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

SITE-SPECIFIC ENVIRONMENTAL ASSESSMENT

OF

GEOLOGICAL & GEOPHYSICAL SURVEY APPLICATION NO. L13-028

FOR

GULF OCEAN SERVICES, INC.

August 27, 2013

RELATED ENVIRONMENTAL DOCUMENTS

Programmatic Environmental Assessment for Geological and Geophysical Exploration for Mineral Resources on the Gulf of Mexico Outer Continental Shelf (OCS EIS/EA MMS 2004-054)

Final 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. § 1501.3(b) 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. L13-028), of the potential effects of Gulf Ocean Services, Inc.'s application for a permit to perform a Geological and Geophysical (G&G) survey on the Outer Continental Shelf (OCS) of the Gulf of Mexico (GOM). The SEA on the subject action is complete and results in a Finding of No Significant Impact (FONSI). Based on the analysis in and conclusions of the SEA, BOEM finds no evidence to indicate that the proposed action will significantly (40 C.F.R. § 1508.27) affect the quality of the human environment within the meaning of Section 102(2)(c) of the National Environmental Policy Act. Preparation of an Environmental Impact Statement (EIS) is not required.

BOEM has determined that the Conditions of Approval listed below and analyzed in the *Programmatic Environmental Assessment for Geological and Geophysical Exploration for Mineral Resources on the Gulf of Mexico Outer Continental Shelf* (OCS EIS/EA MMS 2004-054); the *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, 2313, 235, 241, and 247; Final Environmental Impact Statement* (Multisale EIS) (USDOI, BOEM, 2012a); and in this SEA are necessary to minimize certain possible adverse effects of this action upon the environment. This FONSI and any subsequent authorization or approval is only valid insofar as the following measures are imposed:

- **VESSEL-STRIKE AVOIDANCE/REPORTING:** The applicant will follow the guidance provided under Joint Notice to Lessees and Operators (NTL) No. 2012-G01 (Vessel Strike Avoidance and Injured/Dead Protected Species Reporting). The NTL's guidance can be accessed on BOEM's internet website at http://www.boem.gov/Regulations/Notices-To-Lessees/2012/2012-JOINT-G01-pdf.aspx.

- **SEISMIC SURVEY OPERATION, MONITORING, AND REPORTING GUIDELINES:** The applicant will follow the guidance provided under Joint NTL No. 2012-G02 (Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program). Additionally, the applicant will comply with the guidance under this NTL when operating in all water depths (not just in water depths >200 m or in the Eastern Planning Area) and the NTL's "Shut-Down conditions" will be applied towards manatees. The NTL's guidance can be accessed on BOEM's internet website at http://www.boem.gov/Regulations/Notices-To-Lessees/2012/2012-JOINT-G02-pdf.aspx.

- **MILITARY WARNING AREA COORDINATION**: Our review indicates that the routes to be taken by boats in support of your proposed activities traverse Military Warning Area W59A (see BOEM Internet website at http://www.boem.gov/Environmental-Stewardship/Environmental-Studies/Gulf-of-Mexico-Region/MWA_boundaries-pdf.aspx for a map of the areas). You shall contact the appropriate individual military command headquarters (see http://www.boem.gov/Environmental-Stewardship/Environmental-Studies/Gulf-of-Mexico-Region/Military-Contacts-pdf.aspx for a list of the contacts) concerning the control of electromagnetic emissions and use of boats in each area before commencing your operations.

- **MARINE TRASH AND DEBRIS AWARENESS AND ELIMINATION:** The applicant will follow the guidance provided under BSEE's Notice to Lessees and Operators (NTL) No. 2012-G01 (Marine Trash and Debris Awareness and Elimination). The NTL's guidance can be accessed on BSEE's internet website at http://www.bsee.gov/Regulations-and-Guidance/Notices-to-Lessees/2012/2012-BSEE-G01-pdf.aspx.

Unit 1 Supervisor, Environmental Operations Section
Office of Environment, GOM OCS Region

August 27, 2013
Date

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SITE-SPECIFIC ENVIRONMENTAL ASSESSMENT (SEA) PREPARED FOR GULF OCEAN SERVICES, INC. GEOLOGICAL AND GEOPHYSICAL SURVEY APPLICATION NO. L13-028

1. PROPOSED ACTION

Gulf Ocean Services, Inc. (Gulf Ocean) has submitted a permit application to conduct a seismic survey and a hazard survey on the Outer Continental Shelf (OCS). This Site-Specific Environmental Assessment (SEA) evaluates the specific impacts associated with Gulf Ocean's proposed Geological and Geophysical (G&G) survey activities. Section 1.3 of this SEA provides specific details on the G&G activities proposed in Gulf Ocean's application. The SEA is tiered from *Geological and Geophysical Exploration for Mineral Resources on the Gulf of Mexico Outer Continental Shelf: Final Programmatic Environmental Assessment* (PEA) (USDOI, MMS, 2004), which evaluated a broad spectrum of potential impacts resulting from G&G activities across the Eastern, Central, and Western Planning Areas of the Gulf of Mexico (GOM) Outer Continental Shelf (OCS). This SEA also tiers from *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, 2313, 235, 241, and 247; Final Environmental Impact Statement* (Multisale EIS) (USDOI, BOEM, 2012a).

"Tiering" is provided in the National Environmental Policy Act (NEPA) implementing regulations (40 C.F.R. § 1502.20 and § 1508.28) and is designed to reduce and simplify the size of environmental assessment documents by eliminating repetitive discussions of impacts discussed in prior NEPA compliance documents, allowing analyses to focus on those site-specific concerns and effects related to the 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.
For this SEA, all of the analyses prepared in the PEA, and the Multisale EIS are sufficiently comprehensive and adequate to support decisionmaking for Gulf Ocean's proposed activities, with the following exceptions:

- **Noise/Vessel-Strike Impacts on Marine Mammals –** new environmental conditions exist, and additional conditions of approval requirements were developed since the preparation of the programmatic analyses;
- **Noise/Vessel-Strike Impacts on Sea Turtles –** new environmental conditions exist, and additional conditions of approval requirements were developed since the preparation of the programmatic analyses;
- **Noise Impacts on Fish and Fisheries –** new environmental conditions exist, and additional peer-reviewed scientific information is available on fish hearing and seismic impacts to fish and fisheries;
- **Space-Use conflicts with other Users of the OCS –** survey operations have the potential to interfere with ongoing military operations in the area of the proposed action; and

Marine mammals, sea turtles, fishes, and commercial and recreational fisheries, as indicated in the PEA, are susceptible to impacts from geophysical activities that may be considered adverse, but not significant. Impacts to fishes and commercial and recreational fisheries from the proposed activities are not expected due to the temporary nature of the operations. This SEA considers the potential for change in the status of resources and the potential for increased sensitivity of those resources to impacts from geophysical activities because of conditions or stresses introduced by the Macondo blowout, spill, and remediation efforts (Macondo Event).

Therefore, Section 3 of this SEA will focus on how the new information, including a discussion of the known effects of the Macondo Event on the analyzed resources, relates to the cumulative environmental effects of this action. Where applicable, relevant affected environment discussions and impact analyses from the PEA and Multisale EIS are summarized and utilized for this site-specific analyses, and are incorporated by reference into this SEA. Relevant mitigation measures identified in the previous PEA and Multisale EIS have been considered in the evaluation of the proposed action.

1.1. BACKGROUND

BOEM and the Bureau of Safety and Environmental Enforcement (BSEE) are mandated to manage the development of OCS oil, gas, and mineral resources while ensuring safe operations and the protection of the human, marine, and coastal environments. One purpose of BOEM's regulatory program is to ensure that the G&G data needed by industry and government are obtained in a technically safe and environmentally sound manner. BOEM and BSEE regulate leasing, exploration, development, production, and decommissioning, and they perform environmental analyses during each of these phases. BOEM's Resource Evaluation (RE) Program oversees "speculative" G&G data acquisition and permitting activities pursuant to 30 C.F.R. Parts 551 and 580. Specifically, 30 C.F.R. Part 551 regulates prelease G&G exploratory operations for oil, gas, and sulfur resources, and 30 C.F.R. Part 580 regulates prelease prospecting activities. BOEM's Office of Leasing and Plans (OLP) oversees "on-lease" or "ancillary" G&G data acquisition pursuant to 30 C.F.R. Part 550, which applies to post lease G&G exploratory operations.

The G&G surveys provide information used by industry and government to evaluate the potential for offshore oil and gas resources and geologic hazards in a particular area. Industry needs accurate data to determine the location, extent, and properties of hydrocarbon resources. They also need information on shallow geologic hazards and seafloor geotechnical properties to assist in the safe and economical exploration, development, production, and transportation of hydrocarbons.

BOEM uses high-resolution geophysical data in each of its primary mission areas. The BOEM and BSEE staff uses these data, such as geohazards review or core sample analysis, to ensure that the proposed site of bottom-founded structures is safe and that the foundations are properly designed. The BOEM staff also uses deep seismic data for estimating the value of resources and bid evaluation to ensure that the Government receives fair-market value for blocks offered for lease. The BSEE Production and Development (PD) staff uses 3D data to map reserves and develop conservation evaluations to ensure the conservation of resources.

Most G&G survey operations direct high-intensity, low-frequency sound waves through layers of subsurface rock that are reflected at boundaries between geological layers with different physical and chemical properties. The reflected sound waves are recorded and processed to provide information about the structure and composition of subsurface, geological formations (McCauley, 1994). In an offshore seismic survey, a high-energy sound source is towed at slow speed behind a survey vessel. The sound source typically used is an airgun – a pneumatic device that produces acoustic output via the rapid release of compressed air. Table II-2 from the PEA lists and provides details on these and other G&G activities commonly occurring in the GOM.

The scope of the effects on GOM resources from activities proposed in Gulf Ocean's G&G survey application, No. L13-028, were fully discussed and analyzed in the PEA. Neither the specific location, equipment, nor the duration of this proposal will result in impacts different from those discussed in the PEA or in the Multisale EIS prepared since that time. However, there is new peer-reviewed scientific literature, monitoring methodologies, and information from the Macondo blowout, spill, and remediation that could cumulatively impact the affected environment. This information was not available or considered during the preparation of the PEA. Therefore, this SEA was prepared by BOEM to evaluate the operator's proposed G&G activities in light of the new information.

1.2. PURPOSE OF AND NEED FOR THE PROPOSED ACTION

The purpose of the proposed action is to conduct a 2D seismic survey using airgun arrays with towed streamers and simultaneously conduct a water bottom hazard survey using side scan sonar, magnetometer, single beam bathymetry and a sub bottom profiler. This information can be utilized to evaluate the potential for, and develop plans for, the development and production of hydrocarbon resources on the OCS, which would help satisfy the Nation's need for energy. Additional information regarding seismic activities can be found on page II-10 and in Table III-1 of the PEA.

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 11 of the OCSLA, 43 U.S.C. 1340, requires anyone seeking to conduct such activities to first obtain approval from BOEM. The Secretary of the Interior oversees the OCS oil and gas program, and BOEM and BSEE are the agencies charged with this oversight and regulated management of the permitted or otherwise authorized oil and gas activities. The Secretary is required to balance orderly resource development with protection of the human, marine, and coastal environments while ensuring that the U.S. public receives a fair return for resources discovered on and produced from public lands (43 U.S.C. 1332(3)).

In response to the proposed action in Gulf Ocean's application, BOEM has regulatory responsibility, consistent with the OCSLA and other applicable laws, to approve, approve with modifications or conditions of approval, or deny the application. BOEM's regulations provide criteria that BOEM will apply in reaching a decision and providing for any applicable conditions of approval.

1.3. Description of the Proposed Action

Gulf Ocean proposes to conduct a 2D seismic survey using airgun arrays with towed streamers and simultaneously conduct a water bottom hazard survey using side scan sonar, magnetometer, single beam bathymetry and a sub bottom profiler.. Gulf Ocean proposes to conduct this survey in the Eugene Island Area in the Central Planning Area (CPA) of the Gulf of Mexico. The area of the proposed action is approximately 35 mi (56 km) from the nearest shoreline and in water depths ranging from 20-30 m (66-98 ft). The operation will be using support vessels whose operations are comparable to that described in the PEA for similar activities. Site-specific analysis was completed using Gulf Ocean's description of the proposed operations; however, specific technical information regarding the G&G activities described in the permit application is proprietary and therefore is not included in this document (Gulf Ocean, 2013). The proposed survey is expected to take approximately one week to complete.

Airguns

In an offshore seismic survey, a high energy sound source is towed at a slow speed behind a survey vessel. The sound source typically used is an airgun array, consisting of pneumatic devices that produce acoustic output through the rapid release of a volume of compressed air. The airgun array is designed to direct the high energy bursts of low-frequency sound (termed a "shot") downward toward the seafloor. Reflected sounds from below the seafloor are received by an array of sensitive hydrophones on cables (collectively termed "streamers") that are either towed behind a survey vessel or attached to cables/nodes placed on or anchored to the seafloor. A typical full-scale array produces a source level of 248-255 dB re µPa-m, zero-to-peak. Typical seismic arrays being used in the GOM produce source levels (sound pressure levels) of approximately 240 dB re 1 µPa @ 1 m. While the seismic array pulses are directed toward the ocean bottom, sound can propagate horizontally for several kilometers (Richardson et al., 1995). Measurements of sources at sea (Goold and Fish, 1998; Sodal, 1999) have demonstrated that, although airgun arrays are primarily a source of low-frequency energy, there is also some transmission of energy at higher frequencies. These energies encompass the entire audio frequency range of 20 Hz to 20 kHz (Goold and Fish, 1998) and may extend well into the ultrasonic range up to 50 kHz (Sodal, 1999).

2. ALTERNATIVES CONSIDERED

2.1. The No Action Alternative

Alternative 1 – *No Action Alternative* – If this alternative is selected, the applicant would not undertake the proposed activity. This alternative might prevent the exploration and development of hydrocarbons, resulting in the potential loss of royalty income and energy resources for the United States.

2.2. The Proposed Action as Submitted

Alternative 2 – If this alternative is selected, the applicant would undertake the proposed activity as requested in the application. The applicant notes that there are no known adverse effects on marine life and proposes no additional conditions of approval (Gulf Ocean, 2013). No additional conditions of approval would be required by BOEM.

2.3. THE PROPOSED ACTION WITH ADDITIONAL CONDITIONS OF APPROVAL

Alternative 3 – This is the Agency's *preferred alternative*. If this alternative is selected, the applicant would undertake the proposed activity, as requested in the application, but with the additional conditions of approval identified by BOEM (listed in Section 2.4 below and described in the effects analyses) to fully address the site- and project-specific impacts of the proposed action.

2.4. SUMMARY AND COMPARISON OF THE ALTERNATIVES

Alternative 1, the no action alternative, would prevent the applicant from acquiring the proper permits and the subsequent collection of seismic data on the OCS. The information would not be available to industry and government to assist in their evaluation of offshore oil and gas resources and geologic hazards in a particular area. Alternative 1 would not result in any impacts to the environmental resources analyzed in Chapter 3, but it does not meet the underlying purpose and need.

Alternative 2 would allow for the collection of seismic data, as requested in the application, but would not include any conditions of approval or monitoring beyond what was stated in the application. Alternative 2 meets the underlying purpose and need of the proposed action but could cause unacceptable impacts to the environmental resources analyzed, as described in Chapter 3 (e.g., hearing loss in marine mammals, injuries to marine mammals and sea turtles from vessel strikes, potential damages to unknown cultural resources on the seafloor). Alternative 2 would not require the implementation of conditions of approval and monitoring measures developed by BOEM, in coordination with the National Marine Fisheries Service (NMFS), to limit the potential for lethal and sublethal impacts to marine mammals and sea turtles. Implementation of these standard conditions of approval and monitoring measures was assumed as part of the analysis in the NMFS 2007 Endangered Species Act (ESA) Biological Opinion and BOEM is committed to requiring their implementation. Additionally, supplemental conditions of approval measures were identified and will need to be imposed to provide further protection for marine mammals (see Section 3.2.3).

Alternative 3 is the preferred alternative, based on the analysis of potential impacts to resources described in Chapter 3, because it meets the underlying purpose and need and also implements conditions of approval and monitoring requirements (described directly below) that adequately limit or negate potential impacts. The G&G activities proposed will provide Gulf Ocean with sufficiently accurate data to determine the location, extent, and properties of potential hydrocarbon resources. Additionally, the collected data supports BOEM's regulatory and oversight responsibilities while promoting the development of hydrocarbon resources, potentially resulting in increased royalty income as well as energy resources for the United States.

