occurred between Galveston Bay and the mouth of the Mississippi River. Recent monthly ichthyoplankton collections over the years 2004-2006 offshore of Alabama have confirmed that peak seasons for ichthyoplankton concentrations on the shelf are spring and summer (Hernandez et al., 2010).

The Macondo Event spill on April 20, 2010, introduced large quantities of oil into the water column between the spill site and the marshes of the central Gulf Coast. Oil from this incident has made contact with shorelines from Galveston, Texas, to Apalachicola, Florida, with the primary areas of oiling occurring from Grande Isle, Louisiana, west of the mouth of the Mississippi River to Santa Rosa Island, Florida. The oil has penetrated estuaries at least along the Louisiana and Mississippi coasts and has been driven farther inshore by the passage of Hurricane Alex, which made landfall near the Texas/Mexico border. Also, Corexit® 9500, the dispersant used during the Macondo Event, is believed to be the least toxic of all of its counterparts to small fish. Early life stages of animals are usually more sensitive to environmental stress than adults (Moore and Dwyer, 1974). The full extent of the ichthyoplankton mortality due to all factors related to the oil and dispersants is unknown and may not be known unless a significant portion of a year class is absent from next year's fishery. Adult fish tend to avoid contact with oil in the water column. Specific effects of oil on fish can include direct lethal toxicity, sublethal disruption of physiological processes (internal lesions), effects of direct coating by oil (suffocation by coating gills), incorporations of hydrocarbons, causing tainting or accumulation in the food chain and changes in biological habitat (Moore and Dwyer, 1974). How assemblages of fish have changed or will change as a result of the Macondo Event is unknown at this time. For detailed information regarding the Macondo Event please refer the Multisale EIS (USDOI, BOEM, 2012).

All affected estuaries are extremely important nursery areas (EFH) for fish and aquatic life. Impacts related to oiling of these areas, depending on the severity, can include destruction of nutrient-rich marshes, which can lead to the erosion of coastlines (when the grass dies, the coastline is moved back and eroded. Marshes and coastlines in the central Gulf Coast have already been significantly damaged in recent years, first in 2005 by Hurricanes Katrina and Rita, then in September 2008 when Hurricanes Gustav and Ike made landfall in Louisiana and Texas, respectively, and then again when Hurricane Isaac made landfall in Louisiana in 2012. The Louisiana Dept. of Wildlife and Fisheries (2008a and b) released preliminary non-quantitative reports of the effects of Hurricane Gustav on Louisiana fisheries. In the reports, they noted the extensive marsh erosion and vegetative debris present in the canals of southeastern Louisiana as well as localized fish kills, the loss of marsh through erosion and displacement, and the encroachment of saltwater into freshwater areas, which is a contributor to loss of EFH.

The benthic fish populations of the Mississippi Canyon Blocks 809 and 810 is expected to be very low in density. Rowe and Kennicutt (2001) found that species richness and abundance decreased with depth in the GOM. In the 2,000- to 3,000-m depth zone, only 71 species representing 33 families were collected, although nearly one-third of the species were epipelagic or mesopelagic and were probably captured in the water column. Descriptions of other ecological groups of fishes that would occur in the area, including oceanic pelagics and mesopelagics, can be found in Chapters 4.1.1.15 and 4.2.1.18 of the Multisale EIS.

3.7.2. Impact Analysis

A detailed impact analysis of the routine, accidental, and cumulative impacts of the proposed development activities on fish and essential fish habitat can be found in Chapters 4.1.1.15.2 and 4.2.1.18.2 (routine), 4.1.1.15.3 and 4.2.1.18.3 (accidental) and 4.1.1.15.4 and 4.2.1.18.4 (cumulative) of the Multisale EIS, and is incorporated by reference. The IPFs associated with developmental activities proposed in Mississippi Canyon Blocks 809 and 810 that could affect EFH and fish resources include: (1) coastal and marine environmental degradation; (2) presence of a MODU; (3) temporary discharge of drilling cuttings and associated drilling fluids; and (4) blowouts and oil spills.

3.7.2.1. Alternative 1

If selected, Alternative 1, no action alternative, would result in the operator not undertaking the proposed activities as described in the plan. Therefore, the IPFs to fish and EFH would not occur. For example, there would be no drilling noise that would result in behavioral change, masking, or non-auditory effects to the fish resources, no long-term or permanent displacement of fish resources from preferred habitats, and no destruction or adverse modification of any habitats.

3.7.2.2. Alternative 2

If selected, Alternative 2, the proposed action, would result in the operator undertaking the proposed activities as requested and conditioned in the plan. As described in the analyses below, impacts to fish and EFH from the proposed action are expected to be short-term, localized and not lead to significant impacts.

Routine Activities

Routine activities, such as the discharge of drilling fluids and cuttings offshore would contribute to localized temporary marine environmental degradation. Drilling operations are restricted in time, and pelagic species in the area could easily avoid discharge plumes. Routine discharges from the MODU would be highly diluted in the open marine environment. The presence of the MODU will act as a fish-attracting device for the short period of time the rig is on site; however routine discharges on fish resources will be very limited in duration.

Accidental Events

Accidental blowouts and spills with associated hydrocarbons also have the potential to affect fish resources and EFH, but there is no evidence to date that fish or EFH in the Gulf have been adversely affected on a regional population level by spills or chronic contamination. The effects of the Macondo Event Spill on ichthyoplankton, juvenile and adult fish in the GOM and the extent of those effects are, at this time, unknown and will be unknown for some time.

A discussion of the impacts of oil on adult fish, fish eggs, and larvae can be found in Chapters 4.1.1.15.3 and 4.2.1.18.3 of the Multisale EIS. Given that the potential for a blowout or a spill is small, there is a limited possibility for large amounts of oil released from a blowout or spill reaching shore.

In the event of a catastrophic spill similar to the Macondo Event, the Catastrophic Spill Analysis in Appendix B of the Multisale EIS discusses the most likely and most significant impacts to fish as it relates to the four phases of a major spill/blowout:

1) **Initial Event** (Section 2.2.2.2.; Page B-6);
2) **Offshore Spill** (Section 3.2.2.2; Page B-17);
3) **Onshore Contact** (Section 4.2.2.2; Page B-32); and
4) **Post-Spill, Long-Term Recovery** (Section 5.2.2.2; Page B-41).

In the event of a catastrophic spill similar to the Macondo Event, any substantive impact to fish is very unlikely because the potential impacts from a catastrophic spill would be similar to aforementioned routine and accidental issues. However, despite the Macondo Event, historical trends in the GOM (see Chapter 1.4) indicate that catastrophic spill events are not likely to occur as a result of drilling and completion activities associated with the proposed action.

Conclusion

The proposed action is expected to have little impact on any fish or EFH endemic to the northern GOM. Specific effects from any one oil spill would depend on several factors, including timing, location, volume and type of oil, environmental conditions, and countermeasures used. If a blowout occurred, ichthyoplankton, fish eggs, or larvae would suffer mortality in areas where their numbers are concentrated and where oil concentrations are high. However, impacts are still expected to be minimal to nonexistent based on the low probability of a spill occurring (see Chapter 1.4)

Cumulative Impacts

Cumulative activities that could impact fish and EFH in the area of the proposed action include State oil and gas activity, coastal development, crude oil imports by tanker, commercial and recreational fishing, hypoxia (i.e., red or brown tides), removal of OCS structures, and offshore discharges of drilling muds and produced waters. It is expected that environmental degradation from the proposed action and non-OCS activities would affect fish populations and EFH; however, the incremental contribution of the proposed action to these cumulative impacts would be small and almost undetectable. Therefore, no significant cumulative impacts on EFH and fish resources would be expected as a result of the proposed activities when added to the impacts of past, present, or reasonably foreseeable oil and gas development in the area as well as other activities in the area.

3.8. ARCHAEOLOGICAL RESOURCES

3.8.1. Affected Environment

Archaeological resources are defined in 30 C.F.R. § 550.105 as "any material remains of human life or activity that are at least 50 years of age and that are of archaeological interest." Archaeological resources on the OCS can be divided into two types: prehistoric and historic. Detailed descriptions of these resource types are provided in Chapters 4.1.1.19 and 4.2.1.22 of the Multisale EIS. The following information is a summary of these descriptions, which are hereby incorporated by reference into this SEA.

Prehistoric

Geological features that have a high probability for associated prehistoric sites in the northwestern and north central Gulf (from Texas to Alabama) include barrier islands and back barrier embayments, river channels and associated floodplains and terraces, and salt dome features. Also, a high probability for prehistoric resources may exist landward of a line that roughly follows the 60-m bathymetric contour, which represents the Pleistocene shoreline during the last glaciation some 12,000 years ago when the coastal area of Texas and Louisiana is generally considered to have been populated. The water depth in the area of the proposed action precludes the potential for prehistoric sites or artifacts.

Historic

Historic archaeological resources on the federal OCS include shipwrecks and a single light house (Ship Shoal Light). Historic research has identified over 4,000 potential shipwreck locations in the Gulf, with nearly 1,500 of these potential shipwreck locations on the OCS (Garrison et al., 1989). The historic record, however, is by no means complete, and the predictions of potential sites may be inaccurate. As demonstrated by several studies (e.g., Pearson et. al. 2003; Lugo-Fernandez et al., 2007; Krivor et al., 2011; and Rawls and Bowker-Lee, in press) many more shipwrecks are likely to exist on the seafloor than have been accounted for in available historic literature, indicating a high-resolution remote sensing survey may be the most reliable method for identifying and avoiding historic archaeological resources.

Historic shipwrecks have, with the exception of three significant vessels found by treasure salvers, been primarily discovered through oil industry sonar surveys in water depths up to 9,000 ft (2,743.2 m). In fact, in the last 5 years, over a dozen shipwrecks have been located in deep water and nine of these ships have been confirmed visually as historic vessels. Many of these wrecks were not previously suspected to exist in these areas, based on the historic record. A 2003 study recommended including some deepwater areas, primarily on the approach to the Mississippi River, among those lease areas requiring archaeological investigation. With this in mind, BOEM revised its guidelines for conducting archaeological surveys in 2005 and added about 1,200 lease blocks to the list of blocks requiring an archaeological survey and assessment. Archaeological survey blocks were further expanded in 2011 and current requirements are posted on the BOEM website under NTL No. 2005-G07 and Joint NTL No. 2011-G01. Since the addition of new lease blocks beginning in 2005, over 30 possible historic shipwrecks have been reported in the expanded area. At present, some form of survey is required for all new bottom disturbing activities. The preservation of historic wrecks found in deep water has been outstanding because of a combination of environmental conditions and limited human access.

The Macondo Event released an estimated 53,000-62,000 bbl of oil per day for almost 3 months. Much of the oil was treated with dispersant at the sea surface and at the source in a water depth of 1,500 m (5,000 ft). In Chapter 4.1.1.19.3 and 4.2.1.22.1.3 of the Multisale EIS it was concluded that "impacts [from an oil spill] to historic resources would be limited to visual impacts and, possibly, physical impacts associated with spill cleanup operations." This analysis did not anticipate the use of dispersants at the wellhead that could result in currently unknown effects from dispersed oil droplets settling to the seafloor and that could possibly contaminate exposed artifacts and wood or steel hulls such as those observed on many deepwater sites (Atauz et al., 2006; Church et al., 2007; Church and Warren 2008; Ford et al., 2008). The BOEM recognizes the need to better understand the effects of deep water oil spills and dispersants on submerged archaeological resources and is pursuing options for developing studies to assist in collection and interpretation of this data; however, even if a study was initiated immediately, the resulting information would not be available in time to inform the analysis for this proposed action.

The best available information does not provide a complete understanding of the effects, if any, of the spilled oil from the Macondo well and potential response/cleanup activities on archaeological resources that may be located in deep water. Though information on the actual impacts to submerged archaeological resources is non-existent at this time, oil settling to the seafloor due to dispersant use at the wellhead could come into contact with archaeological resources. At present, there is no evidence of this having occurred. A recent experimental study has suggested that while the degradation of wood in terrestrial environments is initially retarded by contamination with crude oil; at later stages, the biodeterioration of wood was accelerated (Ejechi, 2003). While there are different environmental constraints that affect the degradation of wood in terrestrial and waterlogged environments, soft-rot fungal activity, one of the primary wood degrading organisms in submerged environments, was shown to be increased in the presence of crude oil.

3.8.2. Impact Analysis

A detailed impact analysis of the routine, accidental, and cumulative impacts of the proposed development activities on historic archeological resources can be found in Chapters 4.1.1.19.1.2 and 4.2.1.22.1.2 (routine), 4.1.1.19.1.3 and 4.2.1.22.1.3 (accidental) and 4.1.1.19.1.4 and 4.2.1.22.1.4 (cumulative) of the Multisale EIS, and is incorporated by reference. The IPF associated with the proposed action that could affect submerged archaeological resources is seafloor disturbances. These discussions are summarized below and hereby incorporated by reference into this SEA..

The routine IPFs associated with Shell's proposed activities in Mississippi Canyon Blocks 809 and 810 that could affect archaeological resources is limited to direct contact or disturbance during well emplacement activities or equipment used for the drilling operations. The historically-available literature is not sufficient to identify historic shipwreck losses in the area of the proposed action as historic records of losses occurring this far offshore are not location-specific (Pearson et. al. 2003; Lugo-Fernandez et al., 2007; Krivor et al., 2011; and Rawls and Bowker-Lee, 2011). However, if a historic resource exists in the area of drilling, direct physical contact with a shipwreck site could destroy fragile remains, such as the hull and wooden or ceramic artifacts, and could disturb the site context (Atauz et al., 2006; Church and Warren, 2008).

