

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

SITE-SPECIFIC ENVIRONMENTAL ASSESSMENT

OF

EXPLORATION PLAN
NO. R-6734

FOR

LLOG EXPLORATION OFFSHORE, LLC

August 7, 2018

RELATED ENVIRONMENTAL DOCUMENTS

Gulf of Mexico OCS Proposed Geological and Geophysical Activities
Western, Central, and Eastern Planning Areas
Final Programmatic Environmental Impact Statement
(OCS EIS/EA BOEM 2017-051)

Gulf of Mexico OCS Oil and Gas Lease Sales: 2017-2022
Gulf of Mexico Lease Sales 249, 250, 251, 252, 253, 254, 256, 257, 259, and 261
Final Environmental Impact Statement
(OCS EIS/EA BOEM 2017-009)

Gulf of Mexico OCS Lease Sale
Final Supplemental Environmental Impact Statement 2018
(OCS EIS/EA BOEM 2017-074)

FINDING OF NO SIGNIFICANT IMPACT (FONSI)

The Bureau of Ocean Energy Management (BOEM) has prepared a Site-Specific Environmental Assessment (SEA) (No. R-6734) complying with the National Environmental Policy Act (NEPA). NEPA regulations under the Council on Environmental Quality (CEQ) (40 CFR §§ 1501.3 and 1508.9), the United States Department of the Interior (DOI) NEPA implementing regulations (43 CFR § 46), and Bureau of Ocean Energy Management (BOEM) policy require an evaluation of proposed major federal actions, which under BOEM jurisdiction includes approving a plan for oil and gas exploration or development activity on the Outer Continental Shelf (OCS).

NEPA regulation 40 CFR § 1508.27(b) requires significance to be evaluated in terms of context and intensity. The context and intensity of impacts caused by similar actions to that proposed were examined at a basin-wide scale in the Gulf of Mexico (GOM) in the:

- Gulf of Mexico OCS Proposed Geological and Geophysical Activities Western, Central, and Eastern Planning Areas Final Programmatic Environmental Impact Statement (GOM G&G PEIS) (OCS EIS/EA BOEM 2017-051),
- Gulf of Mexico OCS Oil and Gas Lease Sales: 2017-2022 Gulf of Mexico Lease Sales 249, 250, 251, 252, 253, 254, 256, 257, 259, and 261 Final Environmental Impact Statement (Multisale EIS) (OCS EIS/EA BOEM 2017-009), and
- Gulf of Mexico Lease Sale Final Supplemental Environmental Impact Statement 2018 (2018 SEIS) (OCS EIS/EA BOEM 2017-074).

This SEA tiers from these evaluations and considers the impacts of the proposed action.

The Proposed Action: LLOG Exploration Offshore, LLC (LLOG) proposes to conduct a zero offset vertical seismic profile and/or checkshot survey with airgun arrays that will be deployed from the drilling rig *Rowan Resolute*. The receivers will be deployed in a wellbore and possible sidetracks. The proposed activity is located southeast of Louisiana in the Central Planning Area of the GOM. The seismic survey area is located within on Mississippi Canyon Block 387, Lease Number OCS-G 22873. The area of the proposed action is located southeast of Venice, Louisiana, approximately 60 miles (96 kilometers) from the nearest shoreline and in Plaquemines Parish, Louisiana. The water depth is approximately 6,592 feet (2,009 meters).

The operation will be using support vessels whose operations are comparable to that described in the GOM G&G PEIS for similar activities. Site-specific analysis was completed using LLOG'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. The proposed survey is planned for September 2018 and will take approximately 3 days to complete (LLOG, 2018).

Factors Considered in this Determination: The context and intensity of the proposed action are further analyzed at the site-specific level in this Environmental Assessment. The impact analysis for the proposed activity focused on the G&G activities and the resources that may be potentially impacted. The impact producing factors (IPF) include: (1) active acoustic sound sources from airguns, (2) vessel noise, (3) vessel traffic, and (4) accidental fuel spill.

In this SEA BOEM has considered three alternatives: (1) No Action; (2) Proposed Action as Submitted; and (3) Proposed Action with Mitigation Measures. BOEM has assessed the impacts of the proposed action on the following resources:

- marine mammals;
- sea turtles; and
- fish.

The use of an active sound source (airgun) is potentially the most disruptive impact for a free-swimming individual or groups of marine mammals, turtles, and fish if they are in proximity to the airgun in operation.

The effect of an active acoustic source is weighted most heavily out of all other potential impacting factors. Individual animals are vulnerable to injury if hit by the survey vessel from the proposed action. Mitigation measures include the monitoring of an exclusion zone by trained protected species observers and activation of survey shutdown requirements when mammals are observed: (1) within the exclusion zone or in proximity to an active sound source; or (2) near the vessel.

The application of passive acoustic monitoring, a visually/acoustically monitored exclusion zone, shutdown criteria, and vessel avoidance are designed to reduce the possibility that animals could be in close proximity to an operating airgun and adversely impacted by the proposed activity. Groups or individuals are therefore not expected to be unduly affected by underwater noise, or exposed to being hit by the survey vessel. Impact significance levels are explained in **Chapter 3.1** of this SEA. Impacts from the proposed activities to marine mammals, sea turtles, fish, and other users have been mitigated to negligible.

Our evaluation in this SEA has selected Alternative 3 and serves as the basis for approving the proposed action. BOEM concludes that no significant impacts are expected to occur to any affected resources by allowing the proposed action to proceed, provided that the specific mitigation measures identified below are met by the operator.

- **VESSEL-STRIKE AVOIDANCE/REPORTING:** The applicant will follow the guidance provided under BOEM's Notice to Lessees and Operators (NTL) No. 2016-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/BOEM-NTL-No-2016-G01/>.
- **SEISMIC SURVEY OPERATION, MONITORING, AND REPORTING GUIDELINES:** The applicant will follow the guidance provided under BOEM NTL No. 2016-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/BOEM-NTL-2016-G02/>. Please report all marine life occurrences, all seismic gear interactions, and equipment hangs as part of the *Protected Species Observer Program* bi-monthly reporting.
- **MARINE TRASH AND DEBRIS AWARENESS AND ELIMINATION:** The applicant will follow the guidance provided under BSEE's Notice to Lessees and Operators (NTL) No. 2015-G03 (*Marine Trash and Debris Awareness and Elimination*). The NTL's guidance can be accessed on BSEE's website at <https://www.bsee.gov/sites/bsee.gov/files/notices-to-lessees-ntl/alerts/ntl-2015-g03.pdf>.

Conclusion: BOEM has evaluated the potential environmental impacts of the proposed action. Based on SEA No. R-6734, BOEM has determined that the proposed action would have no significant impact on the marine, coastal, or human environment provided that the avoidance and mitigation measures required by through conditions of approval are met by the operator. Therefore, an Environmental Impact Statement will not be required.

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BOUDREAU
Date: 2018.08.07 12:51:33 -05'00'

August 7, 2018

Chief, Environmental Operations Section
Office of Environment, GOM OCS Region

Date

Table of Contents

Page

FINDING OF NO SIGNIFICANT IMPACT (FONSI).....	2
1. PROPOSED ACTION.....	5
1.1. Background.....	6
1.2. Purpose of and Need for the Proposed Action.....	6
1.3. Description of the Proposed Action.....	7
2. ALTERNATIVES CONSIDERED.....	7
2.1. No Action Alternative.....	7
2.2. Proposed Action as Submitted.....	7
2.3. Proposed Action with Additional Mitigation Measures.....	7
2.4. Summary and Comparison of the Alternatives.....	8
2.5. Alternatives Considered but Not Analyzed in Detail.....	9
3. DESCRIPTION OF THE AFFECTED ENVIRONMENT AND ENVIRONMENTAL IMPACTS ...	10
3.1. Introduction.....	10
3.2. Marine Mammals.....	12
3.2.1. Description.....	12
3.2.2. Impact Analysis.....	12
3.2.3. Cumulative Impact Analysis.....	18
3.3. Sea Turtles.....	20
3.3.1. Description.....	20
3.3.2. Impact Analysis.....	21
3.3.3. Cumulative Impact Analysis.....	23
3.4. Fish Resources and Essential Fish Habitat.....	24
3.4.1. Description.....	24
3.4.2. Impact Analysis.....	25
3.4.3. Cumulative Impact Analysis.....	28
3.5. Other Considerations.....	28
4. CONSULTATION AND COORDINATION.....	28
5. BIBLIOGRAPHY.....	29
6. PREPARERS.....	39
7. REVIEWERS.....	39

**SITE-SPECIFIC ENVIRONMENTAL ASSESSMENT (SEA)
PREPARED FOR
LLOG EXPLORATION OFFSHORE LLC
REVISED EXPLORATION PLAN
NO. R-6734**

1. PROPOSED ACTION

The purpose of this Site-Specific Environmental Assessment (SEA) is to assess the specific impacts associated with LLOG Exploration Offshore LLC's (LLOG) proposed ancillary geological and geophysical (G&G) survey activities on the Outer Continental Shelf (OCS) of the Gulf of Mexico (GOM). **Chapter 1.3** of this SEA provides specific details on the G&G activities proposed in LLOG's Revised Exploration Plan (EP).