Conditions for Approval Required under the Preferred Alternative

The need for and utility of the following conditions of approval are discussed in the relevant impact analysis sections of this SEA. The following conditions of approval and reporting requirements were identified to ensure adequate environmental protection and post-activity compliance:

- **VESSEL-STRIKE AVOIDANCE/REPORTING:** The applicant will follow the guidance provided under Joint Notice to Lessees and Operators (NTL) No. 2012-G01 (Vessel Strike Avoidance and Injured/Dead Protected Species Reporting). The NTL's guidance can be accessed on BOEM's internet website at http://www.boem.gov/Regulations/Notices-To-Lessees/2012/2012-JOINT-G01-pdf.aspx.
- **SEISMIC SURVEY OPERATION, MONITORING, AND REPORTING GUIDELINES:** The applicant will follow the guidance provided under Joint NTL No. 2012-G02 (Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program). Additionally, the applicant will comply with the guidance under this NTL when operating in all water depths (not just in water depths >200 m or in the Eastern Planning Area) and the NTL's "Shut-Down conditions" will be applied towards manatees. The NTL's guidance can be accessed on BOEM's internet website at http://www.boem.gov/Regulations/Notices-To-Lessees/2012/2012-JOINT-G02-pdf.aspx.
- **MILITARY WARNING AREA COORDINATION**: Our review indicates that the routes to be taken by boats in support of your proposed activities traverse Military Warning Area W59A (see BOEM

Internet website at http://www.boem.gov/Environmental-Stewardship/Environmental-Studies/Gulf-of-Mexico-Region/MWA_boundaries-pdf.aspx for a map of the areas). You shall contact the appropriate individual military command headquarters (see http://www.boem.gov/Environmental-Stewardship/Environmental-Studies/Gulf-of-Mexico-Region/Military-Contacts-pdf.aspx for a list of the contacts) concerning the control of electromagnetic emissions and use of boats in each area before commencing your operations.

- **MARINE TRASH AND DEBRIS AWARENESS AND ELIMINATION:** The applicant will follow the guidance provided under BSEE's Notice to Lessees and Operators (NTL) No. 2012-G01 (Marine Trash and Debris Awareness and Elimination). The NTL's guidance can be accessed on BSEE's internet website at http://www.bsee.gov/Regulations-and-Guidance/Notices-to-Lessees/2012/2012-BSEE-G01-pdf.aspx.

2.5. ALTERNATIVES CONSIDERED BUT NOT ANALYZED IN DETAIL

A viable alternative is required to be a logical option for carrying out the proposed action, ensure that the purpose of and need can be met, and be feasible under the regulatory directives of the OCSLA and all other applicable guidance. As such, other alternatives regarding Agency oversight of the G&G permitting program, identified in Sections II.B-II.E of the PEA, were reviewed with the alternatives listed above chosen as reasonable for the current proposed action. Several other alternatives were considered and reviewed during the coordination of the resource reviews, but they were ultimately dismissed and not analyzed further since they did not meet the aforementioned requirements. The following alternative was considered and given review; however, it was not accepted for the reasons discussed below.

Alternative Requiring Imposition of Joint NTL No. 2012-G02 Shut-Down Conditions for Delphinids

This analysis also considered whether to apply the shutdown conditions of Joint NTL No. 2012-G02 to delphinids. From a biological standpoint, the best available information suggests that delphinids are considered mid-frequency specialists (i.e., auditory bandwidth of 150 Hz to 160 kHz) (Southall et al., 2007). Low frequency seismic arrays, such as the one considered for use under this proposed action, generally operate in the frequency range of 20 Hz to 20 kHz (Goold and Fish, 1998) and may extend well into the ultrasonic range up to 50 kHz (Sodal, 1999). Therefore, while the majority of the seismic noise occurs at frequencies below that of delphinids, there are some components that may enter into the hearing range of delphinids (Goold and Fish, 1998). These higher frequency components would be at lower intensity levels (i.e., not as loud). It is unclear, though, from a scientific standpoint whether any of the seismic noise that might be heard by delphinids is in fact disruptive.

Delphinids are known to bow ride on operating seismic vessels. BOEM funded a data synthesis study on the effectiveness of seismic survey mitigation measures and marine mammal observer reports (USDOI, BOEM, 2012b) that analyzed PSO data collected from 2002-2008 in the GOM. Approximately 58% of all dolphin sightings, occurred within the 500 m exclusion zone, and of these, 33% were exhibiting bow-riding behavior.

Looking at these records for a typical year (2009), approximately 400 (~27%) were delphinids within the 500 meter exclusion zone with operating airguns. In that same year, there were 55 records of shut downs for whales within the 500 m exclusion zone. If sources had also been shut down for the 400 sightings of delphinids, this would have resulted in a 7-fold increase in the number of shutdowns. There is little doubt then that a shutdown provision for delphinids within the exclusion zone would have a significant impact on seismic operations, such as those under the proposed action.

BOEM next considered whether a provision could be applied to allow for a reasonable exception for bow riding delphinids. For example, a provision could be considered that would allow PSOs to call for a power down (versus immediate shut down) of the seismic source to the smallest airgun should any delphinid enter, or come close to entering, the 500 meter exclusion zone referenced on page 2, paragraph 4 of Joint NTL No. 2012-G02. If the delphinid(s) leave the exclusion zone or engage in bow riding behavior then the PSO could call for the immediate return of the array to full power. This would allow for an opportunity for the PSO to determine if the behavior of the animal(s) warranted a shut down and if

not would allow the applicant to return to full power more quickly (versus a shut down followed by a 30 minute clearance of the zone and a 20-40 minute ramp up procedure).

Based on the PSO sighting records, it is clear that shut downs for delphinids would result in an impact to industry activities. Unlike other sound producing activities (e.g., sonar), seismic surveys occur on specified tracklines that need to be followed in order to meet the data quality objectives of the survey. In other words, seismic vessels in operation cannot simply divert away from nearby marine mammals without a loss in data quality. As stated above, an analysis of 2009 PSO data indicate that if shut downs for delphinids within the exclusion zone were employed there would have been a 7-fold increase in shut downs of seismic arrays that year. Each of these shut downs would have required a 30 minute observation period to ensure animals have left the exclusion area followed by a 20-40 minute ramp up procedure. In all likelihood, these shut downs would then have required the applicants to return to an earlier point in the track line and resurvey the area again. This not only results in substantially more expense in down time and repositioning of seismic arrays and streamers but would also likely increase the duration of and amount of total seismic noise for each affected survey area.

Conclusion

Based on the analysis above, BOEM believes it is essential to more fully investigate and vet the application of Joint NTL No. 2012-G02 to delphinids before requiring it as a condition of approval in the GOM (under Alternative 3) or considering it as an additional alternative to the proposed action. It is BOEM's intention, therefore, to fully analyze the application of this condition of approval.

3. DESCRIPTION OF THE AFFECTED ENVIRONMENT AND ENVIRONMENTAL IMPACTS

3.1. INTRODUCTION

The discussion below will: (1) describe/summarize the pertinent potentially affected resources; (2) determine whether the proposed G&G activities and their impact-producing factors (IPF's) will have significant impacts on the marine, coastal, or human environments of the GOM; and (3) identify significant impacts, if any, that may 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 each potentially affected resource, BOEM staff reviewed and analyzed all currently available peer-reviewed literature and integrated these data and findings into the analyses below. The analyses cite the best available, relevant scientific literature. BOEM performed this analysis to determine whether Gulf Ocean's proposed seismic survey activities will significantly impact the marine, coastal, or human environments of the GOM. 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). The criteria for impacts to environmental resources are generally classified into one of the three following levels:

Significant Adverse Impact (including those that could be mitigated to nonsignificance);

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 PEA (USDOI, MMS, 2004); and the Multisale EIS (USDOI, BOEM, 2012a); and relevant literature pertinent to historic and projected activities.

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 and fisheries;
- coastal and marine birds (including ESA-listed species);
- benthic communities;

- archaeological resources;
- military uses;
- recreational and commercial diving;
- marine transportation;
- geology/sediments; and
- air and water quality.

In the PEA, the impact analysis focused on a broad group of G&G activities and resources with the potential for non-negligible impacts. First, a matrix identifies impact agents associated with each type of G&G activity (Table III-1 of the PEA; USDOI, MMS, 2004). The impact agents include: (1) airgun noise; (2) sonar noise; (3) seafloor disturbance; (4) vessel traffic; (5) towed streamers; and (6) aircraft traffic. A second matrix in the PEA identifies resources potentially affected by each type of G&G activity (Table III-2 of the PEA; USDOI, MMS, 2004). The preliminary analysis in the PEA considers surveys of the type proposed by Gulf Ocean as well as impacts to resources relevant to the proposal. To assist with subsequent coordination, the PEA's analysis further defines the level of impact associated with each interaction as follows:

No Impact (i.e., no measurable impact to a resource evident);

Negligible Impact (i.e., measurable but relatively minor impact to a resource predicted); or

Potentially Adverse Impact (i.e., possible measurable impact to a resource predicted).

The PEA notes that seismic surveys have historically covered a large area of the GOM each year and, when unmitigated, have the greatest potential for "significant" impacts to protected and other sensitive marine species in comparison with other OCSLA-approved activities, including, but not limited to, exploration and development drilling. Further, it acknowledges increasing concerns in the regulatory and scientific communities regarding acoustic impacts on marine life, including marine mammals, turtles, and fishes. Species of particular concern are those whose hearing capabilities (based on vocalization characteristics) fall within the low frequencies introduced into the marine environment by seismic and geophysical activities. The PEA provides a comprehensive characterization of biological resources that may be adversely affected by G&G activities. This information is summarized in the various resource-specific descriptions of the affected environment and impact analyses in sections that follow.

However, for the purposes of this SEA, BOEM has not included analyses on resource areas that were evaluated and considered under the PEA as having negligible impacts (see 40 C.F.R. § 1508.27) from G&G activities. Additionally, since no expansion or modification of support bases or related vessel construction work are proposed as a result of this activity, socioeconomic effects were not analyzed due to the type, the temporary nature, and employment size of the survey activity. The most recent evaluation of the best available peer-reviewed scientific literature continues to support this conclusion for the following resource categories:

- coastal and marine birds (including ESA-listed species);
- benthic communities;
- recreational and commercial diving;
- archaeological resources;
- marine transportation;
- geology/sediments; and
- air and water quality.

For this SEA, BOEM evaluated the potential impacts from the applicant's proposed G&G activities in the GOM on the following resource categories:

- marine mammals (including threatened/endangered and non-ESA-listed species);
- sea turtles (all are ESA-listed species);
- fish and fisheries;
- other users of the OCS (i.e., space-use conflicts with military operations).

Macondo Well Blowout, Spill, and Remediation (Macondo Event)

The blowout of and subsequent spill from the Macondo Well in Mississippi Canyon Block 252 resulted in the sinking of the *Deepwater Horizon* offshore drilling rig, the deaths of 11 of its crew, and a catastrophic oil spill in the GOM. The cumulative impact analysis in this SEA also considers the potential impacts from the pollution event, oil-spill response, and remediation efforts. The proposed action may present IPFs, which are those factors that could result in incremental or additional effects considering existing environmental conditions and other actions associated with the blowout, spill, and remediation.

There is ongoing research to assess the impacts to resources from the Macondo Event. Results of this research are forthcoming, and BOEM will update future analyses as this information becomes available. For many resources, the data are still being collected and analyzed through the National Resource Damage Assessment (NRDA) process. BOEM continues to seek data and research results from the NRDA process and the scientific community.

3.2. MARINE MAMMALS

3.2.1. Description

The U.S. Gulf of Mexico marine mammal community is diverse and distributed throughout the northern Gulf waters. Twenty-one species of cetaceans regularly occur in the Gulf of Mexico (Jefferson et al., 1992; Davis et al., 2000) and are identified in the NMFS GOM Stock Assessment Reports (Waring et al., 2012) in addition to one species of Sirenian. The Gulf of Mexico'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.

There are species that have been reported from Gulf waters, either by sighting or stranding, that are not considered in this document (Würsig et al. 2000; Mullin and Fulling 2004). These species include the blue whale (*Balaenoptera musculus*), the northern right whale (*Eubalaena glacialis*), and the Sowerby's beaked whale (*Mesoplodon bidens*), all considered extralimital in the Gulf of Mexico, and the humpback whale (*Megaptera novaeangliae*), the fin whale (*Balaenoptera physalus*), the sei whale (*Balaenoptera borealis*), and the minke whale (*Balaenoptera acutorostrata*), all considered rare occasional migrants in the Gulf (Würsig et al., 2000; Mullin and Fuling, 2004). Because these species are uncommon in the GOM, they are not included in the most recent NMFS Stock Assessment Reports for the GOM (Waring et al., 2012).

Threatened or Endangered Marine Mammal Species

There is only one cetacean, the sperm whale (*Physeter macrocephalus*), and one sirenian, the West Indian manatee (*Trichechus manatus*) that regularly occur in the GOM and that 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. The West Indian manatee (*Trichechus manatus*) typically inhabits only coastal marine, brackish, and freshwater areas.

The life history, population dynamics, status, distribution, behavior, and habitat use of baleen and toothed whales can be found in Appendix E of the PEA and Chapters 4.1.1.11 and 4.2.1.12 of the Multisale EIS, and is incorporated by reference. Additional information may also be found in the NMFS 2009 SAR (Waring et al., 2012).

Non-ESA-Listed Marine Mammal Species

One baleen cetacean (Bryde's whale) and 19 toothed cetaceans (including beaked whales and dolphins) occur in the Gulf of Mexico. None of these species are protected under the ESA however all marine mammals are protected under the Marine Mammal Protection Act (1972).

The only commonly occurring baleen whale in the northern Gulf of Mexico is the Bryde's whale (*Balaenoptera edeni*). The other baleen whales that have been sighted in the GOM are either considered rare or extralimital by Waring et al. (2011). Most sightings have been made in the DeSoto Canyon region and off western Florida, although there have been some in the west-central portion of the northeastern

GOM. The best estimate of abundance for Bryde's whales in the northern GOM is 15 individuals (Waring et al., 2012).

Non-ESA-listed toothed whales include all of the dolphin and small whale/"blackfish" species in the GOM. Two species groups may warrant particular concern regarding seismic activities. 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).

Marine Mammal Hearing

All marine mammals produce and use sound to communicate with another animal of the same species to navigate and sense their environment, to locate and capture prey, and to detect and avoid predators (Southall et al., 2007). The hearing of marine mammals varies based on individuals, absolute threshold of the species, masking, localization, frequency discrimination, and the motivation to be sensitive to a sound (Richardson et al., 1995). Southall et al. (2007) described the frequency sensitivity in five functional hearing groups of marine mammals by combining behavioral and electrophysiological audiograms with comparative anatomy, modeling, and response measured in ear tissues. For potentially affected marine mammal species in the GOM, the main functional hearing groups include (1) low-frequency cetaceans with an estimated auditory bandwidth of 7 Hz to 22 kHz, (2) mid-frequency cetaceans with functional hearing of approximately 150 Hz to 160 kHz, and (3) high-frequency cetaceans with functional hearing estimated from 200 Hz to 180 kHz. These hearing sensitivity and frequency ranges are based on audiograms that are obtained by either: (1) behavioral testing on captive, trained animals; or (2) electrophysiological or auditory evoked potential (AEP) methods (Richardson et al., 1995). Currently, there are no behavioral or AEP audiograms for low-frequency cetaceans available. Audiograms, both behavioral and AEP, are available for some mid-frequency and high-frequency cetaceans (Richardson et al.; 1995; Nedwell et al., 2004: Southall et al., 2007; Au and Hastings, 2008).

3.2.2. Impact Analysis

The IPFs associated with the proposed action that could affect both ESA-listed and non-ESA-listed marine mammals are primarily noise from survey activities and collisions with seismic survey vessels. Chapter III.C.1 of the PEA contains a discussion of the potential impacts from survey operations on marine mammal resources (USDOI, MMS, 2004). Additional information about routine impacts from oil and gas activity on impacts on marine mammals is addressed in Chapters 4.1.1.11.2 and 4.2.1.12.2 of the Multisale EIS and the current ESA Section 7 consultation for 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 (5-Year Program) (USDOC, NMFS, 2007). The discussions are summarized below and are incorporated by reference into this SEA. In their 2007 Biological Opinion, NMFS recognized that "sperm whales are expected to be harassed through disruption of important biological behaviors as a result of the use of airguns in seismic surveys." However, the water depths in the area of the proposed action preclude the potential for the aforementioned cetaceans. The best available scientific information also indicates that seismic airgun noise may affect non-ESA-listed marine mammal species (Southall et al, 2007).

3.2.2.1. Alternative 1

If selected, Alternative 1, the no action alternative, the applicant would not undertake the proposed activities. Therefore, the impact producing factors to marine mammals would not occur. For example, there would be no vessel noise or seismic airgun 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. Since there would be no vessel traffic related to the towing of the airgun array, there would be no risk of collisions with marine mammals.

3.2.2.2. Alternative 2

If selected, Alternative 2, the proposed action as proposed, the applicant would undertake the proposed activities, as requested and conditioned in the application. Examples of potential impacts to marine

mammals without implementation of the above referenced conditions of approval and monitoring include, but are not limited to: injury from vessel strikes, hearing loss from seismic noise, disruption of feeding and other behaviors from seismic noise and vessel presence. This Alternative would not adequately limit or negate potential impacts to marine mammals.

3.2.2.3. Alternative 3

If selected, Alternative 3, the proposed action with additional conditions of approval, the applicant would undertake the proposed activities, as requested and conditioned in the application; however, the applicant would be required to undertake additional conditions of approval as identified by BOEM, in coordination with NMFS and in accordance with the NMFS ESA consultation requirements (i.e., Joint NTL No. 2012-G02 (Protected Species Observers) and Joint NTL No. 2012-G01 (Vessel Strike Avoidance)). Additional conditions of approval related to reducing impacts on animals that may be under stress as a result of the Macondo Event and/or the ongoing unusual mortality event (UME) are also discussed below and outlined in Chapter 2.4. For the reasons set forth below, inclusion of these measures under Alternative 3 limits or minimizes potential impacts to marine mammals.