The IPFs that could be associated with accidental events include seafloor disturbances from jettisoned/lost debris and, as discussed above, deterioration from potential oil spills. Similar to routine impacts, discarded/lost material that falls to the seabed has the potential to damage and/or disturb any archaeological resources. Oil spills and their remediation efforts could also accelerate deterioration of archaeological resources. A detailed discussion of all potential impacts is found below.

3.8.2.1. Alternative 1

If selected, Alternative 1, the no action alternative, would result in the operator not undertaking the proposed activities as described in the plan. Therefore, the IPFs mentioned above (i.e., bottom disturbance associated with well emplacement and the use of equipment associated with drilling operations) would not take place, and any impact that these actions could cause would not occur. Likewise, under the no action alternative, there would be no possibility of a spill. As a result, whatever archaeological resources may be present in the area of potential effect (APE) would not be affected in any way if the no-action alternative were selected.

3.8.2.2. Alternative 2

Alternative 2, the proposed action, would result in the operator undertaking the proposed activities as requested and conditioned in the plan. As described in the proposed plan and discussed below, the proposed activities are not expected to have significant impacts on known or unknown historical archaeological resources.

Routine Activities

Historic modeling assumes that shipwrecks would be found closest to shore along the Federal/State boundary or within 10 miles (16 km) of their reported loss location. However high-resolution data acquired by oil and gas industry remote sensing surveys now indicates that this model may be too limited. For example, several vessel casualties from World War II with historically reported coordinates were later discovered well over 10 mi (16 km) outside the 9-block square area assumed to be their location by the model (Irion, 2002). An early nineteenth century steamship lost off the Texas coast was found by treasure salvers over 120 mi (193 km) from the area of its presumed loss in the MMS model (Irion, Official Communication, 2011). These situations, coupled with the fact that no confirmed historic shipwreck sites had been found in any of the designated historic high probability area in 20 years, led to a new study released in 2003 (Pearson et al., 2003) to reassess the high-probability model. Some of the recommendations of this study were implemented in July 2005 with the revision of NTL No. 2005-G07, *Archaeological Resource Surveys and Reports*, which added 1,802 lease blocks, mostly in deepwater areas in Mississippi Canyon (MC), Green Canyon (GC), and Viosca Knoll (VK) areas, to the "high-probability" block list requiring archaeological surveys. Table 3.8.1 below notes the results of the requisite surveys implemented since 2003.

Table 3.8.1.
Archaeological Surveys and Resources Identified since 2003.

Year	Blocks Surveyed	Confirmed Shipwreck Sites	Potential Shipwreck Sites Mitigated by Avoidance (identified through requisite industry surveys)
2003	233	1	514 magnetic anomalies and 43 sonar targets
2004	139	3	342 magnetic anomalies and 57 sonar targets
2005	902	16	768 magnetic anomalies and 116 sonar targets
2006	237	37	799 magnetic anomalies and 254 sonar targets
2007	319	18	652 magnetic anomalies and 189 sonar targets
2008	166	17	705 magnetic anomalies and 212 sonar targets
2009	117	9	479 magnetic anomalies and 103 sonar targets
2010[1]	74	8	275 magnetic anomalies and 101 sonar targets

Prior to NTL No. 2005-G07, there were only 48, 9-mi^2 lease blocks in the MC area that required archaeology surveys/assessments; in which, 9 potential shipwrecks were previously located. Since implementation of the NTL and addition of 794 blocks in the MC area, an additional 25 confirmed shipwrecks have been discovered to date as a result of the surveys conducted on only 306 of those new MC blocks. During that same time period, BOEM also conducted 2,250 archaeological reviews of proposed oil and gas operations in the MC area and identified 537 previously-unreported sonar targets that may or may not represent historic sites. The addition of the new blocks, industry's resultant survey data, and the subsequent increase in the number of shipwrecks discovered further suggests that the potential distribution of significant historic resources is wider than originally thought. To date, two historically-significant shipwrecks (Table 3.8.2.) were found to have suffered damage from drilling activities because of a lack of knowledge of their presence.

[1] BOEMRE GOMR received a substantially lower number of surveys following the Macondo Event.

Table 3.8.2. Archaeological Sites Identified since 2001 that Have Suffered Damage.			
Shipwreck ID Number	Protraction	Survey Available Prior to Permitting (to assist in mitigation)	Damage
15321	VK	No	Anchor chain from a MODU bisected shipwreck causing major damage to site. The site and the damage from the MODU anchoring array were identified during a pipeline survey.
521	GC	No	Site was impacted during anchoring of a MODU. Anchor and chain was hung up on the site during anchor recovery. The site and damage were identified during a pipeline survey and though the damage appears to be major, a complete impact assessment has yet to be conducted.

Recent research on historic shipping routes from the 16th through the 19th centuries concluded that the area of the proposed action is located along the colonial French and Spanish trade routes between Veracruz, New Orleans, and Havana, increasing the likelihood that historic shipwrecks could be located in this area of the GOM (Lugo-Fernandez et al., 2007; Krivor et al., 2011; see Figure 3-1). Krivor et al. (2011) projected a 100 mi (161 km) wide swath encompassing the variation in the depiction of the historic trade routes on contemporary maps. The routes generally struck a course north northeastward from Veracruz until reaching the Loop Current between 25º and 27.5º north latitude, then traveled westward to west Florida, then turned southeast, crossed the Florida Straits, and reached Havana. A wide variability within the general route may be expected as a result of several factors that affected navigation during this period including: the limited capabilities of the navigational technology available to sailors, shifting currents, and prevailing wind patterns and storms.

The study area (including the area of the proposed action) continued to be traversed extensively by shipping throughout the 19th and 20th centuries as new ports developed along the Texas coast, such as Galveston (est. 1825) and Brazos Santiago (1848). With the advent of steam, oil screw, and gasoline or diesel-propelled vessels and improved navigational instruments, sailors' options to set a course irrespective of prevailing winds and currents greatly increased expanding even further the potential for a shipwreck to have occurred in the proposed project area.

No historic information or survey data exists that would determine one way or the other if an archaeological resource is present in the area of the proposed action. However, based upon the studies noted above, the presence of an archaeological resource remains a realistic possibility. As such, Shell's proposed activities have the potential to cause impacts in the event that a heretofore unknown resource is present.

The BOEM's regulation at 30 C.F.R. § 550.194 requires that an archaeological survey be conducted prior to development of leases within the high-probability zones for historic and prehistoric archaeological resources. Currently, Mississippi Canyon Blocks 809 and 810 are designated as a high-probability blocks. However, at present, some form of survey is required for all new bottom disturbing activities. Shell provided a survey as part of BOEM's pre-seabed disturbance guidance which was implemented in 2011 (Shell, 2013).

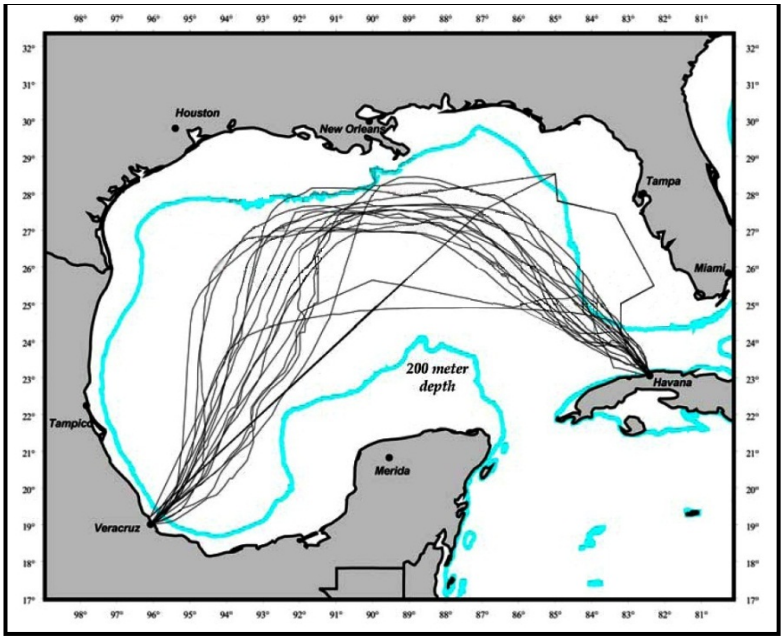

Figure 3-1. Sailing routes across the Northern GOM as depicted on 16th through mid-19th century maps (*from* Lugo-Fernandez et al., 2007).

Impacts to a historic site could result from direct physical contact causing irreversible damage. The undisturbed provenience of archaeological data (i.e., the 3-dimensional location of archaeological artifacts) allows archaeologists to accumulate a record of where every item is found, and to develop a snapshot as to how artifacts relate to other items or the site as a whole. The analysis of artifacts and their provenience is one critical element used to make a determination of eligibility to the National Register of Historic Places and is essential in understanding past human behavior and ways of life. Impacts from drilling operations could alter the provenience and destroy fragile remains, such as the hull, wood, glass, ceramic artifacts and possibly even human remains, or information related to the operation or purpose of the vessel. The destruction and loss of this data eliminates the ability of the archaeologist to fully and accurately detail activity areas found at the site, variation and technological advances lost to history, the age, function, and cultural affiliation of the vessel, and its overall contribution to understanding and documenting the maritime heritage and culture of the region.

Accidental Events

Although unlikely, accidental blowouts and spills from the proposed action could lead to oil contact with submerged archaeological resources. While there is no information on the actual impacts of the Macondo Event on submerged archaeological resources, should an accidental blowout and spill occur during the operator's proposed action, oil may settle on the seafloor due to dispersant use at the wellhead and could come into contact with archaeological resources. Although there is uncertainty and limited data on the effects of an oil spill at depth on submerged archaeological resources, a recent experimental study has suggested that while the degradation of wood in terrestrial environments is initially retarded by contamination with crude oil; at later stages, the biodeterioration of wood was accelerated (Ejechi, 2003). While there are different environmental constraints that affect the degradation of wood in terrestrial and waterlogged environments, soft-rot fungal activity, one of the primary wood degrading organisms in submerged environments, was shown to be increased in the presence of crude oil. No impacts are expected from marine remediation efforts because bottom-disturbing activities are not anticipated due to the water depth.

Another IPF that could result from an accidental event is from the loss of debris from the MODU during drilling operations. Debris such as structural components (i.e., grating, wire, tubing, etc.), boxes, pallets, and other loose items can become dislodged during heavy seas or storm events and fall to the seabed. Similarly, thousands of joints of drill pipe are used during drilling operations; requiring regular transport out to the MODU via workboats. There is the potential to lose pieces of drill pipe during transfer operations or when "tripping pipe" in and out of the wellbore. Similar to the impacts noted under Routine Activities, if lost drill pipe or debris were to fall onto an unknown archaeological resource near the well sites, damage could destroy fragile remains, such as the hull and wooden or ceramic artifacts, and could disturb the site's context and associated artifact assemblage. Additionally, lost material could result in the masking of actual archaeological resources or the introduction of false targets that could be mistaken in the remote sensing record as historic resources.

In the event of a catastrophic spill similar to the Macondo Event, the Catastrophic Spill Analysis in Appendix B of the Multisale EIS discusses the most likely and most significant impacts to archaeological resources as it relates to the four phases of a major spill/blowout:

1) **Initial Event** (Section 2.2.3.1.; Page B-10);
2) **Offshore Spill** (Section 3.2.3.1; Page B-25);
3) **Onshore Contact** (Section 4.2.3.1; Page B-37); and
4) **Post-Spill, Long-Term Recovery** (Section 5.2.3.1; Page B-44).

In the event of a catastrophic spill similar to the Macondo Event, any substantive impact to archaeological resources is very unlikely because the potential impacts from a catastrophic spill would be similar to aforementioned routine and accidental issues. However, despite the Macondo Event, historical trends in the GOM (see Chapter 1.4) indicate that catastrophic spill events are not likely to occur as a result of drilling and completion activities associated with the proposed action.

Conclusion

Based on the previous information and the survey conclusions, there is no reason to believe that archaeological resources could be present in the area of the proposed action. If an unknown archaeological resource were to exist where bottom-disturbing operations are proposed to occur, and the operator were unaware of its existence prior to disturbing the bottom, the operator's activities might have a significant impact on that resource. Such impact would be damage and/or disturbance to the resource from drilling the well and from the associated equipment. Impacts from accidental events related to the proposed action such as accidental oil spills and their remediation efforts are not expected because of the water depth at the well sites and the historically low probability of a loss of well control/blowout. However, debris resulting from accidental events could lead to impacts similar to those expected from routine impacts such as contact with the well and/or well equipment.

Cumulative Analysis

Cumulative impacts on unknown archaeological resources that may be present in the area of the proposed action could result from other GOM activities. Since the water depth at the proposed well sites range from 3,650 to 3,940 ft (1,113 to 1,201 m) and the area of the proposed action is over 53 mi (85 km) from shore, those activities would be limited to commercial fishing, marine transportation, and adjacent oil and gas exploration, development, and production operations.

During adjacent oil and gas operations, commercial fishing, and maritime transportation activities, there is associated the loss or discard of debris that could result in the masking of archaeological resources or the introduction of false targets that could be mistaken in the remote sensing record as historic resources. The area of the proposed action is also located near active areas of active OCS exploration and production fields. Future exploration, development, and production operations and/or any related infrastructure support could lead to bottom disturbances in the area of the proposed action; however, no additional activities have been proposed or are under review at this time. Similarly, geological and geophysical (G&G) surveys have been permitted near the area of the proposed action. These surveys sometimes involve the seabed deployment of receivers and associated anchors that have the potential to damage unknown archaeological resources that may exist in the area of the proposed action; however, their small size and relatively light weight (~65 lbs [34 kg]) is not expected to cause significant impacts.