The SEA is tiered from:

- Gulf of Mexico OCS Proposed Geological and Geophysical Activities Western, Central, and Eastern Planning Areas Final Programmatic Environmental Impact Statement (GOM G&G PEIS) (OCS EIS/EA BOEM 2017-051) (USDOJ, BOEM, 2017a),
- Gulf of Mexico OCS Oil and Gas Lease Sales: 2017-2022 Gulf of Mexico Lease Sales 249, 250, 251, 252, 253, 254, 256, 257, 259, and 261-Final Environmental Impact Statement (Multisale EIS) (OCS EIS/EA BOEM 2017-009) (USDOJ, BOEM, 2017b), and
- Gulf of Mexico Lease Sale Final Supplemental Environmental Impact Statement 2018 (2018 SEIS) (OCS EIS/EA BOEM 2017-074) (USDOJ, BOEM, 2017c).

“Tiering” is provided in the National Environmental Policy Act (NEPA) implementing regulations (40 CFR §§ 1502.20 and 1508.28). It is designed to reduce and simplify the size of environmental assessments by eliminating repetitive discussions of impacts considered 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 the United States Department of the Interior (DOI) regulations at 43 CFR § 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 GOM G&G PEIS, Multisale EIS, and 2018 SEIS serve as a comprehensive starting point for the site specific environmental analysis of the proposed activities. To ensure analysis are sufficiently comprehensive and adequate to support decision making for LLOG's proposed activities, the following factors were identified for further analysis and are addressed in this SEA:

- **Active Acoustic Sound Sources and Vessel Noise and Traffic Impacts on Marine Mammals** – the environmental baseline since completion of the GOM G&G PEIS may have experienced slight changes and/or new information has become available;
- **Active Acoustic Sound Sources and Vessel Noise and Traffic Impacts on Sea Turtles** – the environmental baseline since completion of the GOM G&G PEIS may have experienced slight changes and/or new information has become available; and
- **Active Acoustic Sound Source Impacts on Fish and Fisheries** – the environmental baseline since completion of the GOM G&G PEIS may have experienced slight changes and/or new information has become available; and

Marine mammals, sea turtles, fishes, and commercial and recreational fisheries, as indicated in the GOM G&G PEIS, 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 that may be ongoing from the *Deepwater Horizon* explosion, spill, and response.

Therefore, **Chapter 3** of this SEA will focus on how the new information relative to the cumulative environmental effects of this action. Where applicable, relevant affected environment discussions and impact analyses from the GOM G&G PEIS, Multisale EIS, and 2018 SEIS are summarized and utilized for this site-specific analyses, and are incorporated by reference into this SEA. Relevant mitigation measures identified in the current GOM G&G PEIS, Multisale EIS, and 2018 SEIS 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, mineral resources, and renewable energy 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 is obtained in an environmentally safe 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 Program oversees "speculative" G&G data acquisition and permitting activities pursuant to 30 CFR §§ 551 and 580. Specifically, 30 CFR § 551 regulates prelease G&G exploratory operations for oil, gas, and sulfur resources, and 30 CFR § 580 regulates prelease prospecting activities. BOEM's Office of Leasing and Plans oversees "on-lease" or "ancillary" G&G data acquisition pursuant to 30 CFR § 550, which applies to postlease 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, renewable energy development, mineral resources exploration and development, and geologic hazards in a particular area. Industry needs accurate data to determine the location, extent, and properties of hydrocarbon resources. Information on shallow geologic hazards and seafloor geotechnical properties assists in the safe and economical exploration, development, production, and transportation of hydrocarbons. Additionally, the results of G&G surveys characterize sea bottom conditions before installing a renewable energy facility or to verify the completion of decommissioning activities.

The scope of the effects on GOM resources from activities proposed in LLOG's G&G survey application, No. R-6734, were fully discussed and analyzed in the GOM G&G PEIS. The proposed activity location, equipment, and duration will not result in impacts different from those discussed in the GOM G&G PEIS, Multisale EIS, or 2018 SEIS prepared since that time. Existing peer-reviewed scientific literature and environmental monitoring suggests the proposed activity will not result in a different cumulative impact conclusion from what was made in the GOM G&G PEIS. This information was not available or considered during the preparation of the GOM G&G PEIS. 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

LLOG has submitted an application to conduct a G&G ancillary activity on the OCS. The purpose of the proposed action is to conduct a zero offset vertical seismic profile (VSP) and/or checkshot survey using airgun arrays. 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 in Appendix F of the GOM G&G PEIS.

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 LLOG's application, BOEM has regulatory responsibility, consistent with the OCSLA and other applicable laws, to approve, approve with modifications or mitigation measures, or deny the application. BOEM's regulations provide criteria that BOEM will apply in reaching a decision and providing for any applicable mitigation measures.

1.3. DESCRIPTION OF THE PROPOSED ACTION

LLOG proposes to conduct a zero offset VSP and/or checkshot survey with airgun arrays that will be deployed from the drilling rig *Rowan Resolute*. The receivers will be deployed in a wellbore. The proposed activity is located southeast of Louisiana in the Central Planning Area of the GOM. The seismic survey area is located within on Mississippi Canyon Block 387, Lease Number OCS-G 22873. The area of the proposed action is located southeast of Venice, Louisiana, approximately 60 miles (mi) (96 kilometers [km]) from the nearest shoreline and in Plaquemines Parish, Louisiana. The water depth is approximately 6,592 feet (ft) (2,009 meters).

The operation will be using support vessels whose operations are comparable to that described in the GOM G&G PEIS for similar activities. Site-specific analysis was completed using LLOG'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. The proposed survey is planned for September 2018 and will take approximately 3 days to complete (LLOG, 2018).

Airguns

The sound source typically used in most seismic surveys is an airgun array. An airgun array consists 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, attached to cables/nodes placed on or anchored to the seafloor, or placed within the wellbore during VSP surveys. A typical full-scale array produces a source level of 248-255 dB re $\mu\text{Pa}\cdot\text{m}$, zero-to-peak (referring to the waveform of the sound pulse). Typical seismic arrays being used in the GOM produce source levels (sound pressure levels) of approximately 240 dB re $1 \mu\text{Pa} @ 1 \text{ m}$. 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. NO ACTION ALTERNATIVE

Alternative 1 – 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. PROPOSED ACTION AS SUBMITTED

Alternative 2 – If this alternative is selected the applicant would undertake the proposed activity as requested in the application. No additional mitigation measures would be required by BOEM.

2.3. PROPOSED ACTION WITH ADDITIONAL MITIGATION MEASURES

Alternative 3 – This is BOEM's *Preferred Alternative*. If this alternative is selected the applicant would undertake the proposed activity, as requested in the application, but with the mitigation and monitoring measures identified by BOEM (listed in Chapter 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

If selected, Alternative 1 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, geologic hazards, or potential renewable energy sites 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.

If selected, Alternative 2 would allow for the collection of seismic data, as requested in the application, but would not include any mitigation or monitoring. 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). Alternative 2 would not require the implementation of mitigation 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 mitigation and monitoring measures was assumed as part of the analysis in the NMFS 2007 Endangered Species Act (ESA) Biological Opinion (BO) and BOEM is committed to requiring their implementation. Additionally, supplemental mitigation and monitoring measures were identified and will need to be imposed to provide further protection for marine mammals (see **Chapter 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 mitigation and monitoring requirements that adequately limit or negate potential impacts. The G&G activities proposed will provide LLOG 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.