Potential Impacts to Marine Mammals from Seismic Noise

Marine mammals exposed to natural or manmade sound may experience physical and psychological effects, ranging in magnitude from none to severe (Southall et al., 2007). Four areas of primary concern for marine mammals exposed to elevated noise levels include the following: (1) permanent loss of hearing; (2) temporary loss of hearing; (3) behavioral response; and (4) masking (Nowacek et al., 2007). Other literature also suggests that there may be non-auditory effects, such as gas-bubble formation and stress.

Scientific uncertainty remains regarding the nature and magnitude of the actual impacts of seismic noise on the behavior of marine mammals, particularly when it comes to distinguishing between a general behavioral response and a biologically significant one. As noted in Southall et al. (2007), some of this uncertainty is related to data suffering from low sample sizes, limited information on received sound levels and background noise, insufficient measurements of all potentially important contextual variables, and/or insufficient controls with most behavioral studies suffering from at least some of these problems.

Permanent Hearing Loss

Permanent loss of hearing in a marine mammal (i.e., permanent threshold shift [PTS]) is defined as the deterioration of hearing due to prolonged or repeated exposure to sounds that accelerate the normal process of gradual hearing loss (Kryter, 1985) or the permanent hearing damage due to brief exposure to extremely high sound levels (Richardson et al., 1995). Permanent threshold shift results in a permanent elevation in hearing threshold; that is, an unrecoverable reduction in hearing sensitivity (Southall et al., 2007). Direct physical effects, such as PTS, require relatively intense, received energy that would be expected to occur only at short distances from the G&G seismic survey source (Nowacek et al., 2007; Zimmer and Tyack, 2007). According to Southall et al. (2007) PTS for cetaceans from multiple pulse sources (e.g., seismic) is established at 230 dB re 1 μPa (peak).

Temporary Hearing Loss

Manmade sound may also cause a temporary and reversible loss of hearing called a temporary threshold shift (TTS), which may continue for minutes to hours or even days. A TTS is quite common in humans and often occurs after being exposed to loud sounds, such as during a fireworks demonstration, in a modern sports stadium, or at a rock concert. The duration of TTS depends on a variety of factors, including intensity and duration of the stimulus, and recovery can take minutes, hours, or days as well. Therefore, animals suffering from TTS over longer time periods, such as hours or days, may be considered to have a change in a biologically significant behavior, as they could be prevented from detecting sounds that are biologically relevant, including communication sounds, sounds of prey, or sounds of predators (U.S. Department of the Navy, 2008a and 2008b). Southall et al. (2007), establishes PTS for cetaceans from multiple pulse sources (e.g., seismic) at 230 dB re 1 μPa (peak).

Behavioral Response

In Southall et al. (2007), an expert panel reviewing available literature on behavioral response to anthropogenic noise were unable to reach a consensus on what level of sound may serve as a threshold for behavioral reactions in marine mammals. A number of studies document behavioral effects in response to seismic surveys, primarily for mysticetes (Richardson et al., 1995). Mysticetes are considered low-frequency cetaceans with an estimated auditory bandwidth of 7 Hz to 22 kHz. The mysticetes (i.e., baleen whales) have been one of the most studied groups of marine mammals in terms of observations of behavioral changes in response to seismic operations. There is clearly a possible overlap between the expected frequencies of best-hearing sensitivity (low threshold) in mysticetes and maximal airgun output at source. It is generally considered that the auditory abilities of all mysticete species are broadly similar, based upon vocalization frequencies and ear anatomy (Ketten, 1998). Given that no direct audiograms of mysticetes have been obtained, it is impossible to define what level of sound above hearing threshold may cause behavioral effects, which would be expected to be variable, complicated, and dependent upon more than simply the received sound level. The mysticete species found in the GOM (i.e., North Atlantic right, blue, fin, sei, humpback, minke, and Bryde's whales) are considered rare, extralimital, or uncommon (Würsig et al, 2000), and their occurrence within the proposed action area and potentially affected acoustic area is not expected.

Sperm whales are a highly vocal species under natural conditions (they click almost continuously during dives). They are considered a mid-frequency cetacean with functional hearing of approximately 150 Hz to 160 kHz. Interruption or cessation of their vocal activity has often been cited as a reaction to manmade noise. Watkins and Schevill (1975) showed that sperm whales interrupted click production in response to pinger (6 to 13 kHz) sounds. Mate et al. (1994) reported temporarily decreased sperm whale abundance in an area of seismic operations in the northeastern GOM. However, acoustic arrays recorded sperm whales producing click sequences during dives within 4 nautical miles of an active, 3D seismic vessel during surveys conducted in 2001. Further, Weir (2008) found few obvious, visible responses of sperm (and humpback) whales to seismic airgun sounds off Angola, although only overt responses were examined, and subtle or longer range responses may not have been detected.

From 2002 to 2005, BOEM funded a multiyear, interdisciplinary study on sperm whales in the GOM, called the Sperm Whale Seismic Study (SWSS). A summary report was produced in 2006 (Jochens et al., 2006) and a synthesis report was released in 2008 (Jochens et al., 2008). These reports provide the following conclusions regarding sperm whales in the GOM and their response to seismic surveys:

- During controlled exposure experiments (CEEs), researchers could detect "no horizontal avoidance of the seismic source for exposure levels (RLs) of <150 dB re 1 μPa (rms)." Similarly, opportunistic studies detected no apparent horizontal avoidance or displacement of sperm whales associated with operational seismic surveys;
- Although a small sample, the CEE data results did not confirm the assumption that whales swim away from an airgun as it ramps up or approaches the whale at full power;
- In contrast to the lack of avoidance response, the CEE results showed there may be statistically significant changes in the swimming and foraging behavior of sperm whales exposed to the sound of airguns in the exposure range (RL) of 111-147 dB re 1 μPa (rms) (131-164 dB re 1 μPa [peak to peak]; see Table I in Madsen et al., 2006) at distances of approximately 1.4-12.6 kilometers from the sound source; and
- There was the "discovery of a statistically significant 60 percent reduction in foraging for one whale coupled with evidence that other whales are less sensitive…"

Sperm whales are most likely to be acoustically aware of their environment and can exhibit behavioral reactions in a number of ways, including interruption of vocal activity and foraging. However, there are, as yet, insufficient data to assign thresholds for acoustic disturbance to sperm whales. An additional factor to consider is the deep-diving habit of sperm whales. Unlike mysticetes, which may remain close to the surface for long periods, sperm whales spend relatively little time at the surface during the course of feeding activity. This means they would be less likely to receive any surface shielding afforded by refractive effects caused by near-surface hydrographic conditions that can occur in some instances. In

addition, the sperm whale may dive to a depth where an operating seismic vessel could potentially pass directly over it without visually detecting the sperm whale.

Little is known about the hearing sensitivity of dwarf/pygmy sperm whales. Pulsed sounds with peak frequencies below 13 kHz have been recorded from pygmy sperm whales (Caldwell and Caldwell, 1987), and the anatomy and physical properties of the dwarf sperm whale head have been shown to be consistent with production of echolocation clicks (Cranford et al., 1996; Goold and Clarke, 2000). Audiograms have only recently been obtained for pygmy sperm whales and dwarf sperm whales (Cook et al., 2006; Finneran, 2009; Ridgway and Carder, 2001), but data remain insufficient to ascribe avoidance thresholds. It is possible, however, that these species may, as in the case of sperm whales, be sensitive to a wide range of sound frequencies, including those produced by seismic gun arrays. This factor, along with their similar deep-diving habits and relatively widespread distributions in the GOM, may warrant concerns for these species from seismic survey activities, similar to those described for the sperm whale.

The Delphinidaeds are also considered mid-frequency cetaceans with functional hearing of approximately 150 Hz to 160 kHz. They represent a diverse group including the true dolphins, killer whales, and pilot whales. There have been few studies of the impact of seismic surveys on members of the Delphinidae; indeed, Richardson et al. (1995) comment on an almost total lack of studies on effects of G&G seismic activities on delphinid species. This higher frequency energy must be taken into account when considering seismic interactions with members of the Delphinidae. Further, and contrary to early perceptions, the high-frequency components of airgun emissions are of sufficient level to exceed the dolphin auditory threshold curve at these low frequencies, even after considerable spreading loss (Goold and Fish, 1998).

Since the delphinid auditory system has a relatively poor response at the low-frequency end (about 110 dB re 1 µPa at 200 Hz; but see Table 2 in Southall et al., 2007) and increases in sensitivity toward the ultrasonic range, it is clear that a gradient of increasing sensitivity exists over a broad frequency range to the frequency of peak sensitivity. Further, although an airgun pulse will have maximal energy at a few tens of Hertz, with energy decreasing towards the higher frequencies, there is also an increase in dolphin hearing sensitivity in this region. So, although toothed whales specialize in hearing ranges generally outside of the majority of seismic survey impulse sounds, there is still the potential for sounds from these surveys to fall within the acoustic sensitivity of toothed whales.

Masking

Auditory masking occurs when a sound signal that is of importance to a marine mammal (e.g., communication calls, echolocation, and environmental sound cues) is rendered undetectable due to the high noise-to-signal ratio in a frequency band relevant to a marine mammal's hearing range. In other words, noise can cause the masking of sounds that marine mammals need to hear in order to function effectively (Erbe et al., 1999). The presence of the masking noise can make it so that the animal cannot discern sounds of a given frequency. Yet at a given level it would be able to do so in the absence of the masking noise. If sounds used by the marine mammals are masked to the point where they cannot provide the animal with needed information, critical natural behaviors could be disrupted and harm could result (Erbe and Farmer, 1998). In the presence of the masking sounds, the sounds the animal needs to hear must, therefore, be of greater intensity for it to be able to detect and to discern the information in the sound.

In the case of seismic surveys in the GOM, where potential masking noise takes a pulsed form with a low duty cycle (~6-10%, or a 1-s disturbance in the sound field in every 10-15 s of ambient noise), the effect of masking is likely to be low relative to continuous sounds such as ship noise. Some whales are known to continue calling in the presence of seismic pulses. Their calls can be heard between the seismic pulses (e.g., Richardson et al., 1986; McDonald et al., 1995; Nieukirk et al., 2004; Smultea et al., 2004). Although there is one report that sperm whales ceased calling when exposed to pulses from a very distant seismic ship (Bowles et al,. 1994), more recent studies report that sperm whales continued calling in the presence of seismic pulses (Madsen et al., 2002; Tyack et al., 2003; Smultea et al., 2004; Holst et al., 2006; Jochens et al., 2008).

Non-Auditory Effects

The best available scientific information shows that resonance can occur in marine animals but may not necessarily cause injury, and any such injury is not expected to occur below a sound pressure level of 180 dB re 1 µPa. Damage to the lungs and large sinus cavities of cetaceans from air space resonance is not regarded as a likely significant, non-auditory injury because resonance frequencies of marine mammal lungs are generally below that of the Surveillance Towed Active Sonar System-Low Frequency Active (SURTASS LFA) sonar signal (Finneran, 2003) and, therefore, the G&G seismic survey source signal. Further, biological tissues are heavily damped, and tissue displacement at resonance is predicted to be exceeding small. Lung tissue damage is generally uncommon in acoustic-related strandings (Southall et al., 2007). Additionally, since there is abundant anatomical evidence that marine mammals have evolved and adapted to dramatic fluctuations in pressure during long, deep dives that seem to exceed their aerobic capacities (Williams et al., 2000), it is very unlikely that significant lung resonance effects could be realized from the proposed G&G seismic survey operations.

Currently, the available research is inconclusive on whether marine mammals can suffer from a form of decompression sickness caused by *in vivo* (in the natural body) nitrogen gas-bubble growth. It is theorized that this may be caused by diving and then surfacing too quickly, forcing nitrogen bubbles to form in the bloodstream and tissues. Jepson et al. (2003) published a brief communication in *Nature* magazine on gas-bubble lesions found in stranded cetaceans (Canary Islands Stranding, 2002). They presented findings of acute and chronic tissue damage in stranded cetaceans that they believe resulted from the formation of *in vivo* gas bubbles and stated that the animals showed severe, diffuse vascular congestion and marked, disseminated microvascular hemorrhages associated with widespread fat emboli in vital organs, particularly the liver. They also stated that the lesions were consistent with acute trauma due to *in vivo* bubble formation that results from rapid decompression, which occurs in decompression sickness. A response to this article was posted in *Nature* by Piantadosi and Thalmann (2004) of the Duke University Medical Center and Divers Alert Network (DAN), stating that whales do not develop sufficient gas supersaturation in the tissues on ascent to cause extensive bubble formation in the liver. All communications state, though, that further investigation is needed, including an analysis of the composition of the gas in the bubbles (Jepson et al., 2003; Piantadosi and Thalmann, 2004; Fernández, et al., 2004). In addition, Jepson et al. (2003) and Fernández, et al. (2005) reported on necropsies of stranded beaked whales, which was interpreted as consistent with a decompression-like syndrome (Nowacek et al., 2007).

Based on the current knowledge of gas exchange and physiology of marine mammals, Hooker et al. (2009) developed a mathematical model to predict blood and tissue levels of nitrogen gas for three species of beaked whales: northern bottlenose; Cuvier's beaked; and Blainville's beaked whales. They suggested that deep-diving marine mammals live with, and manage high levels of nitrogen gas in their tissues and blood. Because of differences in dive behavior, predicted nitrogen levels were higher in Cuvier's beaked whales than in northern bottlenose whales and Blainville's beaked whales. The authors state that some Cuvier's beaked whale strandings could be explained by a higher abundance of the species in the area; their results suggest that species differences in behavior and/or physiology may also play a role.

Studies pertaining to the effects of stress and stress responses in mammals, including studies on marine mammals, have been reviewed by Wright et al. (2007) and Curry (1999). The stress studies investigate physiological responses to disturbance (e.g., increase in stress hormones or heart rate) rather than looking for changes in behavior (e.g., avoidance and disruption of foraging). However, in most cases, the biological importance of stress responses in marine mammals (e.g., effects on energetics, survival, reproduction, and population status) remains unknown.

Potential Impacts to Marine Mammals from Vessel Noise

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).

Potential Impacts to Marine Mammals from Vessel Strikes

Given the scope, timing, and transitory nature of the proposed action, and the conditions of approval and monitoring requirements, the proposed seismic survey is not expected to result in vessel strikes to marine mammals in the GOM. The possibility of a ship strike between a slow-moving seismic survey vessel (typically between 4 and 5 knots) and a marine mammal is low (USDOI, MMS, 2004). Further, BOEM requires the implementation of Joint NTL No. 2012-G01, which provides guidelines on the implementation of monitoring programs to minimize the risk of vessel strikes to protected species and to report observations of injured or dead protected species. The NMFS 2007 ESA Biological Opinion recognizes that "measures included in Joint NTL No. 2012-G01 should reduce the risk of collisions with sperm whales to discountable level." 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, 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), these incidents are mainly caused by small water craft operating inshore and are rare in water depths where the survey activities are proposed, and consequently, seismic survey operations should pose little, if any, risk to them.

Conclusion

The sections above discuss marine mammal hearing in general and the potential range of effects to marine mammals from seismic noise, including: (1) permanent loss of hearing; (2) temporary loss of hearing; (3) behavioral response; (4) masking; and (5) non-auditory effects. As described, seismic noise has the potential individually or cumulatively to result in any of these potential 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 is 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 pulsed noise, such as seismic, given their hearing ranges overlap most closely with the noise frequencies produced from seismic (Southall et al., 2007). The only commonly occurring baleen whale in the northern Gulf of Mexico is the Bryde's whale. However, the potential for significant impacts is minimized given its small estimated population and implementation of the required shut down.
- Manatees are not typically common in the proposed action area, as they inhabit only coastal marine, brackish, and freshwater areas and are not expected to occur in the area of the proposed action.
- 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 seismic noise (Southall et al., 2007). Therefore, the potential for seismic noise produced from this proposed action to cause auditory and non-auditory effects, PTS, TTS, behavioral changes, or masking on these species is further limited although not entirely eliminated.
- To further minimize or reduce the potential for impacts, BOEM instituted several key mitigation and monitoring requirements under Joint NTL No. 2012-G02 (Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program) described below. These measures were developed in 2003 in coordination with NMFS. They are meant to be conservative (i.e., they afford additional protection to the species). As a result of the implementation of this NTL, page 71 of the NMFS 2007 Biological Opinion concluded that PTS was unlikely to occur to sperm whales given the requirements under Joint NTL No. 2012-G02 and that implementation of these measures would limit the potential for harassment. These measures, although needing further testing for effectiveness, represent the best available mitigation strategy for seismic surveys as recognized in the most recent NMFS Incidental Take Authorizations (ITA) under the MMPA. For examples of recent ITA's, see "Marine Geophysical Survey in the Eastern Tropical Pacific Ocean, October-November 2010" at http://www.nmfs.noaa.gov/pr/pdfs/fr/75fr-64996.pdf and "Marine Seismic Survey in the Arctic Ocean, August to September 2010" at

http://www.nmfs.noaa.gov/pr/pdfs/permits/fr75-60174.pdf. The following is a summary of the mitigation and monitoring requirements under Joint NTL No. 2012-G02:

  - establishment of a 500-m exclusion zone, in waters greater than 200 m in depth, around the seismic source vessel (This exclusion zone is then continually monitored for the presence of whales [and sea turtles] by dedicated Protected Species Observers [PSOs]);
  - shut down of the seismic sound source should a PSO observe a whale within or approaching the exclusion zone;
  - delay of the restart of surveys until the animal has left the area and no other whales (or sea turtles) are sighted for an additional 30 minutes; and
  - slow ramp-up of seismic sound sources at the start or restart of surveys (e.g., the gradual increase in seismic noise) so as to allow an animal to leave the area before the seismic sound reaches potentially disturbing levels.