Any known or unknown archaeological resources that may be present Mississippi Canyon Blocks 809 and 810 could be impacted by contact with oil from a blowout or spill from adjacent oil and gas operations. Similarly, cumulative impacts from accidental oil spills and remediation efforts for adjacent oil and gas operations are not expected because of the water depth at the well sites and the historically low probability of a loss of well control/blowout.

Considering the potential cumulative impacts from all other GOM activities, the operator's proposed activities would constitute the primary effect if any, on any known or unknown archaeological resource that may exist in the area of the proposed action. However, since BOEM's review of the available survey data indicates no submerged archaeological resources are present in the area of the proposed action, no significant cumulative impacts are expected as a result of the proposed action when added to the impacts of past, present, or reasonably foreseeable oil and gas development in the area as well as other proximal activities.

4. CONSULTATION AND COORDINATION

Consultations with FWS and NMFS under Section 7 of the Endangered Species Act of 1973 on the effects of the Five-Year Outer Continental Shelf Oil and Gas Leasing Program (2007-2012) in the Central and Western Planning Areas of the GOM were completed in 2007. The BOEM (Previously MMS) requested annual concurrence from both NMFS and FWS under these existing consultations. For 2010, NMFS communicated their concurrence, by an email message, to BOEM on December 3, 2009, and FWS communicated their concurrence, by an email message to BOEM on December 8, 2009.

In response to the Macondo Event, BOEM will request reinitiation of the existing consultations from both FWS and NMFS. The existing consultations remain in effect until the reinitiated consultation is completed and new Biological Opinions are available. In the interim, BOEM will continue to comply with all Reasonable and Prudent Measures and the Terms and Conditions under these existing consultations, along with implementing the current BOEM-imposed mitigation, monitoring, and reporting requirements. Based on the most recent and best available information at the time, BOEM will also continue to closely evaluate and assess risks to listed species and designated critical habitat in upcoming environmental compliance documentation under NEPA and other statutes.

5. PUBLIC COMMENT

Once the operator's plan was deemed submitted (as per 30 C.F.R. § 550.266(a)), on July 1, 2013 it was placed on Regulations.gov for a 10-day public review. Upon the close of the comment period on July 13,, 2013, no comments were received.

6. REFERENCES

Aharon, P., D. Van Gent, B. Fu, and L.M. Scott. 2001. Fate and effects of barium and radium-rich fluid emissions from hydrocarbon seeps on the benthic habitats of the Gulf of Mexico offshore Louisiana. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2001-004. 142 pp.

American Petroleum Institute (API). 1989. Effects of offshore petroleum operations on cold water marine mammals: A literature review. Washington, DC: American Petroleum Institute. 385 pp.

Anderson, C.M. and R.P. LaBelle, eds. 2000. Update of comparative occurrence rates for offshore oil spills. Spill Science & Technology Bulletin. 6(5-6):303-321, October-December 2000.

Anderson, C.M., M. Mayes, and R. LaBelle. 2012. Update of occurrence rates for offshore oil spills. Bureau of Ocean Energy Management (OCS Report BOEM 2012-069), Herndon, Virginia, 76p. Internet website: Accessed June 27, 2013. http://www.boem.gov/uploadedFiles/BOEM/Environmental_Stewardship/Environmental_Assessment/Oil_Spill_Modeling/AndersonMayesLabelle2012.pdf

Atauz, A.D., W. Bryant, T. Jones, and B. Phaneuf. 2006. Mica shipwreck project: Deepwater archaeological investigation of a 19th century shipwreck in the Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2006-072. 116 pp.

Australian Maritime Safety Authority (AMSA). 2003. Post Spill Monitoring: Background Paper. Prepared by Wardrop Consulting and the Cawthron Institute for the Australian Maritime Safety Authority (AMSA) and the Marine Safety Authority of New Zealand (MSA). Published by AMSA, Canberra. ISBN: 0 642 70991 2.

Basan, P.B., C.K. Chamberlain, R.W. Frey, J.D. Howard, A. Seilacher and J.E. Warme. 1978. Trace fossil concepts. Society of Economic Paleontologists and Mineralogists, Short Course No. 5, Tulsa, OK. 181 pp.

Brooks, J.M., C. Fisher, H. Roberts, B. Bernard, I. McDonald, R. Carney, S. Joye, E. Cordes, G. Wolff, E. Goehring. 2009. Investigations of chemosynthetic communities on the lower continental slope of the Gulf of Mexico: Interim report 2. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2009-046. 360 pp.

Camilli, R., C.M. Reddy, D.R. Yoerger, B.A.S. Van Mooy, M.V. Jakuba, J.C. Kinsey, C.P. McIntyre, S.P. Sylva, and J.V. Maloney. 2010. Tracking hydrocarbon plume transport and biodegradation at Deepwater Horizon. Published online August 19, 2010. Science 8 October 2010:330:6001(201-204). DOI:10.1126/science. 1195223.

Church, R.A. and D.J. Warren. 2008. Viosca Knoll wreck: Discovery and investigation of an early nineteenth-century sailing ship in 2,000 feet of water. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2008-018. 41 pp.

Church, R., D. Warren, R. Cullimore, L. Johnston, W. Schroeder, W. Patterson, T. Shirley. M. Kilgour, N. Morris, and J. Moore. 2007. Archaeological and biological analysis of World War II shipwrecks in the Gulf of Mexico: Artificial reef effect in deep water. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2007-015. 387 pp.

Cohen, Y., Nissenbaum, A., and Eisler, R. 1977. Effects of Iranian Crude Oil on the Red Sea Octocoral *Heteroxenia fuscenscens*. Environmental Pollution. 12(3): 173.186.

Continental Shelf Associates, Inc. (CSA). 2006. Effects of oil and gas exploration and development at selected continental slope sites in the Gulf of Mexico. Volume II: Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2006-045. 636 pp.

Continental Shelf Associates, Inc. and Texas A&M University, Geochemical and Environmental Research Group (GERG). 2001. Mississippi/Alabama Pinnacle Trend Ecosystem Monitoring: Final Synthesis Report. U.S. Dept. of the Interior, Geological Survey, Biological Resources Division, USGS/BRD/CR-2001-0007 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA, OCS Study MMS 2001-080. 415 pp. + apps.

Cook, B.B. and A.H. Knap. 1983. The effects of crude oil and chemical dispersant on photosynthesis in the brain coral, Diploria strigosa. Marine Biology 78:21-27.

Cordes, E.E., M.P. McGinley, E.L. Podowski, E.L. Becker,S., Lessard-Pilon, S.T. Viada, and C.R. Fisher. 2008. Coral communities of the deep Gulf of Mexico. Deep-Sea Research 55(6):777-787.

Darnell, R.M., R.E. Defenbaugh, and D. Moore. 1983. Atlas of biological resources of the continental shelf, northwestern Gulf of Mexico. U.S. Dept. of the Interior, Bureau of Land Management, New Orleans, LA. BLM Open File Report No. 82-04.

Davis, R.W., W.E. Evans, and B. Würsig. 2000. Cetaceans, sea turtles and seabirds in the northern Gulf of Mexico: Distribution, abundance and habitat associations. Volume II: Technical report. U.S. Dept. of the Interior, Geological Survey, Biological Resources Division, USGS/BRD/CR-1999-0006 and U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-003. 346 pp.

Dean, T.A and S.C. Jewett. 2001. Habitat-Specific Recovery of Shallow Subtidal Communities Following the Exxon Valdez Oil Spill. Ecological Applications. 11(5): 1456-1471.

Deepwater Horizon Unified Command (DHUC). 2010. Deepwater Horizon response: Operations and ongoing response – December 11, 2010. Internet website: http://www.restorethegulf.gov/release/2010/12/11/operations-and-ongoing-response-december-11-2010. Accessed June 27, 2013.

Diercks, A-R., R.C. Highsmith, V.L. Asper, DJ. Joung, Z. Zhou, L. Guo, A.M. Shiller, S.B. Joye, A.P. Teske, N. Guinasso, T.L. Wade, and S.E. Lohrenz. 2010. Characterization of subsurface polycyclic aromatic hydrocarbons at the *Deepwater Horizon* site. Geophysical Research Letters, Vol. 37, L20602, doi:10.1029/2010GL045046.

Eckdale, A.A., R.G. Bromley, and S.G. Pemberton. 1984. Ichnology: The use of trace fossils in sedimentology and stratigraphy. Society of Economic Paleontologists and Mineralogists, Short Course No. 15, Tulsa, OK. 317 pp.

Ejechi, B.O. 2003. Biodegradation of wood in crude oil polluted soil. *World Jour. Microb. & Biotech.* 19:799–804.

Energy Resources Co., Inc. (ERCO). 1982. Ixtoc Oil Spill Assessment Final Report. Prepared for the Bureau of Land Management. Contract No. AA851-CTO-71.

Fisher, C.R. 1990. Chemoautotrophic and methanotrophic symbioses in marine invertebrates. Reviews in Aquatic Sciences 2:399-436.

Fisher, C., H. Roberts, E. Cordes, and B. Bernard. 2007. Cold seeps and associated communities of the Gulf of Mexico. Oceanography 20(4):118-129. Internet website: .http://www.tos.org/oceanography/archive/20-4_fisher.html#view. Accessed June 27, 2013.

Florida A&M University. 1988. Meteorological database and synthesis for the Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 88-0064. 486 pp.

Ford, B., A. Borgens, W. Bryant, D. Marshall, P. Hitchcock, C. Arias, and D. Hamilton. 2008. Archaeological excavation of the Mardi Gras Shipwreck (16GM01), Gulf of Mexico continental slope. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2008-037. 313 pp.

French-McCay, D.P. 2004. Oil spill impact modeling: development and validation. Environmental Toxicology and Chemistry, 23(10), 2441-2456.

Frey, R.W. 1975. The study of trace fossils: A synthesis of principles, problems, and procedures in ichnology. New York, NY: Springer-Verlag. 562 pp.

Fu, B. and P. Aharon. 1998. Sources of hydrocarbon-rich fluids advecting on the seafloor in the northern Gulf of Mexico. Gulf Coast Association of Geological Societies Transactions 48:73-81.

Gallaway, B.J. and M.C. Kennicutt II. 1988. Chapter 2. The characterization of benthic habitats of the northern Gulf of Mexico. In: Gallaway, B.J., ed. Northern Gulf of Mexico continental slope study, final report: Year 4. Vol. II: Synthesis report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 88-0053. Pp. 2-1 to 2-45. Internet website: http://www.data.boem.gov/PI/PDFImages/ESPIS/3/3696.pdf. Accessed June 27, 2013.

Gallaway, B.J., L.R. Martin, and R.L. Howard, eds. 1988. Northern Gulf of Mexico continental slope study, annual report: Year 3. Volume II: Technical narrative. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 87-0060. 586 pp. Internet website: http://www.data.boem.gov/PI/PDFImages/ESPIS/3/3774.pdf. Accessed May 28, 2013

Garrison, E.G., C.P. Giammona, F.J. Kelly, A.R. Tripp, and G.A. Wolf. 1989. Historic shipwrecks and magnetic anomalies of the northern Gulf of Mexico: Reevaluation of archaeological resource management zone 1. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 89-0024. 241 pp.

Geraci, J.R. and D.J. St. Aubin. 1980. Offshore petroleum resource development and marine mammals. A review and research recommendations. *Marine fisheries review*, 42:1-12.

Gómez Gesteira, J.L. and J.C. Dauvin. 2000. Amphipods are Good Bioindicators of the Impact of Oil Spills on Soft-Bottom Macrobenthic Communities. Marine Pollution Bulletin. 40(11): 1017-1027.

Gordon, J.C.D., d. Gillespie, L.E. Rendell, and R. Leaper. 1996. Draft report on playback of ATOC like sounds to sperm whales (*Pheseter macrocephalus*) off the Azores. Wildlife Conservation Research Unit, Dept. of Zoology, Oxford, UK.

Greene, C.R. 1986. Underwater sounds from the semisubmersible drill rig SEDCO 708 drilling in the Aleutian Islands. Sect. 1 *In*: API Publ 4438. Am. Petrol. Inst., Washington, DC. 69p.

Guzmán, H.M. and I. Holst. 1993. Effects of Chronic Oil-Sediment Pollution on the Reproduction of the Caribbean Reef Coral Siderastrea siderea. Marine Pollution Bulletin. 26(5): 276-282.

Harvey, J.T. and M.E. Dahlheim. 1994. Cetaceans in oil. In: *Marine Mammals and the Exxon Valdez*. T.R. Loughlin, ed. Academic Press, San Diego: 257-264.

Hazen, T.C., E.A. Dubinsky, T.Z. DeSantis, G.L. Andersen, Y.M. Piceno, N. Singh, J.K. Jansson, A. Probst, S.E. Borglin, J.L. Fortney, W.T. Stringfellow, M. Bill, M.E. Conrad, L.M. Tom, K.L. Chavarria, T.R. Alusi, R. Lamendella, D.C. Joyner, C. Spier, J. Baelum, M. Auer, M.L. Zemla, R. Chakraborty, E.L. Sonnenthal, P. D'haeseleer, H.N. Holman, S. Osman, Z. Lu, J.D. Van Nostrand, Y. Deng, J. Zhou, and O.U. Mason. 2010. Deep-sea oil plume enriches indigenous oil-degrading bacteria. *Science* 330:6001(204-208).

Hernandez, F.J., S. Powers, and W. Graham. 2010. Seasonal variability in ichthyoplankton abundance and seasonal composition in the northern Gulf of Mexico off Alabama. Fish Bull 108:193-207.