Other alternatives regarding Agency oversight of the G&G permitting program, identified in **Chapter 2** of the GOM G&G PEIS, were reviewed with the alternatives listed above chosen as reasonable for the current proposed action.

Conditions for Approval Required under the Preferred Alternative

The need for and utility of the following mitigation measures are discussed in the relevant impact analysis sections of this SEA. The following mitigation measures 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 BOEM's Notice to Lessees and Operators (NTL) No. 2016-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/BOEM-NTL-No-2016-G01/>.
- **SEISMIC SURVEY OPERATION, MONITORING, AND REPORTING GUIDELINES:** The applicant will follow the guidance provided under BOEM NTL No. 2016-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/BOEM-NTL-2016-G02/>. Please report all marine life occurrences, all seismic gear interactions, and equipment hangs as part of the *Protected Species Observer Program* bi-monthly reporting.
- **MARINE TRASH AND DEBRIS AWARENESS AND ELIMINATION:** The applicant will follow the guidance provided under BSEE's Notice to Lessees and Operators (NTL) No. 2015-G03 (*Marine Trash and Debris Awareness and Elimination*). The NTL's guidance can be accessed on BSEE's website at <https://www.bsee.gov/sites/bsee.gov/files/notices-to-lessees-ntl/alerts/ntl-2015-g03.pdf>.

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 Chapter 2 of the GOM G&G PEIS, 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 NTL No. 2016-G02 Shut-Down Conditions for Delphinids

This analysis also considered whether to apply the shutdown conditions of BOEM NTL No. 2016-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, 2012) that analyzed protected species observer (PSO) data collected from 2002-2008 in the GOM. Approximately 58 percent of all dolphin sightings occurred within the 500 m exclusion zone, and of these, 33 percent 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, bullet 4 under Definitions of NTL No. 2016-G02. If the delphinids 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 shutdown 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 (USDOI, BOEM, 2012b) indicates 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 NTL No. 2016-G02 to delphinids before requiring it as a mitigation measures 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 mitigation measures.

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) 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 LLOG's proposed 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 CFR § 1508.27). The criteria for impacts to environmental resources are generally classified into one of the three following levels:

1. *Significant Adverse Impact* (including those that could be mitigated to nonsignificance);
2. *Adverse but Not Significant Impact*, or
3. *Negligible Impact*.

Preliminary screening for this assessment was based on a review of this relevant literature; previous SEAs; the GOM G&G PEIS (USDOL, BOEM, 2017a); the Multisale EIS (USDOL, BOEM, 2017b); the 2018 SEIS (USDOL, BOEM, 2017c); 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 (including listed species and ichthyoplankton);
- commercial and recreational 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 GOM G&G PEIS, 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 (Chapter 3 of the GOM G&G PEIS; USDOJ, BOEM, 2017a). The impact agents include: The impact factors include: (1) active acoustic sound sources; (2) vessel and equipment noise; (3) vessel traffic; (4) aircraft traffic and noise; (5) stand-off distance; (6) vessel discharges; (7) trash and debris; (8) seafloor disturbance; (9) drilling discharges; (10) entanglement; and (11) accidental fuel spills. The preliminary analysis in the GOM G&G PEIS considers surveys of the type proposed by LLOG as well as impacts to resources by type of activity. To assist with subsequent coordination, the GOM G&G PEIS's analysis further defines the level of impact associated with each interaction as follows:

- **Nominal:** little or no measurable/detectable impact;
- **Minor:** impacts are detectable, short term, extensive or localized, but less than severe;
- **Moderate:** impacts are detectable, short term, extensive, and severe; or impacts are detectable, short term or long lasting, localized, and severe; or impacts are detectable, long lasting, extensive or localized, but less than severe; and
- **Major:** impacts are detectable, long lasting, extensive, and severe.

The GOM G&G PEIS 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 GOM G&G PEIS 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 GOM G&G PEIS as having negligible impacts (see 40 CFR § 1508.27) from G&G activities. Such a procedure is consistent with the NEPA concept of tiering (40 CFR § 1502.20). 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:

- commercial and recreational fisheries;
- coastal and marine birds (including ESA-listed species);
- benthic communities;
- archaeological resources;
- recreational and commercial diving;
- 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); and
- fish and fisheries (including listed species and ichthyoplankton).

3.2. MARINE MAMMALS

3.2.1. Description

A complete description of marine mammals can be found in Chapter 4.9 of the Multisale EIS and 2018 SEIS, and is incorporated by reference. The U.S. GOM marine mammal community is diverse and distributed throughout the northern Gulf waters. Twenty-one species of cetaceans regularly occur in the GOM (Jefferson et al., 1992; Davis et al., 2000) and are identified in the NMFS GOM Stock Assessment Reports (SAR) (Hayes et al., 2016). There is also one species of Sirenian. The GOM's marine mammals are represented by members of the taxonomic order Cetacea, which is divided into the suborders Mysticeti (i.e., baleen whales) and Odontoceti (i.e., toothed whales), as well as the order Sirenia (i.e., manatee).

Threatened or Endangered Marine Mammal Species

Only one cetacean, the sperm whale (*Physeter macrocephalus*) regularly occurs in the GOM and is listed as endangered under the Endangered Species Act (ESA). On January 8, 2016 (81 FR 1000), the United States Fish and Wildlife Service (FWS) issued a proposed rule and notice to reclassify the West Indian manatee from endangered to threatened (*Federal Register*, 2016a) which was later issued as a Final Rule (82 FR 16668) on April 5, 2017 (USDOJ, FWS, 2017). On December 8, 2016 (81 FR 88639), NMFS issued a proposed rule to list the Bryde's whale (*Balaenoptera edeni*) as endangered (*Federal Register*, 2016b). Detailed information on these species can be found in Chapter 4.2 and Appendix E of the GOM G&G PEIS and in Chapter 4.9 of the Multisale EIS and 2018 SEIS, and in the NMFS 2016 SAR (Hayes et al., 2016), and is incorporated by reference.

Non-ESA-Listed Marine Mammal Species

One baleen cetacean, (Bryde's whale) and 19 toothed cetaceans (including beaked whales and dolphins) that are not listed under ESA regularly occur in the GOM. While these species are not protected under the ESA; all marine mammals are protected under the Marine Mammal Protection Act (1972).

Additional information on non-ESA-listed marine mammal species of the GOM is provided in Chapter 4.2 and Appendix E of the GOM G&G PEIS and in Chapter 4.9 of the Multisale EIS and 2018 SEIS, and in the [NMFS 2016 SAR \(Hayes et al., 2016\)](#) and is incorporated by reference into this SEA.

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 35 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 4.2 of the GOM G&G PEIS contains a discussion of the potential impacts from survey operations on marine mammal resources (USDOJ, BOEM, 2017a). Additional information about routine impacts from oil and

gas activity on impacts on marine mammals is addressed in Chapter 4.9 of the Multisale EIS and 2018 SEIS and the current ESA Section 7 consultation for the Five-Year Outer Continental Shelf Oil and Gas Leasing Program (2017-2022) 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 BO, 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.” 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 Alternative 1, the No Action Alternative, is selected the applicant would not undertake the proposed activities. Therefore, the IPFs 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 Alternative 2, the Proposed Action, is selected 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 mitigation measures 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 Alternative 3, the Proposed Action with Additional Mitigation Measures, is selected the applicant would undertake the proposed activities, as requested and conditioned in the application; however, the applicant would be required to undertake additional mitigation measures as identified by BOEM, in coordination with NMFS and in accordance with the NMFS ESA consultation requirements (i.e., NTL No. 2016-G01 for *Vessel Strike Avoidance and Injured/Dead Protected Species Reporting* and NTL No. 2016-G02 for *Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program*). 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 Active Acoustic Sound Sources

Marine mammals exposed to natural or manmade noise 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 hearing loss; (2) temporary hearing loss; (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 hearing loss 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). PTS 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 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 μ Pa (peak).