- The NMFS 2007 Biological Opinion concluded that "masking would be unlikely to occur due to the characteristics of airgun pulses (page 71).

- The NMFS 2007 Biological Opinion also found that impacts to sperm whales would be expected to be limited to the potential for TTS and behavioral changes. The same can be inferred for other mid-frequency hearing specialists, such as dwarf/pygmy sperm whales and dolphins. The Biological Opinion also states that behavioral changes, should they occur, would be "limited to the duration of exposure to the noise."

- Reporting requirements mandated in Joint NTL No. 2012-G02 have resulted in more than 5 years of observation data. BOEM has contracted a study to summarize and synthesize submitted seismic survey observer reports for the years 2003-2008. Results of the synthesis will lead to recommendations for both BOEM and NMFS as to the effectiveness of required mitigation measures, as well as suggestions for new and/or improved mitigation.

- The NMFS sets the 180-decibel (dB) root-mean-squared (rms) isopleth where on-set of auditory injury or mortality to cetaceans may occur. Southall et al. (2007) suggests this level should rather be at 230 dB rms for a single-sound exposure event, such as seismic noise. The 500-m exclusion zone established in Joint NTL No. 2012-G02 encompasses an area larger than where the 180 dB rms isopleths would fall and, thus, represents a conservative protective zone. The likelihood of injury, when the zone is monitored for needed shut downs, is therefore greatly minimized.

In conclusion, the scope, timing, and transitory nature of the proposed action and the conditions of approval and monitoring requirements in place, the noise related to the proposed seismic survey 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. The geographic scope of the proposed action is small in relation to the ranges of marine mammals in the GOM. The proposed seismic 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. Survey activities will involve limited vessel traffic related to the towing of the airgun array that carries some risk of collisions; however, animals may avoid the sound source of the moving vessels, reducing the likelihood of collision. BOEM has issued applicable regulations and guidelines to minimize/negate the chance of vessel strike to marine mammals, including Joint NTL No. 2012-G01 (Vessel Strike Avoidance and Injured/Dead Protected Species Reporting), and BOEM also employs protected species lease stipulations.

3.2.3. Cumulative Impact Analysis

Chapter III.B.7 of the PEA, and Chapters 4.1.1.11.4 and 4.2.1.12.4 of the Multisale EIS address the cumulative impacts on marine mammals as a result of oil and gas activities, including the proposed G&G activities. Additionally, 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 similar to the Macondo Event:

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).

The proposed action may cumulatively affect protected marine mammals when viewed in light of the Macondo Event, as well as the ongoing unusual mortality event (UME). Marine mammals could be impacted by the degradation of water quality resulting from operational discharges, vessel traffic, noise generated by platforms, drillships, 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.

Few deaths are expected from chance vessel collisions, ingestion of plastic material, commercial fishing, and pathogens. Deaths as a result of structure removals are not expected to occur due to mitigation measures (see NTL 2010-G05 Decommissioning Guidance for Wells and Platforms, at http://www.boem.gov/Regulations/Notices-To-Lessees/2010/10-g05.aspx). 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. 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). Natural phenomenon, such as tropical storms and hurricanes, are impossible to predict but do occur in the GOM.

Macondo Event

The Macondo Event in Mississippi Canyon Block 252 with the resulting oil spill and related spill-response activities (including use of dispersants) have impacted marine mammals that have come into contact with oil and remediation efforts. The animals' exposure to hydrocarbons persisting in the sea may result in sublethal impacts (e.g., decreased health, reproductive fitness and longevity, and increased vulnerability to disease) and some 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 or migration routes. More detail on the potential range of effects to marine mammals from contact with spilled oil is found in Geraci and St. Aubin (1990) and on the NMFS's Office of Protected Resources website at http://www.nmfs.noaa.gov/pr/pdfs/health/oil_impacts.pdf. As noted above, the Catastrophic Spill Analysis in Appendix B of the Multisale EIS also discusses the most likely and most significant impacts to marine mammals from a spill similar to the Macondo Event.

In addition, there are links from this NMFS website (http://www.nmfs.noaa.gov/pr/health/oilspill/) to the latest available information on oiled or affected marine mammals documented in the area, incident response, as well as additional information. However, the best available information does not provide a complete understanding of the effects of the spilled oil and active response/cleanup activities on marine mammals. For example, it is expected that the large amount of chemical dispersants used on the oil may act as an irritant on the animals' tissues and sensitive membranes (Aubin and Geraci, 1990). The increased human presence (e.g., vessels) has likely added to changes in behavior and/or distribution, thereby potentially stressing animals further, perhaps making them more vulnerable to various physiologic and toxic effects. Currently, the following efforts are underway to gather and analyze more data to better understand the range of actual effects to marine mammals in the GOM from the blowout, spill, and remediation:

- Short-term response and restoration efforts through the NRDA process. There are a number of NRDA marine mammal studies ongoing including bottlenose dolphin health assessments, sperm whale satellite tagging, passive acoustic monitoring, prey species analyses, and ongoing necropsy work. These data, when available, will continue to be included in all relevant analyses.

- The NMFS and U.S. Fish and Wildlife Service (FWS) ESA Section 7 Emergency Consultations will provide BOEM guidance to reestablish the baseline for ESA-listed species. In 2002, BOEM submitted a request to NMFS for a 5-year rule under the MMPA authorizing the incidental taking of sperm whales, under specified conditions, by G&G activities in the GOM. BOEM has worked closely with NMFS to update all the information submitted in 2002-2005 and to incorporate the most recent and best available information. BOEM updated and submitted a revised petition package to NMFS in 2011. The next step is for NMFS to finalize the EIS. BOEM was informed that NMFS will publish the Draft EIS for public comment in 2012.

- Current interagency government efforts to develop mid- and long-term plans to research and monitor the effects from the blowout/spill on marine mammals. The Marine Mammal Commission's August 2011 report (MMC, 2011) makes specific suggestions about research and research priorities for marine mammals in the GOM.

There is additional ongoing research to assess the impacts to resources from the Macondo Event. Results of this research are forthcoming, and BOEM will update future analyses as this information becomes available. For many resources, the data are still being collected and analyzed through the NRDA process. BOEM continues to seek data and research results from the NRDA process and the scientific community.

Unusual Mortality Event (UME) for Cetaceans in the GOM

On December 13, 2010, NMFS declared an unusual mortality event (UME) for cetaceans (whales and dolphins) in the Gulf of Mexico. An UME is defined under the Marine Mammal Protection Act as a "stranding that is unexpected, involves a significant die-off of any marine mammal population, and demands immediate response." Evidence of the UME was first noted by NMFS as early as February 2010. As indicated in the table below, a total of 1,035 cetaceans (5% stranded alive and 95% stranded dead) have stranded since the start of the UME, with a vast majority of these strandings involving premature, stillborn, or neonatal bottlenose dolphins between Franklin County, Florida, and the Louisiana/Texas border. The 1,035 includes 6 dolphins killed during a fish-related scientific study and 1 dolphin killed incidental to a dredging operation. More detail on the UME can be found on NMFS' website (USDOC, NMFS, 2013).

Unusual Mortality Event Cetacean Data for the Northern Gulf of Mexico

Cetaceans Stranded	Phase of Oil-Spill Response	Dates
114 cetaceans stranded	Prior to the response phase for the oil spill	February 1, 2010 - April 29, 2010
122 cetaceans stranded or were reported dead offshore	During the initial response phase to the oil spill	April 30, 2010 - November 2, 2010
799 cetaceans stranded*	After the initial response phase ended	November 3, 2010 – August 18, 2013**

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

**The initial response phase ended for all four states on November 2, 2010, but then re-opened for eastern and central Louisiana on December 3, 2010 and closed again on May 25, 2011.

Numbers are preliminary and may be subject to change. As of August 18, 2013, the UME involves 1,035 cetacean "strandings" in the northern Gulf of Mexico [USDOC, NMFS, 2013].

It is unclear at this time whether the increase in strandings is related partially, wholly, or not at all to the Macondo Event. The NMFS has also documented an additional 11 UME's that have been previously declared in the GOM for cetaceans since 1991. However, the current data in the table above also shows a marked increase in strandings during the Macondo Event response and afterwards. According to the website (USDOC, NMFS, 2011), NMFS considers the investigation into the cause of the UME and the potential role of the Macondo Event to be, "ongoing and no definitive cause has yet been identified for the increase in cetacean strandings in the northern Gulf in 2010 and 2011." It is therefore unclear whether increases in stranded cetaceans during and after the Macondo Event response period are or are not related

to impacts from the Macondo Event and will likely remain unclear until NMFS completes its UME and NRDA evaluation processes.

Additional Conditions of Approval/Monitoring Measures to Reduce Potential for Cumulative Effects

Prior to the onset of the current UME and the Macondo Event, and as previously described, BOEM instituted several key mitigation and monitoring requirements under Joint NTL No. 2012-G02 (Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program) and Joint NTL No. 2012-G01 (Vessel Strike Avoidance). This includes, among other requirements, such measures as establishment of exclusion zones, use of protected species observers (PSOs), shut down procedures for whales and ramp-up protocols.

As a result of the UME and the Macondo Event, BOEM believes that additional protective measures are needed for this proposed action to address all marine mammal species potentially affected by the UME and/or Macondo Event that may also be impacted by this proposed action. These measures are needed to provide an abundance of caution given the causes of the UME are unknown and the potential for population level effects, if any, from the UME and/or the Macondo Event are still undetermined. The following analysis outlines these additional conditions of approval and monitoring measures proposed for implementation under Alternative 3.

Additional Conditions of Approval No. 1: Use of Lowest Practicable Sound Source and Calibration of Seismic Array to Maximize Vertical (and Limit Horizontal) Acoustic Propagation

This condition of approval would require the applicant to verify in writing, prior to survey acquisition, that the proposed airgun arrays to be used, are of the lowest sound intensity level that still achieves the survey goals. Further, this verification will also include confirmation that the airgun array has been tuned to maximize subsurface illumination, and minimize, to the extent practicable, horizontal propagation of noise. Industry has previously advised BOEM that these actions are already largely utilized, given an applicant's desire to economically use the least amount of acoustic energy necessary for the purposes of the survey and to also direct the maximum amount of sound energy downward to achieve better data collection results. Additional active and post-activity reporting requirements for this condition are included in the reporting requirements section below. Therefore, Alternative 3 includes additional conditions of approval that will require use of the lowest practicable sound Source and calibration of the seismic array to maximize vertical (and limit horizontal) acoustic propagation.

Additional Conditions of Approval No. 2: Implementation of a 30-km Spatial Restriction Between Simultaneously-Operating Deep-Penetration Seismic Surveys

The UME and Macondo Event have adjusted, to some yet unknown degree, the environmental baseline for marine mammals affected by these events. Given this proposed action occurs within areas affected by both events and the above analysis of impacts from seismic noise and vessel strikes suggests the potential for impacts to occur to at least some of these same populations, BOEM believes that a measure is needed to further reduce the potential for cumulative impacts. This Alternative 3 then analyzes and includes the implementation of a 30-km separation distance between simultaneously operating deep penetration seismic surveys. Survey here is defined as one BOEM permitted/authorized survey, which may or may not include multiple seismic source vessels (i.e., WAZ surveys). The purpose of the separation is to allow for a corridor for marine mammal movement between simultaneous deep penetration surveys so that animals can avoid and move in between surveys without being acoustically disturbed from multiple seismic sources.

The analysis focuses on what separation distance is appropriate for the proposed action. A review of comments recently submitted in response to BOEM's revised petition to NMFS for MMPA rulemaking for seismic survey activity in the GOM suggests a number of distances. The agency has received some comments suggesting an 80-km separation distance while others suggest 30 to 40 km ranges. Industry has indicated to BOEM that to avoid acoustic interference from simultaneous surveys, industry practice leads to a separation distance of at least 30 to 50 km in most cases.

The RMS "best fit" measurements detailed in Tolstoy et al. (2009) indicate a 160 dB isopleth for deep water (1600 m) to be approximately 2.7 km, while in shallow water (50 m) the 160 dB isopleth was measured to occur at approximately 12.5 km.

Based on the discussion above, Alternative 3 includes additional conditions of approval that requires applicant to maintain, to the extent it can practicably and safely do so, a minimum separation distance of 30 km from any other vessels concurrently conducting deep penetration seismic surveys within the area of the proposed action. This includes a 30-km buffer when operating at the fringes of the proposed action area. The 30-km distance is clearly conservative in terms of buffers between surveys. Tolstoy et al. (2009) indicated much smaller isopleths for deep water; however, given industry's assertion that a 30-50 km separation is typical, this should not present a problem for implementation.

To assist in implementation of this measure, BOEM will provide the applicant with a list and contact information for all deep penetration seismic applicants concurrently permitted/authorized to operate within or near the proposed action Area.

Additional Conditions of Approval No. 3: Implementation of Joint NTL No. 2012-G02 Guidance and Conditions for all Water Depths

As noted above, to further minimize or reduce the potential for impacts, BOEM instituted several key mitigation and monitoring requirements under Joint NTL 2012-G02 (Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program). These measures were developed in 2003 in coordination with NMFS and are meant to be conservative (i.e., they afford additional protection to the species). However, this NTL only applies to water depths of 200 m or greater. Given the unknown effects from the Macondo Event, BOEM believes it is prudent to apply this NTL to all water depths. Therefore, Alternative 3 includes additional conditions of approval that will require implementation of Joint NTL No. 2012-G02 in all water depths.

Additional Conditions of Approval No. 4: Implementation of Shut-Down Requirements in Joint NTL No. 2012-G02 to Apply Towards Manatees

Although manatees are not anticipated in the proposed action Area, Alternative 3 would require that the shut down provision set forth on page 3, paragraph 4 of Joint NTL No. 2012- G02 apply to manatees as well as whales. BOEM believes it is precautionary, but warranted, to apply this additional protection for manatees given the unknown effects from the Macondo Event on manatees. Therefore, Alternative 3 includes additional conditions of approval that imposes implementation of the shut-down requirements in Joint NTL No. 2012-G02 regarding manatees.

Additional Conditions of Approval No. 5: Supplementary Reporting Needs for the Additional Conditions of Approval

The applicant will be required to submit a bi-weekly report during active seismic operations containing the following information to assist BOEM in ensuring compliance with all conditions of approval. The dates, locations, and duration of any Deep-Penetration Seismic Surveys conducted during the reporting period;

- The sound source levels used during any Deep-Penetration Seismic Surveys conducted during the reporting period. To the extent the sound source levels exceed those proposed in the permittee's application, the permittee shall provide a written explanation for the difference; and
- Confirmation that the permittee maintained, to the extent it could practicably and safely do so, the separation distance or if applicable, a written explanation of why the minimum separation distance was not maintained.

All reports submitted to BOEM will be reviewed, redacted (as necessary) to protect any confidential or proprietary information, and posted on its internet website.

Conclusion

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. With the implementation of the required conditions of approval for seismic survey and vessel operations under Alternative 3, as well as the limited scope, timing, and geographic location of the proposed action, effects from the proposed seismic activities on marine mammals will be negligible. For animals that may be undergoing stress/sublethal impacts from the Macondo Event as well as the UME, the additional conditions of approval should act to further reduce impacts and provide an abundance of precaution.

3.3. SEA TURTLES

3.3.1. Description

The life history, population dynamics, status, distribution, behavior, and habitat use of sea turtles can be found in Appendix E of the PEA and Chapters 4.1.1.12 and 4.2.1.13 of the Multisale EIS and is incorporated by reference into this SEA. 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. The loggerhead turtle is the most abundant turtle in the GOM (Dodd, 1988). The leatherback turtle is the most abundant turtle in the northern GOM continental slope (Mullin and Hoggard, 2000). 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 Gulf of Mexico 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 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.