Irion, Jack B., 2002. Cultural Resource Management of Shipwrecks on the Gulf of Mexico Outer Continental Slope. Paper presented at the 2nd MIT Conference on Technology, Archaeology, and the Deep Sea. Internet website: http://web.mit.edu/deeparch/www/events/2002conference/papers/Irion.pdf. Accessed June 27, 2013.

Irion, Jack B. 2011. Official Communication. Bureau of Ocean Energy Management, Regulation and Enforcement. New Orleans, LA. February 23, 2011.

Izon, D., E.P. Danenberger, and M. Mayes. 2007. Absence of fatalities in blowouts encouraging in MMS study of OCS incidents 1992-2006. Drilling Contractor, July/August. Pp 84-90. Internet website: http://drillingcontractor.org/dcpi/dc-julyaug07/DC_July07_MMSBlowouts.pdf. Accessed June 27, 2013.

Jefferson, T.A., S. Leatherwood, L.K.M. Shoda, and R.L. Pitman. 1992. Marine mammals of the gulf of Mexico: A field guide for aerial and shipboard observers. Texas A&M University Printing Center, College Station, TX. 92 pp.

Jochens, A.E., L.C. Bender, S.F. Di Marco, J.W. Morse, M.C. Kennicutt II, M.K. Howard, and W.D. Nowlin, Jr. 2005. Understanding the processes that maintain the oxygen levels in the deep Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2005-032. 129 pp. Internet website: http://www.data.boem.gov/PI/PDFImages/ESPIS/2/2933.pdf Accessed June 27, 2013.

Kennicutt II, M.C., ed. 1995. Gulf of Mexico offshore operations monitoring experiment, Phase I: Sublethal responses to contaminant exposure, final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 95-0045. 709 pp. Internet website: http://www.data.boem.gov/PI/PDFImages/ESPIS/1/1267.pdf. Accessed June 27, 2013.

Kennicutt, M.C., J. Sericano, T. Wade, F. Alcazar, and J.M. Brooks. 1987. High-molecular weight hydrocarbons in the Gulf of Mexico continental slope sediment. Deep-Sea Research 34:403-424.

Kennicutt II, M.C., R.H. Green, P. Montagna, and P.F. Roscigno. 1996. Gulf of Mexico offshore operations monitoring experiment (GOOMEX), Phase I: Sublethal responses to contaminant exposure—introduction and overview. Can. J. Fish. Aquat. Sci. 53:2540-2533.

Kessler, J.D., D.L Valentine, M.C. Redmond, M. Du., E.W. Chan, S.D. Mendes, E.W. Quiroz, C.J. Villanueva, S.S. Shusta, L.M. Werra, S.A. Yvon-Lewis, and T.C. Weber. 2011. A persistent oxygen anomaly reveals the fate of spilled methane in the deep Gulf of Mexico. Science Express, 10.1126/science.1199697. Internet website: http://www.sciencemag.org/content/early/2011/01/05/science.1199697. Accessed June 27, 2013.

Krivor, M.C., J. de Bry, N.J. Linville, and D.J. Wells. 2011. Archival investigations for potential colonial-era shipwrecks in ultra-deep water within the Gulf of Mexico. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA. 158 pp.

Louisiana Dept. of Wildlife and Fisheries. 2008a. The impact of Hurricane Gustav on the fisheries resources of Louisiana: Preliminary report. September 8, 2008. 4 pp.

Louisiana Dept. of Wildlife and Fisheries. 2008b. The impact of Hurricane Ike on the fisheries resources of Louisiana: Preliminary report. October 2, 2008. 5pp.

Loya, Y. and Rinkevich, B. 1979. Abortion Effect in Corals Induced by Oil Pollution. Marine Ecology Progress Series. 1: 77-80.

Lugo-Fernández, A., D.A. Ball, M. Gravois, C. Horrell, and J.B. Irion. 2007. Analysis of the Gulf of Mexico's Veracruz-Havana route of *La Flota de la Nueva España.* Journal of Maritime Archaeology 2:24-47. June 2007.

Lutcavage, M., P. Plotkin, B. Witherington, and P.L. Lutz. 1997. Human impacts on sea turtle survival. In: Lutz, P.L. and J.A. Musick, eds. The biology of sea turtles. Boca Raton, FL: CRC Press. Pp. 387-409.

Lutz, P.L. and M. Lutcavage. 1989. The effects of petroleum on sea turtles: Applicability to Kemp's ridley. In: Caillouet, C.W., Jr. and A.M. Landry, Jr., eds. Proceedings of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management. Texas A&M University Sea Grant College Program, Galveston. TAMU-SG-89-105. Pp. 52-54.

MacDonald, I.R., ed. 1992. Chemosynthetic ecosystems study literature review and data synthesis: Volumes I-III. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 92-0033 through 92-0035.

MacDonald, I.R., ed. 2002. Stability and change in Gulf of Mexico chemosynthetic communities. Volume II: Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2002-036. 456 pp.

Malme, C. I., Smith, P. W., and Miles, P. R. 1986. ''Characterisation of geophysical acoustic survey sounds,'' OCS Study. Prepared by BBN Laboratories Inc., Cambridge, for Battelle Memorial Institute to the Department of the Interior-Mineral Management Service, Pacific Outer Continental Shelf Region, Los Angeles, CA.

Marine Resources Research Institute (MRRI). 1984. South Atlantic OCS Area Living Marine Resources Study. Phase III. Volume 1. Final Report. Prepared for the Minerals Management Service, Contract No. 14-12-0001-29185.

McConnaughey, J. 2012. Louisiana's 2nd dead zone could stretch past Alabama. Associate Press. February 8, 2012. Internet website: http://www.gulfhypoxia.net/news/default.asp?XMLFilename=201202081436.xml. Accessed on on June 27, 2013.

MEC Analytical Systems, Inc. 1995. Disturbance of Deep-Water Reef Communities by Exploratory Oil and Gas Operations in the Santa Maria Basin and Santa Barbara Channel. Final Report. Prepared for U.S. Department of the Interior, Minerals Management Service, Pacific OCS Region, Camarillo, CA. Contract No. 14-35-0001-30601, OCS Study MMS 95-0030. 380 pp. Internet website: http://www.data.boem.gov/PI/PDFImages/ESPIS/3/3522.pdf. Accessed June 27, 2013.

Moore, S.F. and R.L. Dwyer. 1974. Effects of oil on marine organisms: A critical assessment of published data. Water Research 8:819-827.

Montagna, P. and Holmberg, T. 2000. Epibiont Recruitment. In McKay, M. and Nides, J. 2000. Proceedings: Eighteenth Annual Gulf of Mexico Information Transfer Meeting. December 1998. US Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-030. 538 pp.

Muller-Karger, F.E., F. Vukovich, R. Leben, B. Nababan, C. Hu, and D. Myhre. 2001. Surface circulation and the transport of the Loop Current into the northeastern Gulf of Mexico: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2001-102. 39 pp.

Murray, S.P. 1998. An observational study of the Mississippi/Atchafalaya coastal plume: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 98-0040. 513 pp.

National Research Council (NRC). 1983. Drilling discharges in the marine environment. Panel on Assessment of Fates and Effects of Drilling Fluids and Cuttings in the Marine Environment. Marine Board, Commission on Engineering and Technical Systems, National Research Council. Washington, DC: National Academy Press.

National Research Council. 1990. The decline of sea turtles: Causes and prevention. Washington, DC: National Academy Press. 183 pp.

National Research Council. 2003. Oil in the sea III: Inputs, fates, and effects (Committee on Oil in the Sea: J.N. Coleman, J. Baker, C. Cooper, M. Fingas, G. Hunt, K. Kvenvolden, J. McDowell, J. Michel, K. Michel, J. Phinney, N. Rabalais, L. Roesner, and R. B. Spies). Washington, DC: National Academy Press. 265 pp.

National Research Council. 2005. Oil Spill dispersants: Efficacy and effects. Washington, DC: National Academy Press. 377 pp.

Neff, J.M. 1990. Composition and fate of petroleum and spill-treating agents in the marine environment. In: Geraci, J.R. and D.J. St. Aubin, eds. Sea mammals and oil: Confronting the risks. San Diego, CA: Academic Press, Inc. Pp. 1-33.

Neff, J.M., T.C. Sauer, and N. Maciolek. 1989. Fate and effects of produced water discharges in nearshore marine waters. Prepared for the American Petroleum Institute, Washington, DC.

Nowlin, W.D., Jr. 1972. Winter circulation patterns and property distributions. In: Capurro, L.R.A. and J.L. Reid, eds. Contributions on the physical oceanography of the Gulf of Mexico. Texas A&M University Oceanographic Studies, Vol. 2. Houston, TX: Gulf Publishing Co. Pp. 3-51.

Operational Science Advisory Team (OSAT). 2010. Summary report for sub-sea and sub-surface oil and dispersant detection: sample and monitoring. Prepared for: Paul F. Zukunft, RADM, U.S. Coast Guard. Federal On-Scene Coordinator. *Deepwater Horizon* MC252. December 17, 2010. Internet website: http://rfflibrary.wordpress.com/2010/12/18/summary-report-for-sub-sea-and-sub-surface-oil-and-dispersant-detection-sample-and-monitoring/. Accessed June 27,

Oil Spill Commission. 2011a. Deepwater: the Gulf oil spill disaster and the future of offshore drilling. Report to the President (ISBN: 978-0-16-087371-3).

Oil Spill Commission. 2011b. The use of surface and subsea dispersants during the BP Deepwater Horizon oil spill. Staff Working Paper No. 4., Updated January 11, 2011. Internet website: http://www.oilspillcommission.gov/resources#staff-working-papers. Accessed June 27, 2013.

Pearson, C.E., S.R. James, Jr., M.C. Krivor, and S.D. El Darragi. 2003. Refining and revising the Gulf of Mexico Outer Continental Shelf Region high-probability model for historic shipwrecks. 3 vols. U.S.

Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2003-060 through 2003-062.

Pequegnat, W.E. 1983. The ecological communities of the continental slope and adjacent regimes of the northern Gulf of Mexico. Prepared by TerEco Corp. for the U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. 398 pp.

Peters, E.C., Meyers, P.A., Yevich, P.P., and Blake, N.J. 1981. Bioaccumulation and Histopathological Effects of Oil on a Stony Coral. Marine Pollution Bulletin. 12(0): 333-339.

Preen, A. 1989. Observations of mating behaviour in dugongs (*Dugong dugon*). Marine Mammal Science 5(4): 382-387.

Pritchard, P.C.H. 1997. Evolution, phylogeny, and current status. In: Lutz, P.L. and J.A. Musivk, eds. The biology of sea turtles. Boca Raton, FL: CRC Press. Pp. 1-28.

Rawls, J.K. and Dayna Bowker-Lee. 2011. Shipwreck research in the New Orleans Notarial Archives. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA, OCS Study BOEMRE 2011-040.

Reddy C.M., Arey J.S., Seewald J.S., Sylva S.P., Lemkau K.L., Nelson R.K., Carmichael C.A., McIntyre C.P., Fenwick J, Ventura G.T., B.A.S. Van Mooy, and R. Camili. 2011. Composition and fate of gas and oil released to the water column during the Deepwater Horizon oil spill. Proceedings of the National Academy of Sciences. Internet website: . http://dx.doi.org/10.1073/pnas.1101242108. Accessed June 27, 2013.

Reddy CM. 2012. Official Communication via electronic mail. Woods Hole, MA. April 4, 2012.

Reimer, A.A. 1975. Effects of Crude Oil on Corals. Marine Pollution Bulletin. 6(3): 39-43.

Richardson, W.J., C.R. Greene, C.I. Mame, and D.H. Thomson. 1995. Marine mammals and noise. San Diego, CA: Academic Press Inc.

Ridgway, S. H., and D. Carder. 2001. ''Assessing hearing and sound production in cetacean species not available for behavioral audiograms: experience with *Physeter, Kogia, and Eschrichtius*,'' Aquat. Mammals 27, 267–276.

Rinkevich, B. and Loya, Y. 1977. Harmful Effects of Chronic Oil Pollution on a Red Sea Scleractinian Coral Population. In Taylor, D.L. (ed). 1977. Proceedings of the Third International Coral Reef Symposium. Volume 2: Geology. Miami Florida. May, 1977.

Rowe, G. and M.C. Kennicutt, eds. 2001. Northern Gulf of Mexico continental slope habitats and benthic ecology: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2001-091. 158 pp.

Ryerson T.B., Camilli R., Kessler J.D., Kujawinski E.B., Reddy C.M., Valentine D.L., Atlas E., Blake D.R., de Gouw J, Meinardi S et al. 2012. Chemical data quantify Deepwater Horizon hydrocarbon flow rate and environmental distribution. Proceedings of the National Academy of Sciences. Internet website: www.pnas.org/cgi/doi/10.1073/pnas.1110564109. Accessed June 27, 2013.

Sadiq, M. and J.C. McCain. 1993. The Gulf War aftermath: An environmental tragedy. Dordrecht: Kluwer Academic Publishers.

Schiro, A.J., D. Fertl, L.P. May, G.T. Regan, and A. Amos. 1998. West Indian manatee (*Trichechus manatus*) occurrence in U.S. waters west of Florida. Presentation, World Marine Mammal Conference, 20-24 January, Monaco.

Schroeder, W.W., S.D. Brooke, J.B. Olson, B. Phaneuf, J.J. McDonough III, and P. Etnoyer. 2005. Occurrence of deep-water *Lophelia pertusa* and *Madrepora oculata* in the Gulf of Mexico. In: Freiwald, A. and J. Murray Roberts, eds. Cold-Water Corals and Ecosystems. New York, NY: Springer Berlin Heidelberg. 1,243 pp.