Temporary Hearing Loss

Manmade noise may also cause temporary and reversible hearing loss 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 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 auditory stimulus; and recovery can take minutes, hours, or days as well. 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. DoN, 2008a and 2008b).

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 35 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., blue, fin, sei, humpback, and minke, whales) are considered rare, extralimital, or uncommon (Würsig et al., 2000), with the exception of the Bryde's whale, and their occurrence within the proposed action area potentially affected by noise is not expected.

Sperm whales are a highly vocal species under natural conditions (they produce echolocation clicks 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 μ Pa (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 μ Pa (rms) (131-164 dB re 1 μ Pa [peak to peak]; see Table I in Madsen et al., 2006) at distances of approximately 1.4-12.6 km 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 a small percentage of time at the surface during the course of feeding activity. They surface for longer periods (average 9 minutes) between deeper dives to replenish myoglobin oxygen reserves (Watwood et al., 2006). This means they may be less likely to receive any mitigative effects afforded by sea state and near surface conditions that could buffer or dissipate sound 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 anatomical and physiological features 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 airgun 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 Delphinids 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 species of 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 delphinids. 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 μ Pa at 200 Hz; but see Table 2 in Southall et al., 2007) and increases in sensitivity toward the ultrasonic range; there is a clear gradient of increasing sensitivity that exists over a broad frequency range up 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; Nieu Kirk 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 μ Pa. 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); therefore, they are below the seismic survey source signal. Further, biological tissues are heavily damped, and tissue displacement at resonance is predicted to be exceedingly 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 seismic survey operations.

Decompression sickness (DCS) may occur as a result of diving to deep depths and then surfacing too quickly, forcing nitrogen bubbles to form in the bloodstream and tissues (Jepson et al., 2003). Historically, there has been much debate on whether marine mammals can suffer from a form of DCS caused by *in vivo* (in the natural body) nitrogen gas-bubble expansion. However, recent pathological findings of two Risso's dolphins (*Grampus griseus*) suggest that, while rare, it is possible as a result of rapid ascent to the surface while struggling with prey during hunting (Fernández et al., 2017). Although more investigation is needed, this study brings to question how exposure to stressful situations, whether from natural (e.g. large prey) or anthropogenic (e.g. military sonar) sources, may affect the diving behavior of marine mammals in order to drive it over a non-reversible condition leading to death.

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 μ Pa-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 BO concluded that the effects to sperm whales from vessel noise are discountable (USDOC, NMFS, 2007).

Potential Impacts to Marine Mammals from Vessel Traffic

Given the scope, timing, and transitory nature of the proposed action, and the mitigation and monitoring requirements, the proposed seismic survey is not expected to result in vessel strikes from increased vessel traffic to marine mammals in the GOM. The possibility of a ship strike between a slow-moving seismic survey vessel (typically moving between 4 and 5 knots) and a marine mammal is low (USDOJ, BOEM, 2017a). Further, BOEM requires the implementation of NTL No. 2016-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 BO recognizes that the risk of collision with sperm whales “is expected to be reduced to discountable levels” with implementation of the vessel strike avoidance measures (USDOC, NMFS, 2007). Deep-diving whale species, the faster diving marine mammal species with less surface recovery time, would be expected to have even less risk of vessel strikes. In 1995, an oil crew workboat struck and killed a manatee in a canal near coastal Louisiana (Fertl et al., 2005). Manatees are infrequently found in water depths where the survey activities are proposed, though some recent deepwater sightings have occurred. As of April 2014, five manatee sightings have been reported in the deepwater of the GOM. These include three sightings from PSOs on seismic vessels and two visual observations from a drilling rig and ship at depths ranging from 465 to 6,000 ft (142 to 1,829 m). Sightings at these depths are uncommon. 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 hearing loss; (2) temporary hearing loss; (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 nonpulse sound (intermittent or continuous) given that their hearing ranges overlap most closely with the noise frequencies produced from drilling (Southall et al., 2007). However, most mysticete species that may occur in the GOM (i.e., North Atlantic right, blue, fin, sei, humpback, and minke) are considered either “extralimital,” “rare,” or “uncommon” within the GOM (Wursig et al., 2000; Hayes et al., 2016). The only commonly occurring baleen whale in the northern GOM is the Bryde’s whale which is limited in its range. Given the small geographic scope of the proposed action, the presence of these species within the action area is unlikely. However, the potential for significant impacts is minimized given the implementation of the required shutdown and ramp-up.
- Manatees are not typically common in the proposed action area, though some deepwater sightings have occurred. As they predominantly inhabit only coastal marine, brackish, and freshwater areas they are not expected to occur regularly in the area of the proposed action.
- The remaining marine mammal species in the GOM are considered either mid-frequency hearing specialists (e.g., sperm whales, beaked whales, and dolphins) with hearing ranges that slightly overlap with sound frequencies produced from seismic noise (Southall et al., 2007), or high-frequency specialists (pygmy and dwarf sperm whales). 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 NTL No. 2016-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 BO concluded that PTS was unlikely to occur to sperm whales given the requirements under NTL No. 2016-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 Marine Mammal Protection Act (MMPA). All PSOs must have completed PSO training in accordance with NMFS National Standards for a Protected Species Observer and Data Management Program: A Model for Seismic Surveys (Baker et al., 2013). The following is a summary of the mitigation and monitoring requirements under NTL No. 2016-G02 in waters >200 m deep:

- establishment of a 500-m exclusion zone around the seismic source vessel (this exclusion zone is then continually monitored for the presence of whales [and sea turtles] by dedicated 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 BO concluded that “masking would be unlikely to occur due to the characteristics of airgun pulses” (page 71).
 - The NMFS 2007 BO 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 BO also states that behavioral changes, should they occur, would be “limited to the duration of exposure to the noise.”
 - Reporting requirements mandated in NTL No. 2016-G02 have resulted in numerous years of observation data. BOEM has completed a study to summarize and synthesize submitted seismic survey observer reports for the years 2002-2008 (Barkaszi et al., 2012). While the data has demonstrated a number of short-term behavioral effects, the consequences in the long-term remain unknown. It is also clear that the data have limitations regarding the collection, interpretation and analysis of behavioral observations in relation to their use in impact assessment. Results of this and future syntheses might lead to recommendations for both BOEM and NMFS as to the effectiveness of current required mitigation measures, as well as suggestions for new and/or improved mitigation.
 - 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 NTL No. 2016-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, given the scope, timing, and transitory nature of the proposed action and given the mitigation measures 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 NTL No. 2016-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 4.2 of the GOM G&G PEIS , and Chapters 4.9 of the Multisale EIS and 2018 SEIS address the cumulative impacts on marine mammals a result of oil and gas leasing, exploration, development and production activities, including G&G activities.

The proposed action may cumulatively affect protected marine mammals when viewed in light of the 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,

vessels, and 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 that the operator must adhere to during operations. 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 phenomena, such as tropical storms and hurricanes, are impossible to predict but do occur in the GOM.

Unusual Mortality Event (UME) for Cetaceans in the GOM

On December 13, 2010, NMFS declared an 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. Through July 2014, and as indicated in the table below, a total of 1,141 cetaceans (5% stranded alive and 95% stranded dead) have stranded during the UME, with a vast majority of these strandings involving premature, stillborn, or neonatal bottlenose dolphins. Based upon analysis of stranding data, NOAA defined the spatial and temporal boundaries of this UME to include all cetaceans that stranded in Alabama, Mississippi, and Louisiana from March of 2010 – July of 2014 and all cetaceans other than bottlenose dolphins that stranded in the Florida Panhandle (Franklin County through Escambia County) from March 2010 – July of 2014. However, NOAA stated that these boundaries could be adjusted in the future based upon the availability of new results or analyses. NOAA has declared the UME closed on July 31, 2014. More detail on the stranding numbers for this UME can be found on NMFS’ website (USDOC, NMFS, 2018): <https://www.fisheries.noaa.gov/national/marine-life-distress/2010-2014-cetacean-unusual-mortality-event-northern-gulf-mexico>

Unusual Mortality Event Cetacean Data for the Northern Gulf of Mexico

Cetaceans Stranded	Phase of Oil-Spill Response	Dates
89 cetaceans stranded	Prior to the response phase for the oil spill	March 1, 2010 - April 29, 2010
119 cetaceans stranded or were reported dead offshore	During the initial response phase to the oil spill	April 30, 2010 - November 2, 2010
933 cetaceans stranded*	After the initial response phase ended	November 3, 2010 – July 31, 2014**

*This number includes 13 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.