Sea Turtle Hearing

The anatomy of sea turtle ears and measurements of auditory brainstem responses of green and loggerhead sea turtles demonstrate that sea turtles are sensitive to sounds, with an effective hearing range within low frequencies (Bartol et al., 1999; Lenhardt et al., 1983; Moein et al., 1994; Ridgway et al., 1969). Although external ears are absent, sea turtles have a tympanum composed of layers of superficial tissue over a depression in the skull that forms the middle ear. The tympanum acts as additional mass loading to the ear, allowing for reduction in the sensitivity of sound frequencies and increasing low-frequency, bone-conduction sensitivity (Bartol et al., 1999; Lenhardt et al., 1985). Lenhardt et al. (1983) and Moein et al. (1993 and 1994) found that bone-conducted hearing appears to be an effective reception mechanism for sea turtles (i.e., loggerhead and Kemp's ridley) with both the skull and shell acting as receiving surfaces for water-borne sounds at frequencies of 250-1,000 Hz. The NMFS 2007 Biological Opinion indicated that adult sea turtles are sensitive to low- and mid-frequency sounds, specifically in the 200- to 2,000-Hz frequency range (USDOC, NMFS, 2007). Unlike marine mammals, sea turtles "do not appear to greatly utilize environmental sound, at least at far distances in the open ocean" (USDOC, NMFS, 2007).

3.3.2. Impact Analysis

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 impact-producing factors associated with the proposed action that could affect sea turtles include: (1) noise from survey activities; and (2) vessel noise and collisions. Section III.C.2 of the PEA contains a discussion of the potential impacts from survey operations on sea turtles (USDOI, MMS, 2004). Additional information about routine impacts from oil and gas activity on sea turtles is addressed in Chapters 4.1.1.12.2 and 4.2.1.13.2 of the Multisale EIS. The discussions are summarized below and are incorporated by reference into this SEA.

3.3.2.1. Alternative 1

If selected, Alternative 1, the no action alternative, the applicant would not undertake the proposed activities. Therefore, the impact producing factors to sea turtles would not occur. For example, there would be no vessel noise or seismic airgun 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 towing of the airgun array, there would be no risk of collisions with sea turtles.

3.3.2.2. Alternative 2

If selected, Alternative 2, the proposed action as proposed, the applicant would undertake the proposed activities, as requested and conditioned in the application. Examples of potential impacts to sea turtles without implementation of the above referenced conditions of approval and monitoring include, but are not limited to: injury from vessel strikes and disruption of feeding and other behaviors from vessel presence. This Alternative would not adequately limit or negate potential impacts to sea turtles.

3.3.2.3. Alternative 3

If selected, Alternative 3, the proposed action with additional conditions of approval, the applicant would undertake the proposed activities, as requested and conditioned in the application; however, the applicant would be required to undertake additional conditions of approval as identified by BOEM, in coordination with NMFS and in compliance with the NMFS ESA consultation requirements (i.e., Joint NTL No. 2012-G02 (Protected Species Observers) and Joint NTL No. 2012-G01 (Vessel Strike Avoidance). For the reasons set forth below, inclusion of these measures under Alternative 3 limits or negates potential impacts to sea turtles (e.g., vessel strikes, behavioral disruption from vessel presence).

Potential Impacts to Sea Turtles from Seismic Noise

The first IPF associated with the proposed action that could affect ESA-listed sea turtles is impacts from seismic survey noise. Although little is known about the effects of anthropogenic noise on sea turtles, potential impacts of seismic surveys may include auditory effects (PTS and TTS) and/or behavioral disturbance. There is limited evidence of TTS in sea turtles. In the 1994 study of juvenile loggerheads, sponsored by the U.S. Dept. of the Army, Corps of Engineers (Moein et al., 1994), sea turtles were contained in a pen in shallow water as they were exposed to pulses from a single airgun. Both behavioral and physiological responses were observed. The turtles avoided airgun pulses at received levels at 175-180 dB re 1 μPa but habituated by the third presentation of the sounds. In some cases, habituated animals remained close to the airgun as it was operating. In 10-15 percent of the sea turtles exposed to airgun pulses, a temporary shift in auditory responses was measured. Received levels causing the shift are not known.

Additional studies have noted possible reactions to low-frequency noise, such as that associated with the proposed action, including startle responses and rapid swimming (McCauley et al., 2000a) and swimming toward the surface at the onset of the sound (Lenhardt, 1994). Recent investigations reported that green and loggerhead sea turtles increased their swimming activities when exposed to low-frequency noise; these activities become more erratic as the exposure level increases (McCauley et al., 2000a). Weir (2007) did not document obvious behavioral avoidance to airguns but suggested responsive actions by sea turtles to the vessel and towed equipment. Sea turtles may alter their behaviors when a vessel approaches, and thereby suspend feeding, resting, or interacting with conspecifics. Such disruptions are expected to be temporary, however, and should not affect the overall survival and reproduction of individual turtles.

Page 18 of the NMFS 2007 Biological Opinion concluded that the effects from seismic noise on sea turtles are "reduced to discountable levels" with the implementation of Joint NTL No. 2012-G02. The Biological Opinion acknowledges that sea turtles may exhibit behavioral change through avoidance response, but this response would be limited to the vicinity of the survey. Further, avoidance is more likely in response to the presence of the vessel than the seismic noise itself (USDOC, NMFS, 2007). Given the scope, timing, and transitory nature of the proposed action, the implementation of Joint NTL No. 2012-G02, and that the best available information indicates that sea turtles do not appear to use environmental sound heavily to meet daily needs for survival, BOEM concurs with NMFS in that effects to sea turtles from seismic noise are expected to be negligible.

Potential Impacts to Sea Turtles from Vessel Noise

The second IPF associated with the proposed action that could affect ESA-listed sea turtles is impacts from vessel noise with seismic vessels. 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).

Potential Impacts to Sea Turtles from Vessel Collision

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. In Florida, where coastal boating is popular, 18 percent of strandings documented between 1991 and 1993 were attributed to vessel collisions (Lutcavage et al., 1997). 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 documented sea turtle collisions with seismic survey-related 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 requires operators to implement Joint NTL No. 2012-G01, which contains vessel strike avoidance measures for sea turtles and other protected species. With implementation of these measures and a Protected Species Observer on the lookout for sea turtles, 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. This Opinion then grants BOEM an Incidental Take Statement that includes a set number of allowable takes of sea turtles by vessel strikes (USDOC, NMFS, 2007). As per the required reporting under Joint NTL No. 2012-G01, 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 requirements under Joint NTL No. 2012-G01). To date, there have been no reported strikes of sea turtles by seismic vessels. Given the scope, timing, and transitory nature of the proposed action and with this established conditions of approval, effects to sea turtles from seismic vessel collisions is expected to be negligible.

Potential Impacts to Sea Turtles from Entanglement

Acoustic buoy releases, tethered acoustic pingers, and nodal tethering lines pose an entanglement risk to sea turtles and other marine life. Entanglement risks can be reduced by using shorter and thicker (more rigid) lines during the nodal surveys. Implementing the following measures act to reduce the risk of entanglement and ensure proper reporting of entanglement situations. Reasonable measures are available to operators using this deployment technique to reduce the risk of entanglement. These measures include: (1) shortening the acoustic buoy line and tethered acoustic pinger line to the shortest length practical; (2) and replacing tether rope lines ≤ ¼"-diameter with a thicker, more rigid tether line modifying the line by tying knots in the line to increase the diameter and rigidness in order to minimize the risk of entanglement. Additional measures include ensuring that a PSO is onboard each vessel during tethered node retrieval operations. The PSOs will document any entanglement of marine species in the nodal gear specifically noting the location where entanglement occurred (e.g. pinger tether, acoustic buoy line, etc.). If a marine protected species becomes entangled, specifically a sea turtle, the PSO will immediately begin resuscitation procedures as described in NOAA Guidelines that are web-posted here (http://www.st.nmfs.noaa.gov/Assets/Observer-Program/pdf/Shrimp_Reef_fish_Manual_9_22_10.pdf). The PSO must also contact the sea turtle stranding network state coordinator to report the incident, condition of the turtle, and request additional instructions to reduce risk of injury or mortality, including rehabilitation and salvage techniques.

To date, there has been only one reported entanglement incident during a nodal survey. The operator recovered the sea turtle and released it. No PSOs were onboard the node recovery vessel and therefor the health of the sea turtle was uncertain upon its release. Given the scope, timing, and transitory nature of

the proposed action and the application of this condition of approval, effects to sea turtles from entanglement during nodal surveys are expected to be negligible.

Conclusion

The sections above discuss sea turtle hearing in general and the potential range of effects to sea turtles from the proposed action, including: (1) seismic noise; and (2) vessel noise and collisions. As described, effects of seismic noise 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.
- To further minimize or reduce the potential for impacts, BOEM instituted several key mitigation and monitoring requirements under Joint NTL No. 2012-G02 (Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program) described below. These measures were developed in 2003 in coordination with NMFS. They are meant to be conservative (i.e., they afford additional protection to the species). As a result of the implementation of this NTL, the NMFS 2007 Biological Opinion concluded that effects of seismic noise on sea turtles was "discountable."
- The scope, timing, and transitory nature of the proposed action will produce limited amounts of seismic noise in the environment.

As described, effects of vessel noise on sea turtles are considered "discountable" (USDOC, NMFS, 2007). The risk of collisions between sea turtles and vessels associated with the proposed action exist but would not rise to the level of significance given:

- BOEM requires compliance with Joint NTL No. 2012-G01, which provides guidelines on monitoring programs 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 recognizes that these measures should appreciably reduce the potential for vessel strikes. Further, this Opinion found "no jeopardy" to sea turtles from vessel strikes related to the proposed action and granted a limited number of Incidental Take Authorizations to BOEM for sea turtle mortalities by vessel strikes. BOEM continues to monitor for any strikes to ensure this authority is not exceeded. To date, there have been no reported strikes of sea turtles by seismic vessels.
- The scope, timing, and transitory nature of the proposed action will result in limited opportunity for sea turtles and vessel strikes.

3.3.3. Cumulative Impact Analysis

Chapter III.C.7 and Chapter I.B of Appendix F of the PEA, and Chapters 4.1.1.11.4 and 4.2.1.12.4 of the Multisale EIS address the cumulative impacts on sea turtles as a result of oil and gas leasing, exploration, development and production activities, including G&G activities. Additionally, 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 similar to the Macondo Event:

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).

Activities considered under the cumulative scenario, including the proposed action, may affect protected sea turtles. Sea turtles may be impacted by the degradation of water quality resulting from operational discharges, vessel traffic, noise generated by platforms, drillships, 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) 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. Deaths as a result of OCS structure removals are not expected to occur due to requisite mitigation measures (see NTL 2010-G05, Decommissioning Guidance for Wells and Platforms, at http://www.boem.gov/Regulations/Notices-To-Lessees/2010/10-g05.aspx). 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. 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). Mitigation measures are in place to reduce vessel strike mortalities (i.e., Joint NTL No. 2012-G01).

Natural disturbances such as hurricanes can cause significant destruction of nests and topography of nesting beaches (Pritchard, 1980; Ross and Barwani, 1982; Witherington, 1986). Tropical storms and hurricanes are a normal occurrence in the GOM and along the Gulf Coast. Generally, the impacts have been localized and infrequent; however, few areas of the Gulf Coast did not suffer some damage in 2004 and 2005. Some impacts of the hurricanes, such as loss of beach habitat, continue to impact sea turtles that would have otherwise used those areas as nesting beaches. Increases or decreases in beach armoring and other structures may impact all nesting sea turtles in the areas affected. Hurricanes and tropical activity may temporarily remove some of these barriers to suitable nesting habitat.

Incremental injury effects from the proposed action on sea turtles are expected to be negligible for seismic and vessel noise and minor for vessel collisions but not rise to the level of significance. This is mainly given the limited scope, duration, and geographic area of the proposed action and the requirements under Joint NTL Nos. 2012-G01 and 2012-G02.

Macondo Event

The Macondo Event in Mississippi Canyon Block 252 and the related spill-response activities impacted sea turtles in the spill area. However, it is currently impossible to quantify the magnitude of impacts to each species. It is expected that sea turtles were exposed to potentially harmful effects via the waters that they drink and swim in, as well as via the prey they consume. Contact with petroleum and the consumption of oil and oil-contaminated prey has the potential to cause chronic (longer term lethal or sublethal oil-related injuries) and acute (spill-related deaths occurring during a spill) effects on turtles. The ongoing spill response and cleanup efforts may also harm animals as they come in contact with booms, skimming vessels, and other remediation efforts. As a result, sea turtles near the Macondo well site and/or in the coastal areas impacted by the spill are likely under a great deal of stress and could be unresponsive to approaching vessels, which may collide with them at sea.

The animals' exposure to hydrocarbons persisting in the sea may result in sublethal impacts (e.g., decreased health, reproductive fitness, and longevity; and increased vulnerability to disease) and some soft tissue irritation, respiratory stress from inhalation of toxic fumes, food reduction or contamination, nesting site contamination, direct ingestion of oil and/or tar, and temporary displacement from preferred habitats or migration routes. More detail on the potential range of effects to sea turtles from contact with spilled oil can be found in Geraci and St. Aubin (1990) and on the NMFS Office of Protected Resources website at http://www.nmfs.noaa.gov/pr/pdfs/health/oil_impacts.pdf. In addition, there are links from this NMFS website to the latest available information on oiled or affected sea turtles documented in the area, incident response, and daily maps of the current location of spilled oil (see http://www.nmfs.noaa.gov/pr/).

The best available information does not provide a complete understanding of the effects of the spilled oil and active response/cleanup activities on sea turtles (e.g., impacts from dispersant use). The increased vessel presence is likely added to changes in behavior and/or distribution, thereby potentially stressing animals further and perhaps making them more vulnerable to collisions and various physiologic and toxic effects. However, efforts are underway to gather and analyze more data to better determine the range of actual effects to sea turtles in the GOM resulting from the Macondo well blowout/spill (see below).

- Short-term response and restoration efforts through the NRDA process. BOEM and NMFS have redirected research efforts originally planned in the Atlantic.
- The NMFS and FWS ESA Section 7 Emergency Consultations will provide BOEM guidance to reestablish the baseline for ESA-listed species. In 2002, BOEM submitted a request to NMFS for a 5-year rule under the MMPA authorizing the incidental taking of sperm whales, under specified conditions, by G&G activities in the GOM. BOEM has worked closely with NMFS to update all the information submitted in 2002-2005 and to incorporate the most recent and best available information. Currently, BOEM is finalizing the revised petition package for NMFS. The next step is for NMFS to finalize the EIS. BOEM was informed that NMFS will publish the Draft EIS for public comment in mid-2011.
- Current interagency government efforts to develop mid- and long-term plans to research and monitor the effects from the blowout/spill on sea turtles.

There is ongoing research to assess the impacts to resources from the Macondo Event efforts. Results of this research are forthcoming, and BOEM will update future analyses as this information becomes available. For many resources, the data are still being collected and analyzed through the NRDA process. BOEM continues to seek data and research results from the NRDA process and the scientific community.

For sea turtles that may be experiencing additional stress/sublethal impacts from the Macondo Event, no additional impacts from the proposed action are expected because of the mitigation and monitoring requirements that would be applied under this proposed action (Joint NTL Nos. 2012-G01 and 2012-G02). These measures are meant to reduce the potential for effects from seismic noise and vessel strikes in sea turtles.

Conclusion

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 implementation of the required mitigation measures for seismic survey and vessel operations (Joint NTL Nos. 2012-G01 and 2012-G02) and the scope of the proposed action, incremental effects from the proposed seismic activities on sea turtles will be negligible (seismic and vessel noise) to minor (vessel strikes). For animals that may have been subject to stress/sublethal impacts from the Macondo Event, no additional or synergistic impacts from the proposed action are expected. 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.

3.4. FISH

3.4.1. Description

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 into this SEA.

Threatened or Endangered Species

Two GOM fish species, the Gulf sturgeon and the smalltooth sawfish, are protected under the ESA. The Gulf sturgeon is listed as threatened; the smalltooth sawfish is listed as endangered. The Gulf sturgeon is predominantly distributed in the nearshore waters of the northeastern GOM, and currently, the smalltooth sawfish is predominantly distributed in the nearshore waters of south Florida (USDOI, FWS, GSMFC, 1995; USDOC, NMFS, 2009).

Non-ESA-Listed Species

Approximately 1,540 species of fishes are recorded in the GOM and Florida Keys (McEachran, 2009). The South Atlantic and Gulf of Mexico Fishery Management Councils recognize approximately 140 fish species within the Federal waters of the GOM. Distinctive fish assemblages are recognized within broad habitat classes including demersal (soft bottom and hard bottom), coastal pelagic, and oceanic pelagic (epipelagic and midwater) species. Fish are also classified by their movement patterns. Billfishes

(marlins and sailfish), swordfish, tuna, and many shark species are considered highly migratory, as they are widely distributed geographically and occur from coastal waters seaward into the open ocean. Highly migratory species move vertically in the water column to feed, usually on a daily basis, and move great geographic distances for feeding or reproduction (USDOC, NMFS, 2006). An example is the overfished Atlantic bluefin tuna, which is known to use the Gulf of Mexico in the spring (March to June) for spawning grounds (Teo et al., 2007a and 2007b; Teo and Block, 2010).

Essential Fish Habitat

The EFH section of the Magnuson Fisheries Conservation and Management Act of 1976, as amended, mandates that the regional Fishery Management Councils, through their Federal Fishery Management Plans, describe and identify EFH for each federally managed species, minimize adverse effects on such habitat caused by fishing, and identify other actions that encourage the conservation and enhancement of such habitats. Almost the entire GOM is within a designated EFH. Further, the Gulf of Mexico regional fishery management councils amended their Gulf of Mexico plans (referred to as Generic Amendment Number 3, 2005) to more specifically designate that habitats less than 100 fathoms are identified and described as EFH.