Shigenaka, G. 2001. Toxicity of oil to reef-building corals: A spill response perspective. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Office of Response and Restoration, Hazardous Materials Response Division, Seattle, WA. NOAA Technical Memorandum NOS OR&R 8. 95 pp.

Shell Offshore Inc. (Shell). 2013. Revised Development Operations Coordination Document. Mississippi Canyon Blocks 765, 808, 809 & 810, OCS-G 12166, 6981, 5868 & 9873, Mississippi Canyon 854 Unit Agreement No. 7543393012, Offshore, Louisiana.

Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene, C.R. Jr., Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A., and Tyack, P. 2007. Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. Aquatic Mammals 33: 411-521.

St. Aubin, D.J. and V. Lounsbury. 1990. "Oil Effects on Manatees: Evaluating the Risks," Chapter 11: J.R. Geraci and D.J. St. Aubin (eds.), Sea Mammals and Oil: Confronting the Risks. San Diego, California: Academic Press, Inc., pp. 241-251.

Sulak, K.J., M.T. Randall, K.E. Luke, A.D. Norem, and J.M. Miller, eds. 2008. Characterization of northern Gulf of Mexico deepwater hard-bottom communities with emphasis on *Lophelia* coral—*Lophelia* reef megafaunal community structure, biotopes, genetics, microbial ecology, and geology. U.S. Dept. of the Interior, Geological Survey (USGS Open-File Report 2008-1148) and Minerals Management Service, Herndon, VA (OCS Study MMS 2008-015). Internet website: http://.biology.usgs.gov//_2008-1148_MMS_2008-015/.html. Accessed June 27, 2013.

Teas, W.G. 1994. Marine turtle stranding trends, 1986-1993. In: Bjorndal, K.A., A.B. Bolten, D.A.Johnson, and P.J. Eliazar, compilers. Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Tech. Memo. NMFS-SEFSC-351. Pp. 293-295.

Trefry, J.H. 1981. A review of existing knowledge on trace metals in the Gulf of Mexico. In: Proceedings of a symposium on environmental research needs in the Gulf of Mexico (GOMEX). Volume II-B. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Environmental Research Laboratory. Pp. 225-259.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2007. Endangered Species Act Section 7 consultation on the effects of the five-year outer continental shelf oil and gas leasing program (2007-2012) in the Central and Western Planning Areas of the Gulf of Mexico. Biological Opinion. June 29. F/SER/2006/02611. 127 pp.

U.S. Dept. of Commerce, National Marine Fisheries Service. 2010. Deepwater Horizon/BP oil spill: Size and percent coverage of fishing area closures due to BP oil spill. Internet website: http://sero.nmfs.noaa.gov/deepwater_horizon/size_percent_closure/index.html. Accessed June 27, 2013.

U.S. Dept. of Commerce, National Marine Fisheries Service and U.S. Dept. of the Interior, Fish and Wildlife Service. 2007a. Leatherback sea turtle (*Dermochelys coriacea*); 5-year review: Summary and evaluation. U.S. Dept. of Commerce, National Marine Fisheries Service, Silver Spring, MD, and U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Service Field Office, Jacksonville, FL. 79 pp. Internet website: http://www.fws.gov/northflorida/SeaTurtles/2007-Reviews/2007-leatherback-turtle-5-year-review-final.pdf. Accessed June 27, 2013.

U.S. Dept. of Commerce, National Marine Fisheries Service and U.S. Dept. of the Interior, Fish and Wildlife Service. 2007b. Green sea turtle (*Chelonia mydas*); 5-year review: Summary and evaluation. U.S. Dept. of Commerce, National Marine Fisheries Service, Silver Spring, MD, and U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Service Field Office, Jacksonville, FL. 102 pp. Internet website http://www.fws.gov/northflorida/SeaTurtles/2007-Reviews/2007-green-turtle-5-year-review-final.pdf. Accessed June 27, 2013.

U.S. Dept. of Commerce, National Marine Fisheries Service and U.S. Dept. of the Interior, Fish and Wildlife Service. 2007c. Hawksbill sea turtle (*Eretmochelys imbricata*); 5-year review: Summary and evaluation. U.S. Dept. of Commerce, National Marine Fisheries Service, Silver Spring, MD, and U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Service Field Office, Jacksonville, FL. 90 pp. Internet website: http://www.fws.gov/northflorida/SeaTurtles/2007-Reviews/2007-hawksbill-turtle-5-year-review-final.pdf. Accessed June 27, 2013.

U.S. Dept. of Commerce, National Marine Fisheries Service and U.S. Dept. of the Interior, Fish and Wildlife Service. 2007d. Kemp's ridley sea turtle (*Lepidochelys kempii*); 5-year review: Summary and evaluation. U.S. Dept. of Commerce, National Marine Fisheries Service, Silver Spring, MD, and U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Service Field Office, Jacksonville, FL. 50 pp. Internet website: http://www.fws.gov/northflorida/SeaTurtles/2007-Reviews/2007-Kemps-ridley-turtle-5-year-review-final.pdf. Accessed June 27, 2013.

U.S. Dept. of Commerce, National Marine Fisheries Service and U.S. Dept. of the Interior, Fish and Wildlife Service. 2007e. Loggerhead sea turtle (*Caretta caretta*); 5-year review: Summary and evaluation. U.S. Dept. of Commerce, National Marine Fisheries Service, Silver Spring, MD, and U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Service Field Office, Jacksonville, FL. 65 pp. Internet website: http://www.fws.gov/northflorida/SeaTurtles/2007-Reviews/2007-Loggerhead-turtle-5-year-review-final.pdf. Accessed June 27, 2013.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010a. Deepwater Horizon oil spill: Characteristics and concerns. Internet website: http://sero.nmfs.noaa.gov/deepwater_horizon/documents/pdfs/fact_sheets/oil_characteristics.pdf. Accessed June 27, 2013.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010b. Administration's Joint Analysis Group releases first scientific report on subsea monitoring data from Gulf spill. Internet website: http://www.noaanews.noaa.gov/stories2010/20100623_brooks.html. Accessed June 27, 2013.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010c. No dead zones observed or expected as part of BP Deepwater Horizon oil spill: Report finds decreased, but stabilized levels of dissolved oxygen in Gulf areas with subsurface oil, September 7, 2010. Internet website: http://www.noaanews.noaa.gov/stories2010/20100907_jag3.html. Accessed June 27, 2013.

U.S. Dept. of Homeland Security. United States Coast Guard. 2010. *Deepwater Horizon* response daily report, period 175. October 12, 2010. Coast Guard Unified Area Command.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management. 2012. Gulf of Mexico OCS oil and gas lease sales; 2012-2017; Western Planning Area Lease Sales 229, 233, 238, 246, and 248; Central Planning Area Lease Sales 227, 231, 235, 241, and 247. final environmental impact statement. 3 vols. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EIA BOEM 2012-019. Internet website: http://www.boem.gov/Environmental-Stewardship/Environmental-Assessment/NEPA/BOEM-2012-019_v1.aspx. Accessed June 27, 2013.

U.S. Dept. of the Interior. Minerals Management Service. 1997. Gulf of Mexico OCS oil and gas lease Sales 169, 172, 175, 178 and 182: Central Planning Area—final environmental impact statement. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 97-0033. Available from NTIS, Springfield, VA: PB98-116916.

U.S. Dept. of the Interior. Minerals Management Service. 2000. Gulf of Mexico deepwater operations and activities: Environmental assessment. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 2000-001. 264 pp.

U.S. Environmental Protection Agency. 2003. National air quality and emissions report, 2003 special studies edition. USEPA Publication No. EPA 454/R-03-005. Research Triangle Park, NC: U.S. Environmental Protection Agency, Office of Air Quality Standards.

U.S. Environmental Protection Agency. 2007. National Estuary Program coastal condition report. U.S. Environmental Protection Agency, Office of Water, Office of Research and Development, Washington DC. EPA-842/B-06/001.

U.S. Environmental Protection Agency. 2009. Coastal condition report III—EPA/842-R-08-002. Internet website: http://.epa.gov//. Accessed June 27, 2013.

U.S. Environmental Protection Agency. 2010. Coastal water sampling. Internet website: Accessed March 14, 2013. http://.epa.gov//.html. Accessed June 27. 2013.

U.S. Environmental Protection Agency. 2011. EPA response to BP spill in the Gulf of Mexico: Questions and Answers on Dispersants. Internet website: http://www.epa.gov/bpspill/dispersants-qanda.html#general. Accessed June 27, 2013.

U.S. Environmental Protection Agency, Region 6. 2012. NPDES General Permit for New and Existing Sources and New Dischargers in the Offshore Subcategory of the Oil and Gas Extraction Point Source Category for the Western Portion of the Outer Contintental Shelf of the Gulf of Mexico (GMG290000) September 28, 2012. Internet website: http://www.epa.gov/region6/water/npdes/genpermit/gmg290000final/gmg290000finalpermit2012.pdf Accessed June 27, 2013.

Valentine, D.L., J.D. Kessler, M.C. Redmond, S.D. Mendes, M.B. Heintz1, C. Farwell, L. Hu, F.S. Kinnaman, S. Yvon-Lewis, M. Du, E.W. Chan, F.G. Tigreros, and C.J. Villanueva. 2010. Propane respiration jump-starts microbial response to a deep oil spill. Science 330:208-211.

Waring GT, Josephson E, Maze-Foley K, Rosel, PE, editors. 2012. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments -- 2011. NOAA Tech Memo NMFS NE 221; 319 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026. Internet website: http://www.nefsc.noaa.gov/publications/tm/tm221/index.html. Accessed June 27, 2013.

Wartzok, D., and D.R. Ketten. 1999. Marine mammal sensory systems. In *Biology of Marine Mammals* (Ed. by J. E. Reynolds and S. A. Rommel), pp. 117-175. Washington, D.C.: Smithsonian Institution Press.

Würsig, B., T. Jefferson, and D. Schmidly. 2000. The marine mammals of the Gulf of Mexico. College Station, TX: Texas A&M University Press.

White House Press Briefing. 2010. Press briefing by Press Secretary Robert Gibbs and National Incident Commander Thad Allen. Posted July 1, 2010. Internet website: http://.whitehouse.gov/press-office/briefing-press-secretary-robert-gibbs-and-national-incident-commander-thad-al. Accessed June 27, 2013.

7. PREPARERS

NEPA Coordinator

Quazi T. Islam	Senior Environmental Scientist

Contributors

Jose Hernanadez	Physical Scientist—Air Quality Issues
Tre Glenn	Biologist—Marine Mammals, Sea Turtles, Protected Species Issues
Darice Breeding	Physical Scientist—Water Quality Issues
Arie Kaller	Biologist—Essential Fish Habitat, Commercial Fishing and Fish Resources
Dave Moran	Biologist—Benthic Communities
Scott Sorset	Marine Archaeologist—Archaeological Issues

Reviewer

Alvin L. Jones	Senior Environmental Scientist
Greg Kozlowski	Unit Supervisor, Operations Assessment Section

8. APPENDIX

Appendix A—Accidental Oil-Spill Discussion

Appendix A
Accidental Oil-Spill Discussion

ACCIDENTAL OIL SPILL DISCUSSION

Introduction

The past several decades of spill data for all water depths on the Gulf of Mexico Federal Outer Continental Shelf (OCS) show that accidental oil spills (≥1,000 barrels [bbl]) associated with oil and gas exploration and development are low-probability events in OCS waters of the Gulf of Mexico (GOM). However, as the 2010 Macondo Event in Mississippi Canyon Area, Block 252 (MC 252) has shown, there is a potential, however slight, for such spills to occur and the impacts have the potential to be catastrophic. The discussion in this appendix describes a low probability catastrophic spill specific to the proposed activity whereas Appendix B of the Multisale EIS (USDOI, BOEM, 2012) provides a more generic overview of potential impacts on the environment from a catastrophic event such as the Macondo spill.

Potential Sources of a Spill

Potential sources of hydrocarbon spills from an OCS drilling activity would include the following:

- a storage tank(s) accident on the MODU;
- a transfer operation mishap between the supply vessel and the MODU;
- a leak resulting from damage to the fuel tanks on one of the supply or crew boats; and/or
- a blowout of one of the proposed wells.

Facility Storage and Transfer Operations

As indicated above, offshore spills from an OCS activity are possible if an accident were to damage a storage tank on board the drilling rig, crewboat, or supply vessels. Transfer incidents during the offloading of diesel fuel to the drilling rig are also possible. The associated tank volumes will vary depending on the rig used and vessel support required for the proposed action. The specifics are outlined in the respective plan and in Chapter 1.4 of the SEA.

Blowout

The Bureau of Ocean Energy Management (BOEM) and the Bureau of Safety and Environmental Enforcement (BSEE) require that all losses of well control (blowouts) be reported. In 2006, BSEE (then MMS) revised the regulations for incident reporting. Consequently, the number of losses of well control or blowouts reported for 2006 may be affected by this change and may make difficult a comparison with data from previous years. The current definition for loss of well control used by BOEM and BSEE:

- uncontrolled flow of formation or other fluids (The flow may be to an exposed formation [an underground blowout] or at the surface [a surface blowout]);
- flow through a diverter; and/or
- uncontrolled flow resulting from a failure of surface equipment or procedures.

Blowouts can occur during any phase of development: exploratory drilling, developmental drilling, completion, production, or workover operations. Blowouts occur when improperly balanced well pressures result in sudden, uncontrolled releases of fluids from a wellhead or wellbore (PCCI, 1999; Neal Adams Firefighters, Inc. 1991). Historically, since 1971, most OCS blowouts have resulted in the release of gas; blowouts resulting in the release of oil have been rare. The most recent blowout occurred on April 20, 2010, at the Macondo well in Mississippi Canyon Block 252 (i.e., Macondo Event). Although this is a rare event, the blowout resulted in the loss of large quantities of gas (to date this volume is undetermined) and oil (estimated 4.9 million bbl of oil) (DHUC, 2010).