The UME investigation and the *Deepwater Horizon* Natural Damage Resource Assessment have determined that the *Deepwater Horizon* Event resulted in the death of marine mammals and is the most likely explanation of the elevated stranding numbers that persisted after the spill event. Seismic surveys were not cited as a cause directly or indirectly. Data has supported that the adrenal and lung disease observed in dolphins was most likely due to exposure to petroleum products from the spill event. This has resulted in both dolphin mortalities, which peaked from March 2010 – July 2014, and fetal loss. Research, while ongoing, suggests that the effect on these populations has not ended, with evidence of failed pregnancies found in 2015 (USDOC, NMFS, 2018).

A study by Carmichael et al. (2012) suggested that natural stressors combined with the *Deepwater Horizon* event may have created a “perfect storm” for bottlenose dolphins in the northern Gulf of Mexico. Many coastal species in the northern Gulf of Mexico, including dolphins, experienced unusually harsh winter conditions in early 2010, which were followed by the *Deepwater Horizon* event. Another potential stressor was introduced in January 2011 when large volumes of cold freshwater, associated with melt water from an unusually large winter snowfall near the Mobile Bay watershed, entered the nearshore coastal systems very rapidly. This event happened days prior to the start of unusually high numbers of perinatal (near term to neonatal) bottlenose dolphin mortalities in the northern GOM from January to April 2011.

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 mitigation measures 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 continuing to experience stress/sublethal impacts from natural or anthropogenic stressors, the additional mitigation measures 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 Chapter 4.3 and Appendix E of the GOM G&G PEIS and Chapters 4.9 of the Multisale EIS and 2018 SEIS 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 (*Dermochelys coriacea*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), Kemp’s ridley (*Lepidochelys kempi*), and loggerhead (*Caretta caretta*). 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. Critical habitat was designated for the distinct population segment of Northwest Atlantic loggerhead turtles on 10 July 2014 in 79 CFR 79 39755 39854 (*Federal Register*, 2014).

In 2007, FWS and NMFS published 5-year status reviews for federally listed sea turtles in the GOM (USDOC, NMFS and USDO, 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. Updated 5-year reviews for hawksbill and leatherback turtles were published in 2013 that support the current listing status for these species (USDOC, NMFS and USDO, FWS, 2013a and b).

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 BO 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 IPFs associated with the proposed action that could affect sea turtles include (1) seismic noise; (2) vessel noise; (3) vessel traffic. Chapter 4.3 of the GOM G&G PEIS contains a discussion of the potential impacts from survey operations on sea turtles (USDOI, BOEM, 2017a). Additional information about routine impacts from oil and gas activity on sea turtles is addressed in Chapters 4.9 of the Multisale EIS and 2018 SEIS. The discussions are summarized below and are incorporated by reference into this SEA.

3.3.2.1. Alternative 1

If Alternative 1, the No Action Alternative, is selected the applicant would not undertake the proposed activities. Therefore, the IPFs 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 Alternative 2, the Proposed Action, is selected 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 mitigation measures and monitoring include, but are not limited to: injury from vessel traffic 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 Alternative 3, the Proposed Action with Additional Mitigation Measures, is selected the applicant would undertake the proposed activities, as requested and conditioned in the application; however, the applicant would be required to undertake additional mitigation measures as identified by BOEM, in coordination with NMFS and in compliance with the NMFS ESA consultation requirements (i.e., NTL No. 2016-G01 (*Vessel Strike Avoidance and Injured/Dead Protected Species Reporting*) and NTL No. 2016-G02 (*Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program*)). 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 Active Acoustic Sound Sources

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 μ Pa 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 BO concluded that the effects from seismic noise on sea turtles are “reduced to discountable levels” with the implementation of NTL No. 2016-G02. The BO 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 NTL No. 2016-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.

Popper et al. (2014) published sound exposure guidelines for fishes and sea turtles. A sea turtle would need to be close to the seismic sound source at 210 dB cum or >207 dB peak to cause mortal injury (Popper et al., 2014). Low frequency sounds can cause moderate TTS in turtles at relatively near or intermediate vicinity to the source. Continuous sounds can cause masking and behavioral effects, though the consequences for survival of sea turtles are unknown (Popper et al., 2014).

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 μ Pa-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 BO concluded that effects to sea turtles from vessel noise are discountable (USDOC, NMFS, 2007). The Popper et al. (2014) sound exposure guidelines were broad-ranging and provided non-quantified, generalized guidelines for shipping noise as a low risk of impairment, unless the turtle is in the near field range (within tens of meters), which would pose a moderate risk of temporary threshold shift (TTS) that can recover over time. The risk for noise to cause masking and behavior effects range from low to high depending on the location of the turtle relative to the noise (Popper et al., 2014).

Potential Impacts to Sea Turtles from Vessel Traffic

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 vessel traffic 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 NTL No. 2016-G01, which contains vessel strike avoidance measures for sea turtles and other protected species. With implementation of these measures and a PSO on the lookout for sea turtles, the NMFS 2007 BO 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 NTL No. 2016-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 NTL No. 2016-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 these established mitigation measures, effects to sea turtles from seismic vessel collisions is 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; (2) vessel noise; and (3) vessel traffic. 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 NTL No. 2016-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 BO 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 NTL No. 2016-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 BO 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 4.3 and Chapter I.B of Appendix F of the GOM G&G PEIS, and Chapter 4.9 of the Multisale EIS and 2018 SEIS address the cumulative impacts on sea turtles as a result of oil and gas leasing, exploration, development and production activities, including G&G activities. The information from these documents is incorporated by reference in this EA.

Activities considered under the cumulative scenario, including the proposed action, may affect protected sea turtles or critical habitat. 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. 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 is in place to reduce vessel strike mortalities (i.e., NTL No. 2016-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 because of the limited scope, duration, and geographic area of the proposed action and the requirements under NTL Nos. 2016-G01 and 2016-G02.

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 (NTL Nos. 2016-G01 and 2016-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). 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 RESOURCES AND ESSENTIAL FISH HABITAT

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 Chapter 4.4 and Appendix E of the GOM G&G PEIS and Chapter 4.7 of the Multisale EIS and 2018 SEIS, 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 and Gulf States Marine Fisheries Commission, 1995; USDOC, NMFS, 2009).

Non-ESA-Listed Species

Approximately 1,540 species of fishes are recorded in the GOM and Florida Keys (McEachran, 2009). NOAA, working with the South Atlantic and Gulf of Mexico Fishery Management Councils, manage 71 and 40 fish and crustacean species, respectively, 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 Atlantic bluefin tuna, which are known to use the GOM in the spring for spawning grounds (Teo et al., 2007a and 2007b; Teo and Block, 2010).

Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act, as amended in 1996 by the Sustainable Fisheries Act, mandates that the regional Fishery Management Councils, through 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 Council amended their Gulf of Mexico plans (referred to as Generic Amendment Number 3, 2005) to more specifically designate that habitats less than 100 fathoms (600 ft) are identified and described as EFH.

Fish Hearing

All fish species have hearing and skin-based mechanosensory systems (inner ear and lateral line) used to detect sound in their environment (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. Many Gulf fish species are known to actively use sound to mediate specific behaviors (e.g., spawning). Anthropogenic (human-generated) sounds may affect fishes through auditory masking, behavioral modification, temporary hearing loss, or physiological injury. Masking of important environmental sounds or social signals could potentially reduce foraging success, increase predation, or disrupt reproduction. Studies suggest responses to anthropogenic sound can vary, even among members of a species. However, startle responses generally include avoidance behaviors away from adverse conditions. Responses may also vary with duration and frequency of exposure to a given signal. Fishes in close proximity to intense sound sources may experience temporarily reduced hearing sensitivity or TTS. These effects depend upon the type of sound, duration of sound, distance of sound, and fish species (Popper and Hastings, 2009). Injury to fishes as a result of rapid changes in pressure (barotrauma) may occur in close proximity to an intense sound source.