Fish Hearing

Compared with mammals, fish hearing is restricted to low frequencies. All fish species have hearing and skin-based mechanosensory systems (inner ear and lateral line). Research indicates that fish detect and, sometimes respond to, sound in their environment for predator/prey and social interactions (Fay and Popper, 2000; Popper, 2003). These sounds may be produced by other fish, other organisms (e.g., snapping shrimp, marine mammals), or other naturally occurring sounds such as waves breaking on the shore, rain on the water surface, etc. Approximately 270 Gulf fish species use sound in behavior (from Myrberg, 1981). Anthropogenic (human-generated) sounds affect fish hearing or other sensory systems and may have reproduction and survival consequences. Potential negative effects include mortality, masking of important environmental sounds or social signals, displacement or interference with sensory orientation, and navigation. These effects depend upon the type of sound, duration of sound, distance of sound, and fish species (Popper and Hastings, 2009).

While a review paper by Webb et al. (2008) provides a broad overview of all aspects of fish hearing, Fay and Popper (2000) and Ladich and Popper (2004) reviewed fish-hearing mechanisms and capabilities. A more recent paper by Popper and Fay (2010) discusses the designation of fishes based on sound detection capabilities. This 2010 paper suggests that the “hearing specialist” and “hearing generalist” designations are no longer valid for fish because these definitions are vague and sometimes contradictory. This paper recommends designating hearing based upon a range of hearing capabilities across species that is more like a continuum that includes the relative contributions of pressure to the overall hearing capabilities of a species. Many fish species’ sensory receptors for sound detection are similar to those of marine mammals (Popper, 2003).

The specific received-sound levels at which permanent, adverse effects could potentially occur to most fish species has rarely been studied and are therefore largely unknown. Information on the impacts of seismic surveys on marine fish populations is also limited. Studies include a limited number of species and individuals, and thus only include portions of a population, none at the population scale (National Science Foundation, 2010). However, the sections below provide a general synopsis of the available information relevant to the effects on fish from exposure to seismic and other anthropogenic sound

3.4.2. Impact Analysis

Distinctive fish assemblages can be found within a broad range of habitats in continental shelf and oceanic waters. The IPF associated with the proposed action that could affect fish is noise from survey activities. Chapter III.D.2 of the PEA contains a discussion of the potential impacts from survey operations on fish resources (USDOI, MMS, 2004). Additional information about routine impacts from oil and gas activity on impacts on fish is addressed in Chapters 4.1.1.15.2 and 4.2.1.18.2 of the Multisale EIS. The discussions are summarized below and are incorporated by reference into this SEA.

3.4.2.1. Alternative 1

If selected, Alternative 1, the no action alternative, the applicant would not undertake the proposed activities. Therefore, the impact producing factors to fish would not occur. For example, there would be no vessel noise or seismic airgun noise that would result in behavioral change, masking, or non-auditory effects to the animals, no long-term or permanent displacement of the animals from preferred habitats, and no destruction or adverse modification of any habitats.

3.4.2.2. Alternative 2

If selected, Alternative 2, the proposed action as proposed, the applicant would undertake the proposed activities, as requested and conditioned in the application. As described in the analyses below, impacts to fish from the proposed action (e.g., hearing loss or behavioral disruption from seismic noise), are expected to be short-term, localized and not lead to significant impacts. Although the conditions of approval outlined in Chapter 2.4 will be included, their implementation will not increase or decrease the potential for effects to fish from the proposed action.

3.4.2.3. Alternative 3

If selected, Alternative 3, the proposed action with additional conditions of approval, the applicant would undertake the proposed activities, as requested and conditioned in the application; however, the applicant would be required to undertake additional conditions of approval as identified by BOEM. As described in the analyses below, impacts to fish from the proposed action (e.g., hearing loss or behavioral disruption from seismic noise), are expected to be short-term, localized and not lead to significant impacts. Although the conditions of approval outlined in Chapter 2.4 will be included, their implementation will not increase or decrease the potential for effects to fish from the proposed action.

Potential Impacts to Fish from Seismic Noise

Fish ears respond to changes in pressure and particle motions (van Bergeijk, 1967; Schuijf, 1981; Kalmijn, 1988 and 1989; Schellert and Popper, 1992; Hawkins, 1993; Fay, 2005). Fish exposed to natural or manmade sound may experience physical and psychological effects, ranging in magnitude from none to severe. Based on the similarities between fish and mammal hearing, the four areas of primary concern for fish exposed to elevated noise levels include: (1) permanent loss of hearing; (2) temporary loss of hearing; (3) behavioral response; (4) masking; and (5) non-auditory effects.

The specific received-sound levels at which permanent, adverse effects could potentially occur to most fish species have rarely been studied and are therefore largely unknown. Information on the impacts of seismic surveys on marine fish populations is also limited. Studies include a limited number of species and individuals, and thus only include portions of a population, none at the population scale (National Science Foundation, 2010). However, the sections below provide a general synopsis of the available information relevant to the effects on fish from exposure to seismic and other anthropogenic sound.

Permanent and Temporary Fish Hearing Loss

To result in hearing loss, a sound must exceed the specific hearing threshold of that fish for a certain period of time (Popper, 2005). The consequences of temporary or permanent hearing loss in individual fish or a fish population is largely unknown. However, it likely depends upon the number of individuals affected and whether critical behaviors involving sound (e.g., predator avoidance, prey capture, orientation and navigation, reproduction, etc.) are adversely affected.

Little is known about the mechanisms and characteristics of potential injury to fish from exposure to seismic survey sounds and what exists is inconclusive. McCauley et al. (2003a and 2003b) found that exposure to airgun sounds (600 pulses with peak-to-peak source levels just below 223 dB re 1 μPa) caused observable anatomical damage to the pink snapper's auditory structures and that this damage did not repair 58 days after exposure. Popper et al. (2005) documented TTS of northern pike and lake chub in the Mackenzie River Delta but found that broad whitefish receiving a source level of 177 dB re 1 μPa^2 s showed no TTS. In both cases, the repetitive exposure to sound was greater than is expected in a typical seismic survey. Fishes involved in the study by Popper et al. (2005) were examined for damage to the sensory cells of the inner ear as a result of exposure to seismic sound, and no damage was observed (Song et al., 2008). Numerous other studies document that no fish eggs, fish larvae, or fish mortality resulted

from exposure to seismic sources (Falk and Lawrence, 1973; Holliday et al., 1987; La Bella et al., 1996; Santulli et al., 1999; McCauley et al., 2000b and 2000c; Thomsen, 2002; Hassel et al., 2003; McCauley et al., 2003a and 2003b; Popper et al., 2005; Payne et al., 2009). Other studies report that mortality of fish eggs, fish larvae, and fish could occur close to seismic sources (Kostyvchenko, 1973; Dalen and Knutsen, 1986; Booman et al., 1996; Dalen et al., 1986).

Behavioral Response

Behavioral effects from seismic noise on fish can include changes in the distribution, migration, mating, and catchability of fish populations. In general, any adverse effects on fish behavior or fisheries due to seismic surveys may depend on the species in question and the nature of the fishery (i.e., season, duration, and fishing method). It may also depend on the age of the fish, its motivational state, its size, and numerous other factors that are difficult, if not impossible, to quantify, particularly under realistic at-sea conditions. Studies investigating the possible effects of sound (including seismic survey sound) on fish behavior were conducted on both uncaged and caged individuals (Chapman and Hawkins, 1969; Pearson et al., 1992; Santulli et al., 1999; Wardle et al., 2001; Hassel et al., 2003; Boeger et al., 2006). In these studies, fish typically exhibited a sharp "startle" response at the onset of a sound, followed by a return to normal behavior after the sound ceased. Investigation by Jorgenson and Gyselman (2009) indicated that behavioral characteristics of Arctic riverine fishes were generally unchanged by exposure to airgun sound.

Disturbance to fish population structures and distributions could result in reduced catch. An example would be temporary displacement of fish from traditional fishing grounds. Hirsh and Rodhouse (2000) reviewed studies investigating the hypothesis that seismic survey sounds have a deleterious effect on (usually commercial) fishing success. In most cases, these studies (e.g., Skalski et al., 1992, and Engås et al., 1996) found that fishing catch of one or more target species declined with the onset of seismic survey operations and remained depressed throughout this activity and for days after. These effects, as reviewed in Boertmann et al. (2010), depend on species, fishing gear, and other environmental parameters. Further, reduced catch rates have been reported in some marine fisheries during seismic surveys; in several cases the findings are confounded by other sources of disturbance (Dalen and Raknes, 1985; Dalen and Knutsen, 1986; Løkkeborg, 1991; Skalski et al., 1992; Engås et al., 1996). No change was determined in catch per unit effort of fish when airgun pulses were emitted, particularly in the immediate vicinity of the seismic survey (Pickett et al., 1994; La Bella et al., 1996; Wardle et al., 2001). For certain species, reductions in catch may have resulted from a change in behavior of the fish, such as a change in vertical or horizontal distribution (Slotte et al., 2004).

Masking

Currently, no studies conclude that seismic surveys result in masking effects on any fish species. Masking is the effect of an acoustic source interfering with the reception and detection of an acoustic signal or other sound of biological importance to a receiver. For a discussion of the biological relevance of ambient and signal sounds to fish, see Fay and Popper (2000). Any sound within an animal's hearing range can mask relevant sounds. Theoretically, the airguns or airgun arrays and vessel sound could contribute minimally to localized, short-term, and transitory masking of sound detection by some marine fishes, at least those species whose sound detection capacities are in the frequency range of the seismic survey sound source(s).

Non-Auditory Effects

As with auditory damage, few data support the possibility of non-auditory injury or mortality of fish near an airgun(s). Theoretically, airguns and airgun arrays potentially injure or kill minimal individuals of some fish species, their larvae, and/or eggs that are very close (a few meters) to a high-energy acoustic source; however, this injury or mortality is most probable and potentially severe in fish with trapped gas pockets, such as swim bladders, which expand and contract in concert with the ambient pressure changes.

Physiological effects refer to cellular and/or biochemical responses by fish to acoustic stress. Such stress potentially affects fish populations by increasing mortality or by reducing reproductive success. Primary and secondary stress responses of fish after exposure to seismic survey sound appear temporary (Sverdrup et al., 1994; McCauley et al., 2000b and 2000c). The periods necessary for these biochemical changes to return to normal are variable and depend on numerous aspects of the biology of the species and of the sound stimulus.

Conclusion

Noise from the airguns under the proposed action could potentially result in acute injury and mortality of a minimal number of individuals of some species of fish, their larvae, and/or eggs when in very close proximity (a few meters) to a high-energy acoustic source. The proposed action would also result in short-term, localized behavioral reactions. This frequency range of airguns overlaps with the likely hearing range of the ESA-listed fish species – the Gulf Sturgeon and smalltooth sawfish. However, these species are not found in the proposed action area. Highly migratory species like the bluefin tuna are found in the proposed action area at certain times of the year. However, given the small area and timeframe exposed to seismic noise under the proposed action, the transience of the moving seismic source relative to the GOM, and the small number of fish potentially within this localized area, the chance of non-auditory injury or mortality would be limited to an insignificant number of individuals. Seismic effects on such a small number of individuals would be insignificant at the population scale and considerably smaller than the natural mortality rate. Therefore, based on the limited best available science, seismic surveys are not expected to result in significant auditory or non-auditory injury or mortality on marine fish at the population scale.

3.4.3. Cumulative Impact Analysis

Cumulative impacts on fish and EFH that result from oil and gas leasing, exploration, development, and production activity including G&G activities are discussed in Chapter III.D.7 and Appendix I of the PEA, and Chapters 4.1.1.15.4 and 4.2.1.18.4 of the Multisale EIS. The information from these documents is incorporated by reference in this SEA. Additionally, 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 similar to the Macondo Event:

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).

Activities considered under the cumulative scenario, including the proposed action, may affect fish and fisheries. Degradation of water quality from multiple human activities as described in the Multisale EIS will continually affect fish and fisheries species. The cumulative impact of these ongoing OCS activities on fish and fisheries is expected to result in a number of chronic and sporadic lethal (injury and mortality) and sublethal (behavioral effects and nonfatal exposure to or intake of OCS-related contaminants or discarded debris) effects that may stress and/or weaken individuals of a local group or population and predispose them to infection from natural or anthropogenic sources. Finally, nonanthropogenic sources such as red tides and tropical storms may add to the cumulative impacts on fish resources in the northern Gulf of Mexico. The proposed action is a short-term event in a portion of the GOM; therefore, the effects from the proposed action will be slight in regards to these ongoing impacts.

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.

Macondo Event

The Macondo Event in Mississippi Canyon Block 252 and the related spill-response activities impacted fish that came into contact with the oil and remediation efforts. The animals' exposure to hydrocarbons persisting in the sea may result in lethal and sublethal impacts, tissue irritation, food reduction or contamination, direct ingestion of oil and/or tar, coating of the gills with oil, and temporary displacement from preferred habitats or migration routes (Moore and Dwyer, 1974).

Oil can be lethal to fish, especially in larval and egg stages, depending on the time of the year of exposure. Weathered crude oil has been shown in laboratory experiments to cause malformation, genetic damage, and even mortality at low levels in fish embryos of Pacific herring (Carls et al., 1999). There is a possibility of mortality in GOM larval fishes that came into contact with the spilled oil, depending on the timing of the spawn and the area influenced by the oil. Additional impacts from dispersant used in

response activities may also be toxic to fish. Although Corexit 9500, the dispersant used, is believed to be the least toxic of all of its counterparts to small fish, its toxicity mixed with oil to specific species is unknown.

The severity and the duration of the effects on the fish assemblages and fisheries of the GOM are unknown at this time. More detail on the potential range of effects to fish from contact with spilled oil is found on Fact Sheets included on the NMFS Office of Protected Resources website at http://www.nmfs.noaa.gov/pr/health/oilspill/.

The best available information does not provide a complete understanding of the effects of the spilled oil and active response/cleanup activities on fish. For example, it is expected that the large amount of chemical dispersants used on the oil may act as an irritant on the animals' tissues and sensitive membranes. Currently, the following efforts are underway to gather and analyze more data to better understand the range of actual effects to fish in the GOM from the Macondo well blowout/spill:

- Short-term response and restoration efforts through the NRDA process, and
- The NMFS and FWS ESA Section 7 Emergency Consultations and NMFS Essential Fish Habitat consultations will provide guidance on the reestablishment of the baseline for ESA-listed species and fish.

There is ongoing research to assess the impacts to resources from the Macondo Event. Results of this research are forthcoming, and BOEM will update future analyses as this information becomes available. For many resources, the data are still being collected and analyzed through the NRDA process. The BOEM continues to seek data and research results from the NRDA process and the scientific community.

Conclusion

The effects of the proposed action, when viewed in light of the effects associated with other relevant activities, may impact fish and fisheries occurring in the GOM. However, given the scope of the proposed action, incremental effects from the proposed seismic activities on fish and fisheries will be negligible. For fish that may be experiencing additional impacts from the Macondo Event, no additional incremental impacts from the proposed action are expected.

3.5. Other Users of the OCS

BOEM is required to consider the impact of the proposed action on other users of the GOM OCS; one of the most prevalent users is the U.S. military. All military activities in the GOM OCS occur within military warning areas designated by the Federal Aviation Administration in coordination with the U.S. Department of Defense. Space-use conflicts related to military activities were addressed in Section III.A.2 and Section II.D in Appendix F of the PEA (USDOI, MMS, 2004); potential impacts related to military warning areas were determined to be negligible. Lessees and permittees conducting G&G operations within these warning areas are required to coordinate with the appropriate military command.

The survey operations and routes to be taken by vessels in support of Gulf Ocean's proposed survey will operate within Military Warning Area (MWAs) W59A BOEM's website contains a map of the MWAs and EWTAs in the GOM (see http://www.boem.gov/Environmental-Stewardship/Environmental-Studies/Gulf-of-Mexico-Region/MWA_boundaries-pdf.aspx) and includes contact information (see http://www.boem.gov/Environmental-Stewardship/Environmental-Studies/Gulf-of-Mexico-Region/Military-Contacts-pdf.aspx.). Using this information, the coordination condition of approval has proven effective over many years to reduce the risk of interrupting planned military or geophysical activities.

3.6. Other Considerations

A discussion of the other resources considered but not analyzed under this SEA is found in Chapter III of the PEA (USDOI, MMS, 2004), and Chapter 3 of the Multisale EIS (USDOI, MMS, 2012a).

4. CONSULTATION AND COORDINATION

The information in this SEA was obtained from BOEM personnel listed on pages VI-1 and VI-2 of the PEA and in consultation with other Federal agencies, the private sector, and academia personnel found on pages IV-1 and IV-2 of the PEA (USDOI, MMS, 2004).