As indicated by the Macondo Event, the loss of well control in deep water has proven to be somewhat different than the loss of well control in shallow waters. Although many of the same wild well control techniques used in shallow-water were used to attempt to control the MC 252 well, these well control efforts were hindered primarily due to the water depth, which required reliance solely upon the use of remotely-operated vehicles (ROVs) for all well intervention efforts. This is a concern in deep water because the inability to quickly regain control of a well may result in increases in the size of a spill, as occurred during the Macondo Event. The Macondo Event required that the operator cap and attempt well control efforts at the seabed in very deep water depths (approximately 5,000 ft; 1,524 m) and, although not simultaneously, the operator was also required to handle fire-fighting efforts at the surface when the incident first occurred.

The main scenario for recovery from a blowout event is via intervention with the Blowout Preventer (BOP) attached to the well. There are built in redundancies in the BOP system to allow activation of selected components with the intent to seal off the well bore. However, if the BOP fails, as indicated in the 1991 Final Report of the Joint Industry Program for Floating Vessel Blowout Control and by the MC 252 blowout incident, there are several available options to control a well blowout. Common kill techniques include bridging, capping/shut-in, capping/diverting, surface stinger, vertical intervention, offset kill, and relief wells (Neal Adams Firefighters, Inc. 1991). Capping options and other source control and containment options are described in more detail under the BSEE Spill Response Program Source Control and Containment section of this Appendix. Although much has been learned about well control in deep water as a result of the Macondo Event, in the event that a deepwater subsea blowout occurs in the future, it is likely that an operator will be required to immediately begin to drill one or more relief wells to gain control of the well. This may be required whether or not this is the first choice for well control because the relief well is typically considered the ultimate final solution for well control.

It is estimated that drilling an intervention well in deep water can take anywhere from 30 to 120 days (Regg, Official Communication, 1998; Stauffer, Official Communication, 1998; McCarroll, Official Communication, 1998; BP, 2010). The actual amount of time required to drill the relief well will depend upon the complexity of the intervention, the location of a suitable rig, the type of operation that must be terminated in order to release the rig (e.g., may need to run casing before releasing the rig), and any problems mobilizing personnel and equipment to the location. The BSEE field engineers feel that, if a blowout were to occur, it is more likely for a blowout in deep water to occur at the seafloor rather than at the surface because there is less containment capability subsea (Regg, Official Communication, 1998, Stauffer, Official Communication, 1998, McCarroll, Official Communication, 1998). Accordingly, the MC 252 blowout was a subsea blowout. However, it is possible that a surface blowout could occur.

The major differences between a blowout during the drilling phase versus the completion or workover phases is the drilling well tendency to “bridge off.” Bridging is a phenomenon that occurs when severe pressure differentials are imposed at the well/reservoir interface and the formation around the wellbore collapses and seals the well. Deepwater reservoirs are susceptible to collapse under “high draw down” conditions. However, a completed well may not have the same tendency to passively bridge off as would a drilling well involving an uncased hole. Bridging would have a beneficial effect for spill control by slowing or stopping the flow of oil from the well (PCCI, 1999). There is a difference of opinion among blowout specialists regarding the likelihood of deepwater wells bridging naturally in a short period of time. Completed wells, or those in production, present more severe consequences in the event of a blowout due to the hole being fully cased down to the producing formation, which lowers the probability of bridging (PCCI, 1999). Therefore, the potential for a well to bridge is greatly influenced by the phase of a well.

Estimating Future Potential Spills

OCS Spills in the Past

This summary of past OCS spills presents data for the period 1996-2010. The 1996-2010 period was chosen to reflect more modern engineering and regulatory requirements than were required prior to this and because OCS spill rates are available for this period (Anderson et al., 2012). Information on past spills that have occurred on the OCS is published on the BSEE website (USDOI, BSEE, 2012). During the period 1996-2010, there were 4,957 deepwater wells spudded or drilled on the OCS, not counting bypasses, in water depths of at least 500 ft (152 m). There have been 17 blowouts from these deepwater wells; 5 resulted in a spill, but only 1 (the Macondo Event) resulted in a spill >1,000 bbl. The other four spills were estimated to be 0.02, 11, 26, and 774 bbl of crude/condensate spilled.

For the period 1996-2010, there were two spills ≥1,000 bbl from OCS platforms, seven spills ≥1,000 bbl from OCS pipelines, and one spill ≥1,000 bbl from OCS blowouts (Tables A-1 through A-3).

Table A-1
Historical Record of OCS Spills ≥1,000 Barrels from OCS Facilities, 1996-2010.

Spill Date	Area and Block (water depth and distance from shore)	Volume Spilled (barrels)	Cause of Spill
September 24, 2005	Multiple locations[1]	5,066	One platform and two rigs destroyed by Hurricane Rita
April 20, 2010	Mississippi Canyon 252 (4,992 ft, 53 mi)	4.9 million	Deepwater Horizon rig, gas explosion, blowout, fire.

[1]See Anderson et al. (2012) for details.

Table A-2
Historical Record of OCS Spills ≥1,000 Barrels from OCS Pipelines, 1996-2010.

Spill Date	Area and Block (water depth and distance from shore)	Volume Spilled (barrels)	Cause of Spill
January 26, 1998	East Cameron 334 (264 ft, 105 mi)	1,211	Anchor drag, damage to tie-in to 30" pipeline
September 29, 1998	South Pass 38 (108 ft, 6 mi)	8,212	Hurricane Georges, mudslide damage
July 23, 1999	Ship Shoal 241 (133 ft, 50 mi)	3,200	Jack-up rig barge crushed pipeline when sat down on it
January 21, 2000	Ship Shoal 332 (435 ft, 75 mi)	2,240	Anchor damage from MODU under tow
September 15, 2004	Mississippi Canyon 20 (479 ft, 19 mi)	1,720	Hurricane Ivan, mudslide damage
September 13, 2008	High Island A264 (150 ft, 73 mi)	1,316	Hurricane Ike, anchor damage parted pipeline
July 25, 2009	Ship Shoal 142 (60 ft, 30 mi)	1,500	Micro-fractures from chronic contacts at pipeline crossing caused failure

*condensate

Table A-3
Historical Record of OCS Spills ≥1,000 Barrels from OCS Blowouts, 1996-2010.

Spill Date	Area and Block (water depth and distance from shore)	Volume Spilled (barrels)	Cause of Spill
April 20, 2010	Mississippi Canyon 252 (4,992 ft, 53 mi)	4.9 million	Deepwater Horizon rig, gas explosion, blowout, fire.

Estimating Spill Rates Using Past OCS Spills

Data from past OCS spills are used to estimate future potential OCS spills. The BOEM has estimated spill rates for spills from the following sources: facilities, pipelines, and drilling. Spill rates for facilities and pipelines have been developed for several time periods, and an analysis of trends for spills is presented in *Update of Occurrence Rates for Offshore Oil Spills* (Anderson et al., 2012). Spill rates for the most recent period analyzed, 1996-2010, are presented here. Data for this period should reflect more modern spill-prevention requirements than was required prior to 1996. When comparing the most recent 15-years data (1996-2010) to the last 15-years data in the previous analysis (1985-1999 data; Anderson and LaBelle, 2000), spill rates increased from 0.13 to 0.25 spills per Bbbl for spills ≥1,000 bbl and increased from 0.05 to 0.13 spills per Bbbl for spills ≥10,000 bbl. These rates are still relatively low and include a spill from Hurricane Rita (2005) and the Macondo well spill in 2010.

Spill rates for facilities and pipelines are based on the number of spills per volume of oil handled. Spill rates for blowouts are based on the number of blowouts with a release of oil per number of wells drilled. Spill rates for the period 1996-2012 are shown in Table A-4. The Macondo Event was the one spill from a blowout during 1996-2010. Spill rates are combined with site-specific data on production or pipeline volumes or number of wells being drilled to result in a site-specific risk for a spill to occur as a result of the proposed action.

Table A-4
Spill Rates Used to Estimate the Future Potential for Spills (Based on 1996-2010 Dataset).

Spill Source	Volume of Oil Handled in Billions of Barrels	Number of Wells Drilled	Number of Spills ≥1,000 Barrels	Risk of Spill from Facilities or Pipelines per Billion Barrels	Risk of Spill from Drilling Blowout per Well
Facilities	8.0	Not Applicable	2	0.25	Not Applicable
Pipelines	8.0	Not Applicable	7	0.88	Not Applicable
Drilling	Not Applicable	13,803 [b]	1[a]	Not Applicable	0.00007[c]

[a] The Macondo Event was the one spill from a blowout during 1996-2010.
[b] Sum of exploratory and development wellbores on OCS.

Hydrocarbon Spill Transport

Subsurface Spills

Submerged oils provide unique challenges in oil tracking and fate and transport modeling. Research funded by BOEM (then MMS) to determine oil-spill behavior from subsurface well blowouts in deep water was conducted in June 2000 in the Norwegian Sea. This field experiment is referred to as DeepSpill. The conclusions of the DeepSpill field experiment, two other follow-up laboratory studies, and three model comparisons were summarized in a 2005 report entitled *Review of DeepSpill Modeling Activity Supported by the DeepSpill JIP and Offshore Operators Committee* (Adams and Socolofsky, 2005). The aforementioned six activities resulted in several conclusions about the fate of oil spilled subsurface within deep water. This 2005 report indicated that jets of oil and gas (if present) will break up into droplets and bubbles. The buoyancy of the oil droplets and gas bubbles will form a buoyant plume, with the gas providing the dominant source of buoyancy (if present). Near the point of release, this plume will behave like a single phase plume. Although slight leakage of entrained seawater and fine oil droplets can be expected in the lee of the plume, basic plume features in this near source can be easily described with conventional integral plume models. Above a certain height, ambient stratification and ambient currents will separate the dispersed phases from the entrained water. Above a current speed of 2.5 cm/sec, the current is the major factor, and separation can be expected at elevations of 180 m (591 ft) or less. It was determined that plume dynamics were relatively unimportant when determining the fate of oil released at depths of 800-1,000 m (2,625-3,281 ft) because the plume stage is short when compared with the water depth (Adams and Socolofsky, 2005).

The DeepSpill work indicated that, above the point of separation, gas bubbles and large oil droplets rise toward the surface while small oil droplets continue with the entrained seawater as a buoyant jet. Some of the modeling work indicated that the oil would rise to surface closer to the release point. However, since the field experiment resulted in only a small fraction of the diesel oil being recovered at the surface, it was determined that much of the oil could have been contained in the form of much finer droplets that were much more widely dispersed. Although earlier studies such as the 1997 S.L. Ross study indicated that the gas would be expected to convert very quickly to hydrates during a deepwater release, observations are lacking from the Macondo Event of released gas converting to hydrates, which reinforces the 2005 report's modeling work conclusions (S.L. Ross Environmental Research Ltd., 1997; Adams and Socolofsky, 2005).

The National Oceanic and Atmospheric Administration (NOAA), the U.S. Environmental Protection Agency (USEPA), and the White House Office of Science and Technology Policy released peer-reviewed, analytical summary reports about subsurface oil monitoring in the GOM during the Macondo Event response. Their second report contains preliminary data collected at 227 sampling stations extending from 1 to 52 km (0.6 to 32.3 mi) from the MC 252 wellhead. This data indicated that the movement of subsurface oil is consistent with ocean currents and that concentrations continue to be more diffuse as one moves away from the source of the leak. These results confirmed the findings of their previous report. The fluorometric sampling confirmed that the subsurface oil moved consistent with the observed ocean currents. During the MC 252 response, many techniques were tested to better understand the extent of this unprecedented oil spill, and it was discovered that fluorometric sampling was useful to help identify the location and concentration of subsurface oil. Fluorometers use light waves to detect anomalies in the water column. Fluorometry measurements show repeated signals between approximately 3,300 and 4,300 ft (1,000-1,400 m) deep that were consistent with diffused oil in the water. For the areas sampled, the fluorescence data indicated movement primarily west-southwest until June 2, 2010. In mid-June, fluorescence indicated movement toward the northeast within the Gulf. As previously indicated, these movements were generally consistent with observed ocean currents in the area at that time (USDOC, NOAA, 2010a).

Therefore, in the event of a subsurface release of oil, it is anticipated that some of the oil would remain subsurface, as described above, while the rest would surface (Federal Interagency Solutions Group, Oil Budget Calculator Science and Engineering Team., 2010). Ryerson et al. (2012) reported that ~36 percent of the hydrocarbon mass flow from the MC 252 wellhead remained subsurface, with the caveat that ~23 percent of the flow was unaccounted for. Based upon the DeepSpill research and experience gained during the MC 252 spill incident, it would be expected that any oil contained within the water column would be transported at that same depth by ocean currents. Refer to the section of this appendix entitled "Assumptions about the Characteristics and Fates of Spilled Hydrocarbons" for a discussion of the projected fate of this subsea oil.

Assumptions about the Characteristics and Fates of Spilled Hydrocarbons

Characteristics of Hydrocarbons

It is assumed that a typical diesel fuel oil is used for most drilling activities. Additionally, the oil that is generally produced in the GOM is a medium weight oil. Refer to Table 2 of Appendix B of the Multisale EIS for further discussion regarding oil classification. For the purposes of this scenario, it will be assumed that the oil will have similar chemical characteristics as the oil spilled during the Macondo Event.

Subsurface Spills

If a subsurface spill occurs, it is anticipated that oil released would behave similarly to the oil released during the DeepSpill experiments and during the Macondo Event. Transport of oil in the water column and on the bottom will be dependent upon the properties of the oil, characteristics of the waterbody, and properties of suspended or bottom sediments (Coastal Response Research Center, 2007).