Hearing mechanisms in fishes have been studied extensively (Fay and Popper, 2000; Ladich and Popper, 2004; Webb et al., 2008), but the specific capabilities of species and the received-sound levels where potentially adverse impacts may occur are not well known. Furthermore, Popper and Fay (2011) suggest the broad designation of fishes as “hearing specialists” and “hearing generalists” is not sufficient to classify the hearing abilities of fishes. They recommend that the range of hearing capabilities across species is more like a continuum that includes the relative contributions of hydrostatic pressure to the overall hearing capabilities of a species. Although studies have investigated physiological impacts (McCauley et al., 2000c; McCauley et al., 2003) and behavioral response (Skalski et al., 1992; Engas et al., 1996; Slotte et al., 2004; Lokkeborg et al., 2012; Fewtrell and McCauley, 2012) in several species, results are generally inconclusive and cannot be applied at the population level (National Science Foundation, 2011). However, information gaps are widely recognized (Hawkins et al., 2014; Popper et al., 2014) and broad guidance has been developed to minimize potential impacts to fishes and sea turtles resulting from anthropogenic sound exposure. The sections below provide a 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 4.4 of the GOM G&G PEIS contains a discussion of the potential impacts from survey operations on fish resources (USDOI, BOEM, 2017a). Additional information about routine impacts from oil and gas activity on fish is addressed in Chapter 4.7 of the Multisale EIS and 2018 SEIS. The discussions are summarized below and are incorporated by reference into this SEA.

3.4.2.1. Alternative 1

If Alternative 1, the No Action Alternative, is selected the applicant would not undertake the proposed activities. Therefore, the IPFs to fish would not occur. For example, there would be no 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 Alternative 2, the Proposed Action as Proposed, is selected 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 mitigation measures outlined in Chapter 2.4 and discussed in the marine mammal and sea turtle sections are requisite for plan approval, their implementation will not increase or decrease the potential for effects to fish from the proposed action.

3.4.2.3. Alternative 3

If Alternative 3, the Proposed Action with Additional Mitigation Measures, is selected the applicant would undertake the proposed activities, as requested and conditioned in the application; however, the applicant would be required to undertake additional mitigation measures 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 mitigation measures outlined in Chapter 2.4 would be included, their implementation would not increase or decrease the potential for effects to fish from the proposed action.

Potential Impacts to Fish from Active Acoustic Sound Sources

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 behavioral effects, ranging in magnitude from negligible to severe. The four areas of primary concern for fish exposed to elevated noise levels include: (1) hearing loss; (2) behavioral response; (3) masking; and (4) non-auditory effects.

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, and reproduction) are adversely affected.

McCauley et al. (2003) found that caged pink snapper exposed to airgun sounds (600 pulses with peak-to-peak source levels of approximately 223 dB re 1 μ Pa) experienced observable anatomical damage to the auditory structures and that this damage did not repair 58 days after exposure. The damage as quantified by missing hair cells was relatively low, but the potential for impaired function in the remaining cells and the wider implications of potentially reduced fitness were not tested. 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 μ Pa₂ 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).

Behavioral Response

Behavioral effects from seismic noise on fishes can include changes in distribution, migration, mating, and ability to be caught. 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). Responses may also depend on the age of the fish, motivational state, size, and numerous unknown factors that are difficult, if not impossible, to quantify. Studies investigating the 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) noted that 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; 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) and simply coincided with the seismic work.

Masking

Masking is defined as 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. 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). However, there have been no documented studies concluding that seismic surveys resulted in the masking of any biologically relevant sounds for any fish species. This is most likely due to the roving nature of the G&G surveys or the limited exposure area where survey-related energy can be found. For example, some surveying technologies (e.g., vibroseis) may have operational frequencies or cycles that present an increased potential for locally masking biologically relevant sounds. For a discussion of the biological relevance of ambient and signal sounds to fish, see Fay and Popper (2000).

Non-Auditory Effects

Existing research suggests there is a potential for non-auditory injury or mortality of fish in the immediate vicinity of a high-energy acoustic source. Airguns and airgun arrays may potentially injure or kill fishes within several meters at the time of discharge (Kostyuchenko, 1973; Dalen and Knutsen, 1986; Booman et al., 1996; Dalen et al., 1996). The potential for injury is greater among fishes with trapped gas pockets or swim bladders that expand and contract with the ambient pressure changes. There are few studies that specifically investigate the effects of airgun sound on fish larvae and eggs, but existing research suggests these life stages are no more vulnerable to intense sound than adult fishes. Other studies document no egg, larvae, or fish mortality resulting 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., 2003; Popper, 2005; Payne et al., 2009).

Physiological effects may also include cellular and/or biochemical responses by fish to acoustic stress. Such stress potentially affects fish by increasing mortality or reducing reproductive success. However, 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 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 to a high-energy acoustic source. The proposed action may result in short-term, localized behavioral reactions. 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. Finally, the frequency range of some G&G survey equipment (e.g., airguns) overlaps with the likely hearing range of the ESA-listed fish species; however, neither of these species are found routinely beyond state waters.

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 4.4 of the GOM G&G PEIS , and Chapter 4.7 of the Multisale EIS and 2018 SEIS. The information from these documents is incorporated by reference in this EA.

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 GOM G&G PEIS, Multisale EIS, and 2018 SEIS 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 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 GOM. 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, and the accommodation time in response to prolonged stress.

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.

3.5. OTHER CONSIDERATIONS

A discussion of the other resources considered but not analyzed under this SEA is found in Chapter 5 of the GOM G&G PEIS (USDOJ, BOEM, 2017a) and Chapter 3 of the Multisale EIS and 2018 SEIS (USDOJ, BOEM, 2017b and c).

4. CONSULTATION AND COORDINATION

The information in this SEA was developed by BOEM subject matter experts and in consultation with other Federal agencies, the private sector, and academia personnel found in Chapter 6 of the GOM G&G PEIS (USDOJ, BOEM, 2017a) and Chapter 5 of the Multisale EIS and 2018 SEIS (USDOJ, BOEM, 2017b and c).

The ESA (16 U.S.C. §§ 1631 et seq.), as amended (43 U.S.C. §§ 1331 et seq.), establishes a national policy designed to protect and conserve threatened and endangered species and the ecosystems upon which they depend. BOEM is currently in consultation with NMFS and FWS regarding the OCS oil and gas program in the GOM. BOEM is acting as the lead agency in the ongoing consultation, with BSEE's assistance and involvement. Following the *Deepwater Horizon* explosion and oil spill, the programmatic consultation was reinitiated and expanded in scope and it will include both existing and future OCS oil and gas leases in the Gulf of Mexico through 2022. This consultation also considers any changes in baseline environmental conditions following the *Deepwater Horizon* explosion, oil spill, and response and includes post lease activities associated with OCS oil and gas activities in the Gulf of Mexico, including G&G and decommissioning activities.

With consultation ongoing, BOEM and BSEE will continue to comply with: all reasonable and prudent measures based on the most recent and best available information available; the terms and conditions under

the existing consultations; and the current BOEM- and BSEE-required mitigation, monitoring, and reporting requirements. BOEM and BSEE will also continue to closely evaluate and assess risks to listed species and designated critical habitat in upcoming environmental compliance documentation under NEPA and other statutes.

BOEM originally petitioned NMFS for incidental-take regulations under Subpart I of the MMPA and consultation under Section 7 of the ESA. When the 2004 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) was completed, BOEM revised its MMPA petition in 2004 with the updated information and is currently in consultation awaiting promulgation of the take regulations. 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 and has resubmitted a revised application on October 17, 2016. The notice of receipt and request for comments and information for the revised application was published in the Federal Register on December 8, 2016 (81 FR 88664).

During the interim, NMFS worked with BOEM in developing the mitigation under NTL No. 2016-G01 (*Vessel Strike Avoidance and Injured/Dead Protected Species Reporting*) and NTL No. 2016-G02 (*Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program*), to ensure that marine mammals and sea turtles were afforded the best possible protection in lieu of the regulations/Incidental Take Statement. Adherence to NTL No. 2016-G02 is assumed in the impact analyses and considered to mitigate the effects of the action in this SEA.