BOEM originally petitioned NMFS for incidental-take regulations under Subpart I of the Marine Mammal Protection Act (MMPA) and consultation under Section 7 of the Endangered Species Act (ESA). When the PEA was completed, BOEM revised its MMPA petition in 2004 with the updated information and is currently in consultation awaiting promulgation of the take regulations. During the interim, NMFS worked with BOEM in developing the mitigation measures under the Joint Notice to Lessees and Operators (NTL) 2012-G02 (Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program), and Joint NTL No. 2012-G01 (Vessel Strike Avoidance and Injured/Dead Protected Species Reporting), to ensure that marine mammals and sea turtles were afforded the best possible protection in lieu of the regulations/Incidental Take Statement. Adherence to these NTLs is assumed in the impact analyses and considered to mitigate the effects of the action in this SEA.

5. BIBLIOGRAPHY

Au, W.L. and M.C. Hastings. 2008. Principles of marine bioacoustics. New York: Springer-Verlag.

Bartol, S.M., J.A. Musick, and M.L. Lenhardt. 1999. Auditory evoked potentials of the loggerhead sea turtle (*Caretta caretta*). Copeia 3:836-840.

Boeger, W.A., M.R. Pie, A. Ostrensky, and M.F. Cardoso. 2006. The effect of exposure to seismic prospecting on coral reef fishes. Brazilian Journal of Oceanography 54:235-239.

Boertmann, D., Tougaard, J., Johansen, K. & Mosbech, A. 2010. Guidelines to environmental impact assessment of seismic activities in Greenland waters. 2nd edition. National Environmental Research Institute, Aarhus University, Denmark. 42 pp. – NERI Technical Report no. 785. http://www.dmu.dk/Pub/FR785.pdf. Accessed August 26, 2013.

Booman, C., H. Dalen, H. Heivestad, A. Levsen, T. van der Meeren, and K. Toklum. 1996. Effekter av luftkanonskyting pa egg, larver og ynell. Undersekelser ved Hauforskningstituttet ogtoclgisk Laboratorium, Universitet; Bergen. *Fisken og Havet*, 3**.**

Bowles, A.E., M. Smultea, B. Würsig, D.P. DeMaster, and D. Palka. 1994. Relative abundance and behavior of marine mammals exposed to transmissions from the Heard Island Feasibility Test. Journal of the Acoustical Society of America 96:2469-2484.

Caldwell, D.K., and M.C. Caldwell. 1987. Underwater echolocation type clicks by captive stranded pygmy sperm whales, *Kogia breviceps*. In: Abstracts, Seventh Biennial Conference on the Biology of Marine Mammals, Miami, Florida, December 5-9, 1987. p. 8.

Carls, M.G., S.D. Rice, and J.E. 1999. Sensitivity of fish embryos to weathered crude oil: Part I. Low-level exposure during incubation causes malformations, genetic damage, and mortality in larval Pacific herring (Clupea pallasi). Environ. Toxicol. Chem. 18:481-493.

Chapman, C.J. and A.D. Hawkins. 1969. The importance of sound in fish behaviour in relation to capture by trawls. FAO Fisheries Report 62:717-729.

Cook, M.L.H., R.A. Varela, J.D. Goldstein, S.D. McCulloch, G.D. Bossart, J.J. Finneran, D. Houser, and D.A. Mann. 2006. Beaked whale auditory evoked potential hearing measurements. J. Comp. Physiol. A. 192:489-495.

Cranford, T.W., M. Amundin, and K.S. Norris. 1996. Functional morphology and homology in the odontocete nasal complex: Implications for sound generation. J. Morphol. 228(3): 223-285.

Curry, B.E. 1999. Stress in mammals: The potential influence of fishery-induced stress on dolphins in the eastern tropical Pacific Ocean. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-260.

Dalen, J. and A. Raknes. 1985. Scaring effects on fish from three dimensional seismic surveys. Institute of Marine Research Report FO 8504/8505, Bergen, Norway (Norwegian with English summary).

Dalen, J. and G.M. Knutsen. 1986. Scaring effects in fish and harmful effects on eggs, larvae and fry by offshore seismic explorations. Symposium on Underwater Acoustics, Halifax.

Davis, R.W., W.E. Evans, and B. Würsig, eds. 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-1999-005 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA, OCS Study MMS 2000-003.

Dodd, C.K., Jr. 1988. Synopsis of the biological data on the loggerhead sea turtle *Caretta* (Linnaeus 1758). U.S. Fish and Wildlife Service Biological Report 88(14). Government Printing Office; Washington, D.C.

Engås, A, S. Løkkeborg, E. Ona, and A.V. Soldal. 1996. Effects of seismic shooting on local abundance and catch rates of cod (*G. morhua*) and haddock (*M. aeglefinus*). Canadian Journal of Fisheries and Aquatic Science 53:2238-2249.

Erbe, C. and D.M. Farmer. 1998. Masked hearing thresholds of a beluga whale in icebreaker noise. Deep-sea Research II:45:1373-1388.

Erbe, C., A.R. King, M. Yedlin, and D.M. Farmer. 1999. Computer models for masked hearing experiments with beluga whales (*Delphinapterus leucas*). Journal of the Acoustical Society of America 105:2967-2978.

Falk, M.R. and M.J. Lawrence. 1973. Seismic exploration: Its nature and effects on fish. Canada Technical Report Series No. CEN/T-73-9. Department of the Environment, Fisheries and Marine Service, Resource Management Branch, Fisheries Operations Directorate, Central Region (Environment), Winnipeg, MB.

Fay, R.R. and A.N. Popper. 2000. Evolution of hearing in vertebrates: The inner ears and processing. Hearing Research 149:1-10.

Fay, R.R. 2005. Sound source localization by fishes. In: Popper, A.N. and R.R. Fay, eds. Sound Source Localization. New York: Springer-Verlag. Pp. 36-66.

Fernández, A., M. Arbelo, R. Deaville, I.A.P. Patterson, P. Castro, J.R. Baker, E. Degollada, H.M. Ross, P. Herráez, A.M. Pocknell, E. Rodríguez, F.E. Howie, A. Espinosa, R.J. Reid, J.R. Jaber, V. Martin, A.A. Cunningham, and P.D. Jepson. 2004. Pathology: Whales, sonar and decompression sickness (reply). Nature 428(6984, 15 Apr.). doi: 10.1038/nature02528a.

Fernández, A., J.F. Edwards, F. Rodriguez, A.E. de los Monteros, P. Herraez, P. Castro, J.R. Jaber, V. Martin, and M. Arbelo. 2005. Gas and fat embolic syndrome involving a mass stranding of beaked whales (Family Ziphiidae) exposed to anthropogenic sonar signals. Veterinary Pathology 42(4):446-457.

Finneran, J.J. 2003. Whole-lung resonance in a bottlenose dolphin (*Tursiops truncatus*) and white whale (*Delphinapterus leucas)*. J. Acoust. Soc. Am. 114(1):529-535.

Finneran, J.J. 2009. Evoked response study tool (EVREST): A portable, rugged system for single and multiple auditory evoked potential measurements. J. Acoust. Soc. Am. 126:491-500.

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.

Geraci, J.R. and D.J. St. Aubin. 1990. Sea mammals and oil: confronting the risks / edited by Joseph R. Geraci and David J. St. Aubin Academic Press, San Diego.

Goold, J.C., and P.J. Fish. 1998. Broadband spectra of seismic survey airgun emissions, with reference to dolphin auditory thresholds. J. Acoust. Soc. Am. 103(4): 2177-2184.

Goold, J.C., and M.R. Clarke. 2000. Sound velocity in the head of the dwarf sperm whale, Kogia simus, with anatomical and functional discussion. J. Mar. Biol. Assoc. U.K. 80(3):535-542.

Gulf Ocean Services, Inc. 2013. Application for permit to conduct geological or geophysical exploration for mineral resources or scientific research in the Outer Continental Shelf, L13-028 , June 2013.

Hassel A., Knutsen T., Dalen J., Løkkeborg S., Skaar K., Østensen Ø., Haugland E. K., Fonn M., Høines Å., Misund O. A. 2003. Reaction of sandeel to seismic shooting: a field experiment and fishery statistics study. Institute of Marine Research, Fisken og Havet. Vol. 4. 63 pp.

Hawkins, A.D. 1993. Underwater sound and fish behaviour. Pages 129-169 *in* T.J Pitcher, ed. Behaviour of Teleost Fishes. Second Edition. Chapman and Hall, London, UK.

Hirsh, A.G. and P.G. Rodhouse. 2000. Impacts of geophysical seismic surveying on fishing success. Reviews in Fish Biology and Fisheries 10:113-118.

Holliday, D.V., R.E. Pieper, M.E. Clarke, and C.F. Greenlaw. 1987. The effects of airgun energy releases on the eggs, larvae, and adults of the northern anchovy (*Engraulis mordax*). API Publication 4453. Report by Tracor Applied Sciences for American Petroleum Institute, Washington, DC.

Holst, M., W.J. Richardson, W.R. Koski, M.A. Smultea, B. Haley, M.W. Fitzgerald, and M. Rawson. 2006. Effects of large- and small-source seismic surveys on marine mammals and sea turtles. Eos, Trans. Am. Geophys. Union 87(36), Joint Assembly Suppl., Abstract OS42A-01. 23-26 May, Baltimore, MD.

Hooker, S.K., R.W. Baird, and A. Fahlman. 2009. Could beaked whales get the bends? Effects of diving behaviour and physiology on modelled gas exchange for three species: *Ziphius cavirostris*, *Mesoplodon densirostris* and *Hyperoodon ampullatus*. Respiratory Physiology & Neurobiology. 167: 235-246.

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. College Station, TX: Texas A&M University Printing Center. 92 pp.

Jepson, P.D., Arbelo, M., Deaville, R., Patterson, I.A.P., Castro, P., Baker, J.R., Degollada, E., Ross, H.M., Herraez, P., Pocknell, A.M., Rodriguez, F., Howie, F.E., Espinosa, A., Reid, R.J., Jaber, J.R., Martin, V., Cunningham, A.A. and Fernández, A. 2003. Gas-bubble lesions in stranded cetaceans. Nature. 425(6958): 575-576.

Jochens, A., D. Biggs, D. Engelhaupt, J. Gordon, N. Jaquet, M. Johnson, R. Leben, B. Mate, P. Miller, J. Ortega-Ortiz, A. Thode, P. Tyack, J. Wormuth, and B. Würsig. 2006. Sperm whale seismic study in the Gulf of Mexico, Summary Report, 2002–2004. OCS Study MMS 2006-034. New Orleans, Louisiana: Minerals Management Service.

Jochens, A., D. Biggs, K. Benoit-Bird, D. Engelhaupt, J. Gordon, C. Hu, N. Jaquet, M. Johnson, R. Leben, B. Mate, P. Miller, J. Ortega-Ortiz, A. Thode, P. Tyack, and B. Würsig. 2008. Sperm whale seismic study in the Gulf of Mexico: Synthesis report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2008-006. 341 pp.

Jorgenson, J.K. and E.C. Gyselman. 2009. Hydroacoustic measurements of the behavioral response of arctic riverine fishes to seismic airguns. Journal of the Acoustical Society of America 126:1598-1606.

Kalmijn, A.J. 1988. Hydrodynamic and acoustic field detection. In *Sensory Biology of Aquatic Animals* (ed. J. Atema, R. R. Fay, A. N. Popper and W. M. Tavolga), pp. 83-130. New York: Springer Verlag.

Kalmijn, A.J. 1989. Functional evolution of lateral line and inner ear systems. Pages 187-216 *in* S. Coombs P. Görner, and H. Münz, eds. The Mechanosensory Lateral Line: Neurobiology and Evolution. Springer-Verlag, New York, NY.

Ketten, D.R. 1998. Marine Mammal Auditory Systems: A summary of audiometric and anatomical data and its implications for underwater acoustic impacts. NOAA Technical Memorandum NMFS-SWFSC-256.

Kostyvchenko, L.P. 1973. Effects of elastic waves generated in marine seismic prospecting on fish eggs in the Black Sea. Hydrobiological Journal 9:45-48.

Kryter, K.D. 1985. The Effects of Noise on Man. 2nd ed. Academic Press, Orlando, FL.

La Bella, G., S. Cannata, C. Froglia, A. Modica, S. Ratti, and G. Rivas. 1996. First assessment of effects of air-gun seismic shooting on marine resources in the Central Adriatic Sea. Pages 227-238 *in* Society of Petroleum Engineers, International Conference on Health, Safety and Environment, New Orleans, Louisiana, 9-12 June.

Ladich, F. and A.N. Popper. 2004. Parallel evolution in fish hearing organs. Pages 95-127 *in* G.A. Manley, A.N. Popper, and R.R. Fay, eds. Evolution of the Vertebrate Auditory System. Springer-Verlag, New York, NY

Lenhardt, M. L., S. Bellmund, R.A. Byles, S.W. Harkins, and J.A. Musick. 1983. Marine turtle reception of bone-conducted sound,'' J. Aud Res. 23, 119–125.

Lenhardt, M.L. 1994. Seismic and very low frequency sound induced behaviors in captive loggerhead marine turtles (*Caretta caretta*). In Proceedings of the fourteenth annual symposium on sea turtle biology and conservation (K.A. Bjorndal, A.B. Bolten, D.A. Johnson & P.J. Eliazar, eds.) NOAA Technical Memorandum, NMFS-SEFC-351, National Technical Information Service, Springfield, Virginia, 238-241.

Lenhardt, M.L., R.C. Klinger, and J.A. Musick. 1985. Marine turtle middle-ear anatomy. J Aud Res 25:66.

Løkkeborg, S. 1991. Effects of geophysical survey on catching success in longline fishing. Paper presented at the International Council for the Exploration of the Sea (ICES) Annual Science Conference. ICES CM B 40:1-9.

Lutcavage, M.E., 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.

Madsen, P. T., R. Payne, N. U. Kristiansen, M. Wahlberg, I. Kerr, and B. Mohl. 2002. Sperm whale sound production studied with ultrasound time/depth-recording tags. Journal of Experimental Biology 205:1899-1906.

Madsen, P.T., M. Johnson, P.J.O. Miller, N. Aguilar deSoto, and P.L. Tyack. 2006. Quantitative measures of air gun pulses on sperm whales (Physetermacrocephalus) using acoustic tags during controlled exposure experiments. Journal of the Acoustical Society of America 120, 2366–2379.

Mate, B. R., K. M. Stafford, and D. K. Ljungblad. 1994. A change in sperm whale (Physeter macrocephalus) distribution correlated to seismic surveys in the Gulf of Mexico. *Journal of the Acoustical Society of America* 96 Pt.2: 3268-3269.

McCauley, R.D. 1994. Endangered Species Act-Section 7 Consultation Biological Opinion. Joseph E. Powers, PhD., Acting Regional Administrator, National Marine Service (NOAA Fisheries) Southeast Regional Office.

McCauley, R. D., J. Fewtrell, A.J. Duncan, C. Jenner, M.-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000a. Marine seismic surveys a study of environmental implications. APPEA J., 40:692-708.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000b. Marine seismic surveys: Analysis of airgun signals; and effects of air gun exposure on humpback whales, sea turtles, fishes and squid. Report from Centre for Marine Science and Technology, Curtin University, Perth, Western Australia, for Australian Petroleum Production Association, Sydney, NSW.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch and K. McCabe. 2000c. Marine seismic surveys – a study of environmental implications. APPEA Journal 40:692-706.

McCauley, R.D., J. Fewtrell, and A.N. Popper. 2003a. High intensity anthropogenic sound damages fish ears. Journal of the Acoustical Society of America 113:638-642.

McCauley, R.D. and D.H. Cato. 2003b. Acoustics and marine mammals: introduction, importance, threats and potential as a research tool. Pages 332-353 *in* N. Gales, M. Hindell, and R. Kirkwood, eds. Marine Mammals: Fisheries, Tourism and Management issues. CSIRO Publications, Melbourne, Victoria, Australia.

McDonald, M.A., J.A. Hildebrand, and S.C. Webb. 1995. Blue and fin whales observed on a seafloor array in the northeast Pacific. J. Acoust. Soc. Am. 98: 712-721.

McEachran, J.D. 2009. Fishes (Vertebrata: Pisces) of the Gulf of Mexico. In: Tunnell, J.W., Jr.., D.L. Felder, and S.A. Earle (eds.). Gulf of Mexico Origins, Waters, and Biota. Texas A&M University Press, Texas.

Moein, S., M. Lenhardt, D. Barnard, J. Keinath, and J. Musick. 1993. Marine turtle auditory behavior. Journal of the Acoustical Society of America 93(4, Pt 2):2,378.

Moein, S.E., J.A. Musick, J.A. Keinath, D.E. Barnard, M. Lenhardt, and R. George. 1994. Evaluation of seismic sources for repelling sea turtles from hopper dredges. Report from Virginia Institute of Marine Science, Gloucester Point, VA, to U.S. Army Corps of Engineers.

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

Mullin, K.D. and W. Hoggard. 2000. Visual surveys of cetaceans and sea turtles from aircraft and ships, chapter 4. In: Davis, R.W., W.E. Evans, and B. Würsig, eds. Cetaceans, sea turtles and birds in the northern Gulf of Mexico: Distribution, abundance and habitat associations. Volume II: Technical report. U.S. Dept. of the Interior, Geologic Survey, Biological Resources Division, USGS/BRD/CR-1999-005 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA, OCS Study MMS 2000-003. 364 pp.