The DeepSpill experiment was conducted in the Norwegian Sea at the Helland Hansen site in June 2000 and included four controlled discharges of oil and gas from a water depth of 844 m (2,769 ft). This experiment was part of the DeepSpill project, organized as a Joint Industry Project (JIP), involving 23 oil companies and BOEM (then MMS). Analysis of water samples taken during this experiment with a rosette sampler (guided by images from the echo sounder) revealed how the composition of the crude oil and diesel released as part of this experiment changed on its way to the sea surface due to dissolution of the water soluble components into the ambient water. The echo sounder images indicated that the methane gas did not reach the sea surface, with the signal from the rising cloud of gas bubbles vanishing from the images at about a water depth of 150 m (492 ft). The crude oil and the diesel oil did reach the sea surface in a relatively shorter period of time than expected. The crude oil release did form water-in-oil emulsion, which was also evident during the Macondo Event. This research also indicated that slicks from a submerged oil release were thinner than those resulting from surface spills, allowing them to weather more rapidly (Johansen et al., 2001). However, the oil released subsea that reached the water surface as a result of the Macondo Event did not seem to behave any differently than would a surface spill of the same oil.

The experiments indicated that oil is water-extracted after its subsea release on its way up to the sea surface. The rate of this extraction depends upon the solubility of the compounds in the water. For example, close to the surface, the naphthalenes are almost completely extracted from the oil. This is important because the water-soluble compounds are the most toxic ones when exposed to marine biota. The results from the experiments showed that the rising of the oil through the water column represents a kind of "stripping" process of some of the most toxic compounds in the oil. Therefore, a portion of the most toxic compounds are left in the water column. The largest concentration of hydrocarbons in the water column will be basically inside the "cloud" of rising oil droplets while the peak concentration may be deeper due to a larger exposure of oil droplets that has passed by. In a surface-generated slick, the most toxic compounds typically evaporate rather than dissolve into the sea (Johansen, et al., 2001).

Likewise, the theory that not all of the oil would surface as a result of a subsurface deepwater release was found to be an accurate assessment based upon observations during the Macondo Event. During the Macondo Event, due to the high speed of its release and application of chemical dispersants, some of the oil was dispersed as oil droplets in the water column as it rose to the surface from a water depth of approximately 5,000 ft (1,524 m). These oil droplets are neutrally buoyant and remain in the water column until they weather. At this time, it is estimated that about 36 percent of the hydrocarbons (by mass) were lost into the water column as a result of dispersion (Ryerson et al., 2012). The NOAA, USEPA, and the White House Office of Science and Technology Policy's summary report about subsurface oil monitoring in the GOM after the MC 252 blowout indicated that average fluorescence in the depths of interest – 3,300 and 4,300 ft (1,005 and 1,311 m) – at sampled locations ranged from 4 to 7 parts per million oil. This estimated value is slightly higher than the laboratory-confirmed values previously reported, which at their highest, near the wellhead, were approximately 1-2 parts per million oil. The fluorometric signal to detect the presence of oil was strongest near the wellhead and decreased with distance, which was consistent with previous sampling. (USDOC, NOAA, 2010a).

For the Macondo Event, research is ongoing related to how much of the oil was dispersed throughout the water column due to the use of subsurface dispersants at the wellhead; however, during the response it was estimated that 10-29 percent of the oil volume discharge could be dispersed by the application of chemical dispersants both on and below the surface (Federal Interagency Solutions Group, Oil Budget Calculator Science and Engineering Team., 2010 (see Fig. 13)). The chemically dispersed oil ended up deep in the water column and just below the surface because both surface and subsurface application was used. Dispersion, whether natural or chemical, increases the likelihood that the oil will be biodegraded, both in the water column and at the surface. However, until it is biodegraded, naturally or chemically dispersed oil, even in dilute amounts, can be toxic to vulnerable species (Lubchenco et al., 2010). Studies are presently ongoing to assess the short and long-term effects of dispersant usage during the Deepwater Horizon event.

Surface Spills

When oil is released in seawater, a combination of physicochemical and biological processes immediately begin to transform the oil into substances with characteristics that differ from the original material, while physical transport processes begin to dissipate it. Physicochemical processes include evaporation, emulsification, dissolution, and photo-oxidation, which are collectively referred to as weathering. Biological processes include microbial oxidation. Microbes consume the oil, and wave action, sun, currents, and continued evaporation and dissolution continue to break down the residual oil in the water and on shorelines. Transport processes include spreading, dispersion and entrainment, sinking and sedimentation, and stranding, which can lead to tar ball formation. These processes are described by the National Research Council (NRC, 2003).

For this scenario, it is assumed that oil would behave somewhat similarly to that spilled during the MC 252 spill. The MC 252 oil was relatively high in alkanes. Because alkanes are made up of single-bonded carbon chains that microorganisms can readily use as a food source, MC 252 oil was considered likely to biodegrade more readily than other crude oils. The MC 252 oil was also considered to be less toxic than some crude oils generally because it was relatively much lower in polyaromatic hydrocarbons (PAHs). The PAHs are highly toxic chemicals that tend to persist in the environment for long periods of time, especially if the spilled oil penetrated into the substrate on beaches or shorelines. The MC 252 oil was also low in sulphur. Like all crude oils, MC 252 oil contained volatile organic compounds (VOC's) such as benzene, toluene, and xylene. Some VOC's are acutely toxic but because they evaporate readily, they are generally a concern only when oil is fresh (USDOC, NOAA, 2010b).

It was estimated by the MC 252 National Incident Command's technical group that approximately 36 percent of the oil spilled as a result of the Macondo Event was lost once it reached the water surface due to dissolution, evaporation, and natural dispersion (Federal Interagency Solutions Group, Oil Budget Calculator Science and Engineering Team., 2010). The majority of this oil that was lost due to evaporation and dissolution (23%). Additional oil was lost due to these same processes as it weathered, although at a much smaller percentage. The evaporation rate was based upon scientific research and observations conducted during the Macondo Event (Federal Interagency Solutions Group, Oil Budget Calculator Science and Engineering Team., 2010). More recent analysis of measurements collected during the oil spill provided estimates of hydrocarbon compositions along different pathways in the environment (Ryerson et al., 2012). Of oil reaching the surface, it was estimated that ~32 percent of the hydrocarbons by mass evaporated and that the remaining surface oil represented a non-volatile mixture.

Once surfaced, the MC 252 oil appeared as black or dark brown oil, sheens, and water-in-oil emulsion, or mousse. The MC 252 oil also formed tar balls. As MC 252 oil reached the surface and spread out across the water, its lighter components, including VOC's, soon evaporated, leaving heavier components behind. Fresh oil appears as a black or dark brown, thick, sticky liquid with petroleum odor. On open water, this oil will spread quickly. In the intertidal zone, this oil could pick up silt and sediment and sink. On the beach, this form of oil could release sheen when washed by tides or waves and could also penetrate beach substrate. Some of the remaining MC 252 oil became sheen, a very thin layer of floating oil (less than 0.0002 inches or 0.005 mm) that can be transparent, grey, silver, or rainbow-colored. Light sheens will degrade quickly while heavier sheens may concentrate on shorelines. The MC 252 oil also mixed with water to form a sticky, pudding-like water-in-oil emulsion, or mousse, typically brown, reddish, or orange in color. Typically, crude oil emulsifies on the sea surface as winds and waves mix it with water, but MC 252 oil also appeared to be incorporating water as it rose to the surface through 5,000 ft (1,524 m) of water. Water content reduces ignitability and biodegradability. Winds and waves tear oil and mousse patches into smaller pieces, eventually producing tar balls. The MC 252 tar balls typically were in the form of small, hard, black pellets. Tar balls can range in size from 5mm to 5 cm (0.20 to 2 inches). Tar balls can be very persistent in the marine environment and travel long distances. On the beach, tar balls may soften in hot sun. In intertidal waters, tar balls can pick up sediment or silt and sink. Occasionally, some burn residue can be mistaken for tar balls. Burn residue is brittle, hard, asphalt-like, and typically mixed with unburned fresh oil. Some of the MC 252 oil gathered offshore just below the water surface in thick mats or patches of emulsified oil (USDOC, NOAA, 2010a).

Dispersion increases the likelihood that the oil will be biodegraded, both in the water column and at the surface. Oil that is chemically dispersed at the surface will move into the top 20 ft (6 m) of the water column where it will mix with surrounding waters and begin to biodegrade. While there is more analysis to be done to quantify the rate of biodegradation in the Gulf after the MC 252 spill, early observations and preliminary research results showed that some of the oil biodegraded fairly quickly. Bacteria that break down the dispersed and weathered surface oil are abundant in the GOM in large part because of the warm water, the favorable nutrient and oxygen levels, and the fact that oil enters the GOM through natural seeps regularly (Lubchenco et al., 2010).

Using the information obtained as a result of the response to the Macondo Event, it is evident that, large amounts of oil could remain on the water surface and within the water column for some period of time during an ongoing spill event if it is not successfully contained by some other subsea source control measure. Approximately 17 percent of the oil was captured through the subsea containment effort during the Macondo Event (Federal Interagency Solutions Group, Oil Budget Calculator Science and Engineering Team., 2010).

Spill Response

Potential impacts from an accidental release of oil from a high-volume blowout are a serious concern; however, the historical database indicates that it is rare for such a pollution event to occur. An operator is responsible for ensuring that the response to an oil spill would be in full accordance with the applicable Federal and State laws and regulations. The BOEM has requirements for preparedness to respond to a spill in the event of an accidental spill (30 C.F.R. Part 254 and 30 C.F.R. 250 Subpart C).

The ability to effectively respond to a spill that might occur in the deepwater areas of the OCS will vary depending upon a number of factors. Among these factors are the chemical and physical characteristics of oil, the volume of oil spilled, the rate of spillage, the weather conditions at the time of the spill, the source of the spill, and the amount of time necessary for response equipment or chemical countermeasures to reach a spill site. The distance from shore for a deepwater drilling project would generally allow more time for cleanup efforts and natural weathering of the oil to take place before oil could reach shore.

Oil-Spill-Response Plan

As required by BOEM and BSEE, operators are required to provide a regional oil-spill-response plan (ROSRP). During the review of an OSRP, the operators can submit a worst case discharge letter in compliance with 30 CFR 254.2(b). This regulatory provision allows an operator to operate their facility for up to two years while the BSEE reviews the OSRP if the operator certifies in writing that they have the capacity to respond to maximum extent possible to a worst case discharge of oil. An OSRP contains procedures for alerting, reporting, and cleaning up in the event of an oil spill. The OSRP is designed to help personnel respond quickly and effectively to environmental incidents and is a "guide" to assist in handling spill-response situations. The operator indicates within their OSRP that they have a current contract with an offshore oil-spill response organization.

The information included in the table below is included in an OSRP. In addition, appendices to this plan include (1) facility information, (2) training information, (3) drill information, (4) contractual agreements, (5) response equipment, (6) support services and supplies, (7) notification and reporting forms, (8) worst-case discharge scenarios, (9) oceanographic and meteorological information, and (10) bibliography. The proposed operations would be required to be conducted under the applicable provisions of OCS regulations and notices and in the interest of safety and pollution control.

Topics Covered by an OSRP			
(1)	OSRP quick guide	(12)	strategic response planning
(2)	preface	(13)	resource protection methods
(3)	introduction	(14)	mobilization and deployment methods
(4)	organization	(15,16)	oil/debris removal/disposal procedures
(5)	spill response operations/communications	(17)	wildlife rehabilitation procedures
(6)	spill detection and source identification	(18)	dispersant use plan
(7,8)	internal and external notifications	(19)	in-situ burn plan
(9)	available technical expertise	(20)	chemical and biological response strategies
(10)	spill assessment	(21)	documentation
(11)	resource identification		

BSEE Spill-Response Program

The BSEE Oil-Spill Program oversees the review of oil-spill response plans, coordinates inspection of oil-spill response equipment, and conducts unannounced oil-spill drills. This program also supports continuing research to foster improvements in spill prevention and response. Studies funded by BSEE address issues such as spill prevention and response, in-situ burning, and dispersant use. In addition, BSEE works with the U.S. Coast Guard (USCG) and other members of the multiagency National Response System to further improve spill-response capability in the GOM.

Subsurface Response

Most oil-spill response strategies and equipment are based upon the simple principle that oil floats. However, as evident during the Macondo Event, this is not always true. Sometimes oil suspends within the water column or sinks to the seafloor and sometimes it does all three: floats, suspends, and sinks. Oil suspended in the water column and moving with the currents is difficult to track using standard visual survey methods. Trajectory models traditionally used to predict floating oil movement and fate are not applicable to submerged oil - oil that is suspended in the water column and/or that sinks. There are no proven methods for the containment of submerged oil, and methods for recovery of submerged oil have limited effectiveness (Coastal Response Research Center, 2007).

Efforts to contain and/or recover suspended oil have focused on different types of nets, either the ad hoc use of fishing nets or specially designed trawl nets. There has been research conducted on the design of trawl nets for recovery of emulsified fuels. However, the overall effectiveness for large spills is expected to be very low. Suspended oil can occur as liquid droplets or semisolid masses in sizes ranging from millimeters to meters in diameter. At spills where oil has been suspended in the water column, responders have devised low technology methods for tracking the presence and spread of oil over space and time. For suspended oil, these methods include stationary systems such a snare sentinels, which can consist of any combination of the following: a single length of snare on a rope attached to a float and an anchor; one or more crab traps on the bottom that are stuffed with snare; and minnow or other type of traps that are stuffed with snare and deployed at various water depths. The configuration would depend upon the water depth where the oil is located within the water column. Currently, it is not possible to determine the particle size, number of particles, or percent oil cover in the water column based upon the visual observations of oil on these systems (Coastal Response Research Center, 2007).