In accordance with the National Historic Preservation Act (54 U.S.C. §§ 300101 *et seq.*), Federal agencies are required to consider the effects of their undertakings on historic properties. The implementing regulations for Section 106 of the National Historic Preservation Act, issued by the Advisory Council on Historic Preservation (36 CFR § 800), specify the required review process. In accordance with 36 CFR § 800.8(c), BOEM intends to use the NEPA substitution process and documentation for preparing an EIS/ROD or an EA/FONSI to comply with Section 106 of the National Historic Preservation Act in lieu of 36 CFR § 800.3-800.6.

5. BIBLIOGRAPHY

- Au, W.L. and M.C. Hastings. 2008. *Principles of Marine Bioacoustics*. New York: Springer-Verlag.
- Baker, K., D. Epperson, G. Gitschlag, H. Goldstein, J. Lewandowski, K. Skrupky, B. Smith, and T. Turk. 2013. *National Standards for a Protected Species Observer and Data Management Program: A Model Using Geological and Geophysical Surveys*. U.S. Department of Commerce. NOAA Technical Memorandum. NMFS-OPR-49. 73 p.
- Barkaszi, M.J., M. Butler, R. Compton, A. Unietis, and B. Bennet. 2012. *Seismic Survey Mitigation Measures and Marine Mammal Observer Reports*. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEM 2012-015. 28 pp + apps.
- 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 July 23, 2018.
- Booman, C., H. Dalen, H. Heivestad, A. Levsen, T. van der Meeren, and K. Toklum. 1996. *Effekter av luftkanonskyting pa egg, larver og ynell. Undersekelsler ved Hauforskningstituttet ogtoctlgisk 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.
- Carmichael R.H., Graham W.M., Aven A., Worthy G., Howden S. 2012. Were Multiple Stressors a 'Perfect Storm' for Northern Gulf of Mexico Bottlenose Dolphins (*Tursiops truncatus*) in 2011? Internet website: <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0041155> Accessed July 23, 2018.
- 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.
- Dalen J., Ona E., Soldal A. V., Sætre R. 1996. Seismic investigations at sea; an evaluation of consequences for fish and fisheries. Institute of Marine Research, *Fisken og Havet*, 9: 26 pp. (Norwegian with English summary).
- Davis, R.W. and G.S. Fargion. 1996. Distribution and Abundance of Cetaceans in the North-Central and Western Gulf of Mexico: Final Report. Volume II: Technical Report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 96-0027. 357 pp.
- 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.
- Federal Register*. 2014. Endangered and threatened species: Critical habitat for the northwest Atlantic Ocean loggerhead sea turtle distinct population segment (DPS) and determination regarding critical habitat for the North Pacific Ocean loggerhead DPS. Final rule (50 CFR 256). 79 FR 39855, pp. 39855-39912.
- Federal Register*. 2016a. Endangered and Threatened Wildlife and Plants: 12-Month Finding on a Petition to Downlist the West Indian Manatee, and Proposed Rule to Reclassify the West Indian Manatee as Threatened; Proposed Rule. Proposed Rules (50 CFR § 17). 81 FR 1000, pp. 1000-1026.
- Federal Register*. 2016b. Endangered and Threatened Wildlife and Plants: Notice of 12-Month Finding on a Petition to List the Gulf of Mexico Bryde's Whale as Endangered Under the Endangered Species Act (ESA); Proposed Rule. 81 FR 88639, pp. 88639-88656.
- Federal Register*. 2017. Endangered and Threatened Wildlife and Plants: Reclassification of the West Indian manatee From Endangered to Threatened (50 CFR § 17). 82 FR 16668, pp. 16668-16704.
- 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. Herraез, 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.
- Fernández, A., E. Sierra, J. Díaz-Delgado, S. Sacchini, Y. Sánchez-Paz, C. Suárez-Santana, M. Arregui, M. Arbelo, and Y. Bernaldo de Quirós. 2017. Deadly acute Decompression Sickness in Risso's Dolphins. *Scientific Reports*. Vol. 7. 13621.
- Fertl, D., A.J. Schiro, G.T. Regan, C.A. Beck, N.M. Adimey, L. Price-May, A. Amos, G.A.J. Worthy and R. Crossland. 2005. Manatee occurrence in the Northern Gulf of Mexico, west of Florida. *Gulf and Caribbean Research* Vol. 17:69-94.
- Fertl, D., A.J. Schiro, G.T. Regan, C.A. Beck, N.M. Adimey, L. Price-May, A. Amos, G.A.J. Worthy and R. Crossland. 2005. Manatee occurrence in the Northern Gulf of Mexico, west of Florida. *Gulf and Caribbean Research* Vol. 17:69-94.
- Fewtrell, J.L. and R.D. McCauley. 2012. Impact of air gun noise on the behavior of marine fish and squid. *Marine Pollution Bulletin* 64:984-993.
- 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.
- 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.

- 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, Fiskeritilsynet. 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.
- Hayes SA, Josephson E, Maze-Foley K, Rosel, PE, editors. 2016. US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments -- 2016. NOAA Tech Memo NMFS NE 241; 274 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at <http://www.nefsc.noaa.gov/publications/> doi:10.7289/V5/TM-NEFSC-241
- Hawkins, A.D, A.E. Pembroke and A.N. Popper. 2014. Information gaps in understanding the effects of noise on fishes and invertebrates. Reviews in Fish Biology and Fisheries 1-26.
- 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.
- Jefferson, T.A., M.A. Webber, and R.L. Pitman. 2008. Marine Mammals of the World: A Comprehensive Guide to Their Identification. Amsterdam: Elsevier. 573 pp.
- Jepson, P.D., Arbelo, M., Deaville, R., Patterson, I.A.P., Castro, P., Baker, J.R., Degollada, E., Ross, H.M., Herraiz, 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. Frogliola, 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., Klinger, R. C., and Musick, J. A. 1985. “Marine turtle middle-ear anatomy,” *Journal of Auditory Research* 25, 66-72.
- 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.
- LLOG Exploration Offshore, LLCfind (LLOG). 2018. Revised Exploration Plan (EP), R-6734, July 2018.
- 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 CMB* 40:1-9.
- Løkkeborg, S., E. Ona, A. Vold, and A. Salthaug. 2012. Sounds from seismic air guns: gear- and species specific effects on catch rates and fish distribution. *Canadian Journal of Fisheries and Aquatic Science* 69:1278-1291.
- 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 (*Physeter macrocephalus*) 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., 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. 2003. High intensity anthropogenic sound damages fish ears. *Journal of the Acoustical Society of America* 113:638-642.
- 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.
- 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.
- National Research Council (NRC). 1990. *Decline of the sea turtles: Causes and prevention*. Committee on Sea Turtle Conservation. Washington, DC: National Academy Press. 280 p.
- National Science Foundation (NSF). 2011. *Final 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.
- 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 TGS 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. 2011. Rethinking sound detection by fishes. *Hearing Research*. doi: 10.1016/j.heares.2009.12.023.
- Popper, A.N., Michael E. Smith, Peter A. Cott, Bruce W. Hanna, Alexander O. MacGillivray, Melanie E. Austin and David A. Mann. 2005. Effects of exposure to seismic airgun use on hearing of three fish species. *The Journal of the Acoustical Society of America*, Vol. 117, No. 6, June 2005.
- Popper, A.N., Hawkins, A.D., Fay, R.R., Mann, D., Bartol, S., Carlson, T., Coombs, S., Ellison, W.T., Gentry, R., Halvorsen, M.B., Løkkeborg, S., Rogers, P., Southall, B.L., Zeddies, D., Tavolga, W.N. 2014. Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. ASA S3/SC1.4 TR-2014. Springer and ASA Press, Cham, Switzerland.
- Pritchard, PCH. 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 (*Dicentrarchus 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 actinopterygian fish. Pages 295-323 *in* B.D. Webster, R.R. Fay, and A.N. Popper, eds. *Evolutionary Biology of Hearing*. Springer-Verlag, New York.
- Schuijff, 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 Environmental 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. Internet website: <http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0010756>. Accessed July 23, 2018.
- Thomsen, B. 2002. An Experiment on How Seismic Shooting Affects Caged Fish. Thesis, Faroese Fisheries Laboratory, University of Aberdeen, Aberdeen, Scotland. 16 August.
- 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 (USDOC), 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 (USDOC), National Marine Fisheries Service (NMFS). 2018. 2010 – 2014 Cetacean Unusual Mortality Event in Northern Gulf of Mexico (Closed). Internet website:

<https://www.fisheries.noaa.gov/national/marine-life-distress/2010-2014-cetacean-unusal-mortality-event-northern-gul-mexico>. Last updated June 2018. Accessed July 23, 2018.