Mullin, K.D. and G.L. Fulling. 2004. Abundance of cetaceans in the oceanic northern Gulf of Mexico, 1996-2001. Marine Mammal Science 20:787-807.

Myrberg, A. A. 1981. Sound communication and interception in fishes. In *Hearing and Sound Communication in Fishes* (ed. W. N. Tavolga, A. N. Popper and R. R. Fay), pp. 395-426. New York: Springer-Verlag.

National Research Council (NRC). 1990 . Decline of the sea turtles: Causes and prevention. Committee on Sea Turtle Conservation. Washington, DC: National Academy Press. 280 pp.

National Science Foundation and U.S. Department of the Interior, Geological Survey. 2011. Final Programmatic Environmental Impacts Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation of Conducted by the U.S. Geological Survey. June 2011. 514 pp. plus Appendices. Accessed August 26, 2013. http://www.nsf.gov/geo/oce/envcomp/usgs-nsf-marine-seismic-research/nsf-usgs-final-eis-oeis-with-appendices.pdf

National Science Foundation (NSF). 2010. Draft Programmatic Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement for Marine Seismic Research funded by the National Science Foundation or Conducted by the U.S. Geological Survey. Arlington, Virginia. 801 pages

Nedwell, J., B. Edwards, A. Turnpenny, J. Gordon. 2004. Fish and Marine Mammal Audiograms: A summary of available information. Subacoustech Report Reference: 534R0214, September 2004. To: Chevron Texaco Ltd., TotaFinaElf Exploration UK Plc, DSTL, DTI and Shell U.K. Exploration and Production Ltd.

Nieukirk, S. L., K.M. Stafford, D.K. Mellinger, R.P. Dziak, and C.G. Fox. 2004. Low-frequency whale and seismic airgun sounds recorded in the mid-Atlantic Ocean. J. Acoust. Soc. Am. 115: 1832 – 1843.

Nowacek, D. P., L H. Thorne, D. W. Johnson, and P.L. Tyack. 2007. Responses of cetaceans to anthropogenic noise. Mammal Rev. 37(2): 81–115.

Payne, J.F., J. Coady, and D. White. 2009. Potential effects of seismic airgun discharges on monkfish eggs (*Lophius americanus*) and larvae. Environmental Studies Research Funds Report 170. St. John‘s, NL.

Pearson, W.H., J.R. Skalski, and C.I. Malme. 1992. Effects of sounds from a geophysical survey device on behavior of captive rockfish (*Sebastes* spp.). Canadian Journal of Fisheries and Aquatic Science 49:1343-1356.

Piantadosi, C.A. and E.D. Thalmann. 2004. Pathology: Whales, sonar and decompression sickness (reply). Nature. 428(6984):U1.

Pickett, G.D., D.R. Eaton, R.M.H. Seaby, and G.P. Arnold. 1994. Results of bass tagging in Poole Bay during 1992. Laboratory Leaflet Number 74. Ministry of Agriculture, Fisheries and Food, Directorate of Fisheries Research, Lowestoft, UK.

Popper, A. N. 2003. Effects of anthropogenic sound on fishes. Fisheries 28:24-31.

Popper, A.N. 2005. A Review of Hearing by Sturgeon and Lamprey. Report for U.S. Army Corps of Engineers, Portland District, Portland, OR. 12 August.

Popper, A. N. and M.C. Hastings. 2009. The effects on fish of human-generated (anthropogenic) sound. *Integrative Zoology* 2009; 4: 43-52

Popper, A.N. and R.R. Fay. 2010. Rethinking sound detection by fishes. Hearing Research (in press). doi: 10.1016/j.heares.2009.12.023.

Pritchard, P.C.H. 1980. The Conservation of Sea Turtles: Practices and Problems. American Zoologist. 20(3): 609-617.

Pritchard, P.C.H. 1997. Evolution, phylogeny, and current status. Lutz, P.L. and J.A. Musick, eds. The Biology of Sea Turtles. Boca Raton, FL: CRC Press. pp. 1-28.

Richardson, W. J., B. Würsig, and C. R. Greene, Jr. 1986. Reactions of bowhead whales, *Balaena mysticetus*, to seismic exploration in the Canadian Beaufort Sea. Journal of the Acoustical Society of America. 79: 1117–1128.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. 1995. Marine mammals and noise. San Diego, CA: Academic Press. 576 pp.

Ridgway S.H., Wever E.G., McCormick J.G., Palin J, Anderson J.H. 1969. Hearing in the giant sea turtle, *Chelonia mydas.* Proc Natl Acad Sci USA. 64:884–890.

Ridgway, S. H., and D.A. Carder. 2001. Assessing hearing and sound production in cetaceans not available for behavioral audiograms: Experiences with sperm, pygmy sperm, and gray whales. Aquatic Mammals. 27(3): 267–276.

Ross, J.P. and Barwani, M.A. 1982. Review of sea turtles in the Arabian area. *In* K.A. Bjorndal, ed. Biology and conservation of sea turtles, pp. 373-383. Washington, DC, Smithsonian Institution Press.

Santulli, A., C. Messina, L. Ceffa, A. Curatolo, G. Rivas, G. Fabi, and V. Damelio. 1999. Biochemical responses of European sea bass (*Dicentrachus labrax*) to the stress induced by offshore experimental seismic prospecting. Marine Pollution Bulletin 38:1105-1114.

Schellert, A.M. and A.N. Popper. 1992. Functional aspects of the evolution of the auditory system of actinoperygian fish. Pages 295-323 *in* B.D. Webster, R.R. Fay, and A.N. Popper, eds. Evolutionary Biology of Hearing. Springer-Verlag, New York.

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.

Schuijf, A. 1981. Models of acoustic localization. Pages 267-310 *in* W.N. Tavolga, A.N. Popper, and R.R. Fay, R.R., eds. Hearing and Sound Communication in Fishes. Springer-Verlag New York, NY.

Skalski, J.R., W.H. Pearson, and C.I. Malme. 1992. Effects of sounds from a geophysical survey device on catch-per-unit-effort in a hook-and-line fishery for rockfish (*Sebastes* spp.). Canadian Journal of Fisheries and Aquatic Science 49:1357-1365.

Slotte, A., K. Hansen, J. Dalen, and E. Ona. 2004. Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast. Fisheries Research 67:143-150.

Smultea, M.A., M. Holst, W.R. Koski, and S. Stoltz. 2004. Marine mammal monitoring during Lamont-Doherty Earth Observatory's seismic program in the Southeast Caribbean Sea and adjacent Atlantic Ocean, April-June 2004. LGL Rep. TA2822-26. Rep. from LGL Ltd., King City, Ont., for L-DEO, Columbia Univ., Palisades, NY. 106 p.

Sodal, A. 1999. Measured underwater acoustic wave propagation from a seismic source. Proc. Airgun Environ-mental Workshop, 6 July, London, UK.

Song J., D.A. Mann, P.A. Cot, B.W. Hanna, and A.N. Popper. 2008. The inner ears of northern Canadian freshwater fishes following exposure to seismic air gun sounds. *Journal of the Acoustical Society of America* 124, 1360-6.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P.L. Tyack. 2007. Marine mammal noise expo-sure criteria: initial scientific recommendations. Aquat. Mamm. 33(4):411-522.

Sverdrup, A., E. Kjellsby, P.G. Krüger, R. Fløysand, F.R. Knudsen, P.S. Enger, G. Serck-Hanssen, and K.B. Helle. 1994. Effects of experimental seismic shock on vasoactivity of arteries, integrity of the vascular endothelium and on primary stress hormones of the Atlantic salmon. Journal of Fish Biology 45:973-995.

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

Teo, S.L.H, A. Boustany, and B.A. Block. 2007a. Oceanographic preferences of Atlantic bluefin tuna, *Thunnus thynnus*, on their Gulf of Mexico breeding grounds. Marine Biology 152:1105-1119.

Teo, S.L.H, A. Boustany, H. Dewar, M.J.W. Stokesbury, K.C. Weng, S. Beemer, A.C. Seitz, C.J. Farwell, E.D. Prince, and B.A. Block. 2007b. Annual migrations, diving behavior, and thermal biology of Atlantic bluefin tuna, *Thunnus thynnus*, on their Gulf of Mexico breeding grounds. Marine Biology 151:1-18.

Teo, S., and B.A. Block. 2010. Comparative influence of ocean conditions on yellowfin and Atlantic bluefin tuna catch from longlines in the Gulf of Mexico. *PlosOne* 5:1-11.

Thomsen, B. 2002. An experiment on how seismic shooting affects caged fish. Thesis, Faroese Fisheries Laboratory, University of Aberdeen, Aberdeen, Scotland. 16 August.

Tolstoy, M., J. Diebold, L. Doermann, S. Nooner, and S.C. Webb. 2009. Broadband calibration of the R/V Marcus G. Langseth four-string seismic sources. Geochemistry, Geophysics, Geosystems. 10, Q08011, doi:10.1029/2009GC002451.

Tyack, P., M. Johnson, and P. Miller. 2003. Tracking responses of sperm whales to experimental exposures of airguns. p. 115-120 *In:* A.E. Jochens and D.C. Biggs (eds.), Sperm whale seismic study in the Gulf of Mexico/Annual Report: Year 1. OCS Study MMS 2003-069. Rep. from Texas A&M Univ., College Station, TX, for U.S. Minerals Manage. Serv., Gulf of Mexico OCS Region, New Orleans, LA.

U.S. Dept. of Commerce (USDOC). National Marine Fisheries Service (NMFS). 2006. Final Consolidated Atlantic Highly Migratory Species Fisheries Management Plan. National Oceanic Atmospheric Administration, National Marine Fisheries Service, Office of Sustainable Fisheries, Highly Migratory Species Division, Silver Springs, MD. Public Document. 1600 pp.

U.S. Dept. of Commerce. National Marine Fisheries Service (NMFS). 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 (USDOC) National Marine Fisheries Service (NMFS). 2009. Recovery Plan for Smalltooth Sawfish (*Pristis pectinata*). Prepared by the Smalltooth Sawfish Recovery Team for the NMFA. Silver Spring, MD 102 pp (page 8).

U.S. Dept. of Commerce. National Marine Fisheries Service. 2011. FAQs on the Investigations of the Ongoing Dolphin Die-off and the Potential Impacts of the Deepwater Horizon BP Oil Spill on Marine Mammals. Internet website: Last updated March 27, 2013. Accessed August 26, 2013. http://www.nmfs.noaa.gov/pr/health/mmume/cetacean_gulfofmexico_faq.htm .

U.S. Dept. of Commerce. National Marine Fisheries Service. 2013. 2010-2013 cetacean unusual mortality event in northern Gulf of Mexico. Internet website: http://www.nmfs.noaa.gov/pr/health/mmume/cetacean_gulfofmexico2010.htm . Last updated June 16, 2013. Accessed August 26, 2013.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management. 2012a. Gulf of Mexico OCS Oil and Gas Lease Sales: 2012-20172; Western Planning Area Sales 229, 233, 238, 246, and 248; Central Planning Area Sales 227, 231, 235, 241, and 247; Final Environmental Impact Statement U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA BOEM 2012-019. Accessed August 26, 2013. http://www.boem.gov/Environmental-Stewardship/Environmental-Assessment/NEPA/BOEM-2012-019_v1.aspx

U.S. Dept of the Interior. Bureau of Ocean Energy Management. 2012b. Seismic Survey Mitigation Measures and Marine Mammal Observer Reports. Gulf of Mexico Region, New Orleans, LA. OCS Study BOEM 2012-015. 28 pp w Appendices. Accessed August 26, 2013. http://www.data.boem.gov/PI/PDFImages/ESPIS/5/5177.pdf.

U.S. Department of the Interior (USDOI). Minerals Management Service (MMS). 2004. Geological and geophysical exploration for mineral resources on the Gulf of Mexico outer continental shelf: Final programmatic environmental assessment. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 2004-054. http://www.boem.gov/BOEM-Newsroom/Library/Publications/2004/2004-054.aspx. Accessed August 26, 2013.

U.S. Department of the Navy (DoN). 2008 a and b. Final Atlantic Fleet Active Sonar Training EIS/OEIS http://www.nmfs.noaa.gov/pr/pdfs/permits/afast_eis.pdf. Accessed August 26, 2013.

U.S. Dept. of the Interior (USDOI), Fish and Wildlife Service (FWS) and Gulf States Marine Fisheries Commission (GSMFC). 1995. Gulf Sturgeon (*Acipenser oxyrinchus desotoi*) Recovery/Management Plan. Prepared by the Gulf Sturgeon Recovery/Management Task Team for the U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Atlanta, GA; the Gulf States Marine Fisheries Commission, Ocean Springs, MS; and the U.S. Dept. of Commerce, National Marine Fisheries Service, Washington, DC.

U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS). 2007a. 2007 Loggerhead Sea Turtle ESA Review. Jacksonville, FL. Accessed August 26, 2013. http://www.fws.gov/northflorida/SeaTurtles/2007-Reviews/2007-loggerhead-turtle-5-year-review-final.pdf

U.S. Fish and Wildlife Service and National Marine Fisheries Service (NMFS). 2007b. 2007 Hawksbill Sea Turtle ESA Review. Jacksonville, FL. Accessed August 26, 2013. http://www.nmfs.noaa.gov/pr/pdfs/species/hawksbill_5yearreview.pdf

U.S. Fish and Wildlife Service and National Marine Fisheries Service (NMFS). 2007c. 2007 Olive Ridley Sea Turtle ESA Review. Jacksonville, FL. Accessed August 26, 2013. http://www.nmfs.noaa.gov/pr/pdfs/species/oliveridley_5yearreview.pdf

U.S. Fish and Wildlife Service and National Marine Fisheries Service. (NMFS). 2007d. 2007 Kemp's Ridley Sea Turtle ESA Review. Jacksonville, FL. Accessed August 26, 2013. http://www.nmfs.noaa.gov/pr/pdfs/species/kempsridley_5yearreview.pdf

U.S. Fish and Wildlife Service and National Marine Fisheries Service. (NMFS). 2007e. 2007 Green Sea Turtle ESA Review. Jacksonville, FL. Accessed August 26, 2013. http://www.nmfs.noaa.gov/pr/pdfs/species/greenturtle_5yearreview.pdf

van Bergeijk, W.A. 1967. The evolution of vertebrate hearing. Pages 1-49 *in* W.D. Neff, ed. Contributions to Sensory Physiology. Academic Press, New York, NY.

Watkins, W. A., and Schevill, W. E. 1975. Sperm whales react to pingers. Deep-Sea Res. 22: 123–129.

Wardle, C.S., T.J. Carter, G.G. Urquhart, A.D.F. Johnstone, A.M. Ziolkowski, G. Hampson, and D. Mackie. 2001. Effects of seismic airguns on marine fish. Continental Shelf Research 21:1005-1027.

Waring, G.T., E. Josephson, K. Maze-Foley, and P.E. Rosel, eds. 2011. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments -- 2010. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration. NOAA Technical Memorandum NMFS-NE-219. 598 pp. Internet website: www.nefsc.noaa.gov/publications/tm/tm219/. Accessed August 26, 2013.

Waring G.T., Josephson E., Maze-Foley K, Rosel, P.E., 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, or online at http://www.nefsc.noaa.gov/publications/tm/tm221/ Accessed August 26, 2013

Webb, J.F., R.R Fay, and A.N. Popper, (Eds). 2008. *Fish Bioacoustics*. New York, NY: Springer Science+Business Media, LLC.

Weir, C.R. 2007. Observations of Marine Turtles in Relation to Seismic Airgun Sound off Angola. Marine Turtle Newsletter. 116:17-20.

Weir, C.R. 2008. Overt responses of humpback whales (*Megaptera novaeangliae*), sperm whales (*Physeter macrocephalus*), and Atlantic spotted dolphins (*Stenella frontalis*) to seismic exploration off Angola. Aquatic Mammals. 34: 71-83.

Williams, T.M., R.W. Davis, L.A. Fuiman, J. Francis, B. J. Le Boeuf , M. Horning, J. Calambokidis, and D. A. Croll. 2000. Sink or Swim: Strategies for Cost-Efficient Diving by Marine Mammals. Science. 288 (5463):133 – 136.

Witherington, B.E. 1986. Human and natural causes of marine turtle clutch and hatchling mortality and their relationship to hatchling production on an important Florida nesting beach. Unpublished Master's Thesis, University of Central Florida, Orlando. 141 p.

Wright, A.J., N. Aguilar Soto, A.L. Baldwin, M. Bateson, C.M. Beale, C. Clark, T. Deak, E.F. Edwards, A. Fernández, A. Godinho, L.T. Hatch, A. Kakuschke, D. Lusseau, D. Martineau, L.M. Romero, L.S. Weilgart, B.A. Wintle, G. Notarbartolo-di-Sciara, and V. Martin. 2007. Do marine mammals experience stress related to anthropogenic noise? Intern. J. Comp. Psychol. 20(2-3):274-316.

Würsig, B., T.A. Jefferson, and D.J. Schmidley. 2000. The Marine Mammals of the Gulf of Mexico. Texas A&M University Press, College Station, TX. 232 pp.

Zimmer W. M. X. and P. L. Tyack. 2007. Repetitive shallow dives pose decompression risk in deep-diving beaked whales. Marine Mammal Science. 23:888–925.

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