Spills involving submerged oil trigger the need for real-time data on current profiles (surface to bottom), wave energy, suspended sediment concentrations, detailed bathymetry, seafloor sediment characteristics, and sediment transport patterns and rates. These data are needed to validate or calibrate models (both computer and conceptual), direct sampling efforts, and predict the behavior and fate of the submerged oil. This information might be obtained through the use of acoustic Doppler current profilers, dye tracer studies, rapid seafloor mapping systems, and underwater camera or video systems that could record episodic events (Coastal Response Research Center, 2007). During the Macondo Event, Fluorometers were used successfully to detect the presence of oil.

Surface Response

Prior to the DeepSpill sea trials, there was some doubt about whether oil released subsea in deep water would reach the sea surface. The surface slick formed after the DeepSpill crude oil releases contained patches of water-in–oil emulsion with film thickness more than adequate for containment with oil booms and also sufficient thickness for efficient treatment with chemical dispersant, similar to what actually happened during the Macondo Event. However, the DeepSpill sea trials indicated that the potential lifetime of the crude oil slick would be short, which resulted in the report suggesting that the slick could be left to disperse naturally without attempting any mechanical cleanup (Johansen et al., 2001). The fact that the experiment did not involve the quantity of crude that was lost per day and on an ongoing basis for approximately 87 days as occurred during the Macondo Event may account for the observed differences in slick behavior between the experiments and the Macondo Event. As occurred during the Norwegian Sea trials, there was no hydrate formation at the damaged riser during the uncontrolled flow during the MC 252 release.

The MC 252 spill incident indicated that, although released at a water depth of 5,000 ft (1,524 m), once the oil surfaced, a variety of response methods were effective on the oil that surfaced near the source. The options for oil combat in deep water are the same as those used for shallower waters (mechanical recovery, dispersion, in-situ burning). Response to the oil as it emulsified and moved farther from the source proved more difficult. The emulsified oil had to be chased down by the responders, making it more difficult for the skimmers to stay in skimmable oil. The emulsified oil was also less likely to be effectively burned or dispersed.

A variety of standard cleanup protocols were used for removing MC 252 oil from beaches, shorelines, and offshore water (Table A-5).

Table A-5
Primary Cleanup Options Used during the MC 252 Response.

	Fresh Oil	Sheens	Mousse	Tar Balls	Burn Residue
On-Water Response	Disperse, skim, burn	Light sheens very difficult to recover, heavier sheens picked up with sorbent boom or sorbent pads	Skim	Snare boom	Manual removal
On-Land Response	Sorbent pads, manual recovery, flushing with water, possible use of chemical shoreline cleaning agents	Light sheens very difficult to recover, heavier sheens picked up with sorbent boom or sorbent pads	Sorbent pads, manual recovery	Snare boom, manual removal, beach cleaning machinery	Manual removal

Source: USDOC, NOAA, 2010b**.**

Source Control and Containment

After the Deepwater Horizon event occurred, BSEE (then BOEMRE) issued NTL No. 2010-N10 which became effective on November 8, 2010. This NTL applies only to operators conducting operations using subsea blowout preventers (BOPs) or surface BOPs on floating facilities. The NTL also informs lessees that BSEE will be evaluating whether each operator has submitted adequate information demonstrating that it has access to and can deploy surface and subsea containment resources that would be adequate to promptly respond to a blowout or other loss of well control. Although the NTL does not require that operators submit revised Oil Spill Response Plans that include this containment information at this time, operators were notified of BOEMRE's intention to evaluate the adequacy of each operator to comply in the operator's current OSRP. The type of information that BSEE will review for pursuant to this NTL includes, but is not limited to:

- Subsea containment and capture equipment, including containment domes and capping stacks.
- Subsea utility equipment, including hydraulic power, hydrate control, and dispersant injection equipment.
- Riser systems.
- Remotely operated vehicles.
- Capture vessels.
- Support vessels
- Storage facilities.

To address the new improved containment systems expectations to rapidly contain a spill as a result of a loss of well control from a subsea well addressed in NTL No. 2010-N10, several oil and gas industry majors initiated the development of a new, rapid response system. This system is designed to fully contain oil flow in the event of a potential future underwater blowout and to address a variety of scenarios. The system would consist of specially designed equipment constructed, tested, and available for rapid response. It is envisioned that this system could be fully operational within days to weeks after a spill event occurs. The system is designed to operate in up to 10,000 feet water depth and will add containment capability of 100,000 BOPD (4.2 million gallons per day). The companies that originated this system are forming a non-profit organization, the Marine Well Containment Company (MWCC), to operate and maintain the system. MWCC will provide fully trained crews to operate the system, will ensure the equipment is operational and ready for rapid response and will conduct research on new containment technologies. This system will connect by risers to vessels that are designed to safely capture, store and offload the oil. This improves safety and environmental protection by fully securing the well via capping and shut-in or by containing the oil flow until the well is under control. It also enhances safe operations by reducing congestion (i.e., fewer vessels, risers/flowlines). Until this equipment is available, MWCC has built a subsea containment equipment system that is engineered to be used in water depths up to 8,000 feet and has the capacity to contain 60,000 barrels of oil per day. This initial response system includes a capping stack with the ability to shut in oil flow or to flow the oil via flexible pipes and risers to surface vessels.

Another option for source control and containment is through the use of the equipment stockpiled by Helix Energy Solutions Group, Inc (Helix). The Helix initiative involves more than 20 smaller energy companies, and supplements the MWCC response effort. Helix has stockpiled the equipment that it found useful in the MC 252 response and is offering it to oil and gas producers for immediate use. The Helix system centers on three ships: the *Helix Producer I*; the *Q4000*: and the *Express* deepwater construction vessel. These vessels played a role in the Macondo response and continue to work in the Gulf. Together, the Helix ships and related equipment can handle up to 55,000 barrels of oil a day, 70,000 barrels of liquid natural gas and 95 million cubic feet of natural gas at depths up to 8,000 feet. The primary difference between the MWCC system and the Helix system is that nothing needs to be built for the Helix system it has been field tested, and is currently available for deployment. Another group, Wild Well Control, is also providing some subsea containment capability and debris removal to offshore operators.

The BOEM and the BSEE will not allow an operator to begin drilling operations until adequate subsea containment and collection equipment as well as subsea dispersant capability is determined by the agency to be available to the operator and sufficient for use in response to a potential incident form the proposed well(s). However, it would be impossible to predict with any degree of certainty the percentage of oil that could be contained subsea in the event of a spill or when or if complete containment would even be possible. There are some situations where this equipment might not be able to be used to control the well, for example, if the drilling structure were to fall directly on top of the well as debris during a loss of well control event. If a loss of well control event occurred in the future, it is possible that it could be contained in a best case scenario within weeks with the utilization of the rapid subsea containment packages thereby greatly limiting the amount of oil potentially lost to the environment.

Summary

In the event of a spill, particularly a blowout, there is no single method of containing and removing it that would be 100 percent effective. Removal and containment efforts to respond to an ongoing spill would likely require multiple technologies, including mechanical cleanup, burning of the slick, and chemical dispersants. Even with the deployment of all of these technologies, it is likely that, with the operating limitations of today's spill response technology, not all of the oil could be contained and removed offshore. It is likely that larger spills in deep waters under the right conditions would require the simultaneous use of all available cleanup methods (mechanical cleanup, dispersant application, and in-situ burning.

That being said, when one considers the historical/statistical data, the recent subsea containment improvements, BOEM's and BSEE's enhanced oversight, and industry's heightened safety awareness since the Macondo Event, it is reasonable to conclude that an accidental spill event is not very likely to occur.

References

Adams, E.E. and S.A. Socolofsky. 2005. Review of deep spill modeling activity supported by the Deep Spill JIP and Offshore Operators Committee: Final report. 26 pp.

Anderson, C.M. and R.P. LaBelle, eds. 2000. Update of comparative occurrence rates for offshore oil spills. Spill Science & Technology Bulletin. 6(5-6):303-321, October-December 2000.

Anderson, C.M., M. Mayes, and R. LaBelle. 2012. Update of occurrence rates for offshore oil spills. Bureau of Ocean Energy Management (OCS Report BOEM 2012-069), Herndon, Virginia, 76p. Internet website: http://www.boem.gov/uploadedFiles/BOEM/Environmental_Stewardship/Environmental_Assessment/Oil_Spill_Modeling/AndersonMayesLabelle2012.pdf. Accessed on June 27, 2013.

British Petroleum (BP). 2010. Work begins to drill relief well to stop oil spill. Internet website: http://www.bp.com/genericarticle.do?categoryId=2012968&contentId=7061778. Released May 4, 2010. Accessed June 27, 2013.

Coastal Response Research Center. 2007. Submerged oil – State of the practice and research needs. Prepared by the Coastal Response Research Center, Durham, NH. 29 pp. + app.

Deepwater Horizon Unified Command (DHUC). 2010. U.S. scientific teams refine estimates of oil flow from BP's well prior to capping. Internet website: http://www.restorethegulf.gov/release/2010/08/02/us-scientific-teams-refine-estimates-oil-flow-bps-well-prior-capping. August 2, 2010. Accessed March 03, 2013.

Federal Interagency Solutions Group, Oil Budget Calculator Science and Engineering Team. 2010. Oil Budget Calculator, Deepwater Horizon Technical Documentation – A Report to the National Incident Command, November 2010. 217 pp. Internet website: http://www.crrc.unh.edu/publications/OilBudgetCalcReport_Nov2010.pdf. Accessed June 27, 2013.

Johansen, O., H. Rye, A.G. Melbye, H.V. Jensen, B. Serigstad, and T. Knutsen. 2001. Deep Spill JIP – Experimental discharges of gas and oil at Helland Hansen–June 2000: Final technical report. 159 pp.

Lubchenco, J., M. McNutt, B. Lehr, M. Sogge, M. Miller, and S. Hammond. 2010. BP Deepwater Horizon oil budget: What happened to the oil? U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration. 5 pp. Internet website: http://www.noaanews.noaa.gov/stories2010/PDFs/OilBudget_description_%2083final.pdf. : Accessed June 27, 2013.

McCarroll, J. 1998. Official Communication. Discussion regarding blowouts. U.S. Dept. of the Interior, Minerals Management Service, New Orleans District Office, New Orleans, LA.

National Research Council (NRC). 2003. Oil in the sea III: Inputs, fates, and effects (Committee on Oil in the Sea: J.N. Coleman, J. Baker, C. Cooper, M. Fingas, G. Hunt, K. Kvenvolden, J. McDowell, J. Michel, K. Michel, J. Phinney, N. Rabalais, L. Roesner, and R. B. Spies). Washington, DC: National Academy Press. 265 pp.

Neal Adams Firefighters, Inc. 1991. Joint Industry Program for floating vessel blowout control: Final report. DEA -63. Neal Adams Firefighters, Inc., Houston, TX.

PCCI Marine and Environmental Engineering (PCCI). 1999. Oil spill containment, remote sensing and tracking for deepwater blowouts: Status of existing and emerging technologies: Final report. PCCI Marine and Environmental Engineering, Alexandria, VA. 66 pp. + apps.

Regg, J. 1998. Official Communication. Discussion regarding blowouts. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA.

Ryerson, T.B., R. Camilli, J.D. Kessler, E.B. Kujawinski, C.M. Reddy, et al. 2012. Chemical data quantify Deepwater Horizon hydrocarbon flow rate and environmental distribution. PNAS. Internet website: www.pnas.org/cgi/doi/10.1073/pnas.1110564109. Accessed June 27, 2013.

S.L. Ross Environmental Research Ltd. 1997. Fate and behavior of deepwater subsea oil well blowouts in the Gulf of Mexico: Internal report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA.

Stauffer, K. 1998. Official Communication. . Discussion regarding blowouts. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA.

U.S. Dept. of Commerce (USDOC). National Oceanic and Atmospheric Administration (NOAA). 2010a. Second Federal Analysis Gives Further Clues about Location and Movement of Subsurface Oil. Internet website: http://www.noaanews.noaa.gov/stories2010/20100722_jag.html. July 23, 2010. Accessed June 27, 2013.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. National Ocean Service. 2010b. Deepwater horizon oil: Characteristics and concerns. 2 pp. Internet website: http://sero.nmfs.noaa.gov/deepwater_horizon/documents/pdfs/fact_sheets/oil_characteristics.pdf. Acessed June 27, 2013.

U.S. Dept. of the Interior (USDOI). Bureau of Ocean Energy Management (BOEM). 2012. Gulf of Mexico OCS oil and gas lease sales; 2012-2017; Western Planning Area Lease Sales 229, 233, 238, 246, and 248; Central Planning Area Lease Sales 227, 231, 235, 241, and 247. final environmental impact statement. 3 vols. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EIA BOEM 2012-019. Internet website: http://www.boem.gov/Environmental-Stewardship/Environmental-Assessment/NEPA/BOEM-2012-019_v1.aspx Accessed on June 27, 2013.

U.S. Dept. of the Interior (USDOI). Bureau of Safety and Environmental Enforcement (BSEE). 2012. All Petroleum Spills ≥ 1 Barrel from OCS Oil & Gas Activities by Size Category and Year, 1964 to 2011. Internet website: http://www.bsee.gov/uploadedFiles/BSEE/Enforcement/Accidents_and_Incidents/PetroleumSpillsBySizeCatYearSourceFourTabs%20from%20Web%2012-Mar-2012(2).xls. Accessed June 27, 2013.

.