- U.S. Dept. of Commerce (USDOC), National Marine Fisheries Service (NMFS) and U.S. Dept. of the Interior (USDO), Fish and Wildlife Service (FWS). 2007a. Green sea turtle (*Chelonia mydas*); 5-year review: Summary and evaluation. U.S. Dept. of Commerce, National Marine Fisheries Service, Office of protected Resources, Silver Spring, MD, and U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Service Field Office, Jacksonville, FL. 102 pp. Internet website: <http://www.fws.gov/northflorida/SeaTurtles/2007-Reviews/2007-green-turtle-5-year-review-final.pdf>. Accessed July 23, 2018.
- U.S. Dept. of Commerce (USDOC), National Marine Fisheries Service (NMFS) and U.S. Dept. of the Interior (USDO), Fish and Wildlife Service (FWS). 2007b. Kemp's ridley sea turtle (*Lepidochelys kempi*); 5-year review: Summary and evaluation. U.S. Dept. of Commerce, National Marine Fisheries Service, Office of protected Resources, Silver Spring, MD, and U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Service Field Office, Jacksonville, FL. 50 pp. Internet website: <http://www.fws.gov/northflorida/SeaTurtles/2007-Reviews/2007-Kemps-ridley-turtle-5-year-review-final.pdf>. Accessed July 23, 2018.
- U.S. Dept. of Commerce (USDOC), National Marine Fisheries Service (NMFS) and U.S. Dept. of the Interior (USDO), Fish and Wildlife Service (FWS). 2007c. Loggerhead sea turtle (*Caretta caretta*); 5-year review: Summary and evaluation. U.S. Dept. of Commerce, National Marine Fisheries Service, Office of protected Resources, Silver Spring, MD, and U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Service Field Office, Jacksonville, FL. 65 pp. Internet website: <http://www.fws.gov/northflorida/SeaTurtles/2007-Reviews/2007-Loggerhead-turtle-5-year-review-final.pdf>. Accessed July 23, 2018.
- U.S. Dept. of Commerce (USDOC), National Marine Fisheries Service (NMFS) and U.S. Dept. of the Interior, Fish and Wildlife Service (FWS). 2007d. Leatherback sea turtle (*Caretta caretta*); 5-year review: Summary and evaluation. U.S. Dept. of Commerce, National Marine Fisheries Service, Office of protected Resources, Silver Spring, MD, and U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Service Field Office, Jacksonville, FL. 65 pp. Internet website: <http://www.fws.gov/northflorida/SeaTurtles/2007-Reviews/2007-leatherback-turtle-5-year-review-final.pdf>. Accessed July 23, 2018.
- U.S. Dept. of Commerce (USDOC), National Marine Fisheries Service (NMFS) and U.S. Dept. of the Interior, Fish and Wildlife Service (FWS). 2007e. Hawksbill Sea Turtle (*Eretmochelys imbricata*); 5-Year Review: Summary and Evaluation. U.S. Dept. of Commerce, National Marine Fisheries Service, Silver Spring, MD, and U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Service Field Office, Jacksonville, FL. 90 pp. Internet website: <http://www.fws.gov/northflorida/SeaTurtles/2007-Reviews/2007-hawksbill-turtle-5-year-review-final.pdf>. Accessed July 23, 2018.
- U.S. Dept. of Commerce (USDOC), National Marine Fisheries Service (NMFS) and U.S. Dept. of the Interior (USDO), Fish and Wildlife Service (FWS). 2013a. Hawksbill sea turtle (*Eretmochelys imbricata*); 5-year review: Summary and evaluation. U.S. Dept. of Commerce, National Marine Fisheries Service, Office of protected Resources, Silver Spring, MD, and U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Service Field Office, Jacksonville, FL. 92 pp. Internet website: http://www.nmfs.noaa.gov/pr/pdfs/species/hawksbillseaturtle2013_5yearreview.pdf. Accessed July 23, 2018.
- U.S. Dept. of Commerce (USDOC), National Marine Fisheries Service (NMFS) and U.S. Dept. of the Interior (USDO), Fish and Wildlife Service (FWS). 2013b. Leatherback sea turtle (*Dermochelys coriacea*); 5-year review: Summary and evaluation. U.S. Dept. of Commerce, National Marine Fisheries Service, Office of protected Resources, Silver Spring, MD, and U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Service Field Office, Jacksonville, FL. 92 pp. Internet website: http://www.nmfs.noaa.gov/pr/listing/5yearreview_leatherbackturtle.pdf. Accessed July 23, 2018.

- U.S. Dept. of the Interior (USDOJ), Bureau of Ocean Energy Management (BOEM). 2017a. Gulf of Mexico OCS Proposed Geological and Geophysical Activities Western, Central, and Eastern Planning Areas Final Programmatic Environmental Impact Statement (GOM G&G PEIS). 4 vols. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA BOEM 2017-051. Internet website: <https://www.boem.gov/BOEM-2017-051-v1/>. Accessed July 23, 2018.
- U.S. Dept. of the Interior (USDOJ), Bureau of Ocean Energy Management (BOEM). 2017b. Gulf of Mexico OCS Oil and Gas Lease Sales: 2017-2022; Gulf of Mexico Lease Sales 249, 250, 251, 252, 253, 254, 256, 257, 259, and 261-Final Environmental Impact Statement (Multisale EIS). 3 vols. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA BOEM 2017-009. Internet website: <https://www.boem.gov/BOEM-EIS-2017-009-v1/>. Accessed July 23, 2018.
- U.S. Dept. of the Interior (USDOJ), Bureau of Ocean Energy Management (BOEM). 2017c. Gulf of Mexico OCS Oil and Gas Lease Sale Final Supplemental Environmental Impact Statement 2018 (2018 SEIS). 2 vols. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA BOEM 2017-074. Internet website: <https://www.boem.gov/BOEM-EIS-2017-074-v1/>. Accessed July 23, 2018.
- U.S. Department of Interior (USDOJ), Fish and Wildlife Service (FWS) and Gulf States Marine Fisheries Commission. 1995. Gulf Sturgeon Recovery Plan. Atlanta Georgia. 170 pp (page 3).
- U.S. Department of Interior (USDOJ), Fish and Wildlife Service (FWS) and Gulf States Marine Fisheries Commission. 1995. Gulf Sturgeon Recovery Plan. Atlanta Georgia. 170 pp (page 3).
- U.S. Department of the Navy (DON). 2008 a and b. Final Atlantic Fleet Active Sonar Training EIS/OEIS <https://www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-military-readiness-activities>. Accessed July 23, 2018.
- 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.
- 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. 2013. U.S. Atlantic and Gulf of Mexico Waring Marine Mammal Stock Assessments – 2012. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-NE-223. 419 pp.
- Waring, G.T., E. Josephson, K. Maze-Foley, and P.E. Rosel. 2014. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments – 2013. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-NE-228. 464 pp.
- Waring, G.T., E. Josephson, K. Maze-Foley, and P.E. Rosel. 2015. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments – 2014. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-NE-231. 361 pp.
- Waring, G.T., Josephson, E., Maze-Foley K, Rosel, P.E., editors. 2016. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments -- 2015. NOAA Tech Memo NMFS NE 238; 512 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at <https://www.fisheries.noaa.gov/resource/document/us-atlantic-and-gulf-mexico-marine-mammal-stock-assessments-2015L>. Accessed July 23, 2018.
- Watkins, W. A., and Schevill, W. E. 1975. Sperm Whales React to Pingers. *Deep-Sea Res.* 22: 123–129.
- Watwood, W.L., Miller, P., Johnson, Madsen, P and Tyack, P. 2006. Deep-Diving Foraging Behaviour of Sperm Whales (*Physeter macrocephalus*); *Journal of Animal Ecology*, Vol. 75, No. 3, pp. 814-8.
- 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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