DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

50 CFR Part 217

[Docket No. 110811494–7925–01]

RIN 0648–BB38

Taking and Importing Marine Mammals; Taking Marine Mammals Incidental to Geophysical Surveys Related to Oil and Gas Activities in the Gulf of Mexico

AGENCY: National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.

ACTION: Proposed rule; request for comments.

SUMMARY: NMFS has received a petition for an incidental take regulation (ITR) from the Bureau of Ocean Energy Management (BOEM). The requested ITR would govern the authorization of take of small numbers of marine mammals over the course of five years incidental to geophysical survey activities conducted by industry operators in Federal waters of the U.S. Gulf of Mexico (GOM). BOEM submitted the petition in support of oil and gas industry operators, who would conduct the activities. A final ITR would allow for the issuance of Letters of Authorization (LOA) to the aforementioned industry operators over a five-year period. As required by the Marine Mammal Protection Act (MMPA), NMFS requests comments on its proposed rule, including the following; the proposed regulations, several alternatives to the proposed regulations described in the ''Proposed Mitigation'' and ''Alternatives for Consideration'' sections of the preamble, two baselines against which to evaluate the incremental economic impacts of the proposed regulations (addressed in the ''Economic Baseline'' section), and, two sections with broader implications: A clarification of NMFS's interpretation and application of the ''small numbers'' standard (see the ''Small Numbers'' section of the preamble); and an alternative method for assessing Level B harassment from exposure to anthropogenic noise (see the ''Estimated Take'' section of the preamble).

DATES: Comments and information must be received no later than August 21, 2018.

ADDRESSES: You may submit comments on this document, identified by NOAA–NMFS–2018–0043, by any of the following methods:

- *Electronic submission:* Submit all electronic public comments via the Federal e-Rulemaking Portal. Go to *www.regulations.gov/#!docketDetail;D=NOAA-NMFS-2018-0043,* click the ''Comment Now!'' icon, complete the required fields, and enter or attach your comments.
- *Mail:* Submit written comments to Jolie Harrison, Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service, 1315 East West Highway, Silver Spring, MD 20910.

Comments regarding any aspect of the collection of information requirement contained in this proposed rule should be sent to NMFS via one of the means provided here and to the Office of Information and Regulatory Affairs, NEOB–10202, Office of Management and Budget, Attn: Desk Officer, Washington, DC 20503, *OIRA@omb.eop.gov.*

Instructions: Comments sent by any other method, to any other address or individual, or received after the end of the comment period, may not be considered by NMFS. All comments received are a part of the public record and will generally be posted for public viewing on *www.regulations.gov* without change. All personal identifying information (*e.g.,* name, address), confidential business information, or otherwise sensitive information submitted voluntarily by the sender will be publicly accessible. NMFS will accept anonymous comments (enter ''N/A'' in the required fields if you wish to remain anonymous). Attachments to electronic comments will be accepted in Microsoft Word, Excel, or Adobe PDF file formats only.

FOR FURTHER INFORMATION CONTACT: Ben Laws, Office of Protected Resources, NMFS, (301) 427–8401. Electronic copies of the application and supporting documents, as well as a list of the references cited in this document, may be obtained online at: *www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-oil-and-gas.* In case of problems accessing these documents, please call the contact listed above.

SUPPLEMENTARY INFORMATION:

Purpose and Need for Regulatory Action

This proposed rule would establish a framework under the authority of the MMPA (16 U.S.C. 1361 *et seq.*) to allow for the authorization of take of marine mammals incidental to the conduct of geophysical survey activities in the GOM. We received a petition from BOEM requesting the five-year regulations. Subsequent LOAs would be requested by industry operators. Take would occur by Level A and/or Level B harassment incidental to use of active acoustic sound sources. Please see the ''Background'' section below for definitions of harassment.

Legal Authority for the Proposed Action

Section 101(a)(5)(A) of the MMPA (16 U.S.C. 1371(a)(5)(A)) directs the Secretary of Commerce to allow, upon request, the incidental, but not intentional taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specified geographical region for up to five years if, after notice and public comment, the agency makes certain findings and issues regulations that set forth permissible methods of taking pursuant to that activity and other means of effecting the ''least practicable adverse impact'' on the affected species or stocks and their habitat (see the discussion below in the ''Proposed Mitigation'' section), as well as monitoring and reporting requirements. Section 101(a)(5)(A) of the MMPA and the implementing regulations at 50 CFR part 216, subpart I provide the legal basis for issuing this proposed rule containing five-year regulations, and for any subsequent LOAs. As directed by this legal authority, this proposed rule contains mitigation, monitoring, and reporting requirements.

Summary of Major Provisions Within the Proposed Rule

Following is a summary of the major provisions of this proposed rule regarding geophysical survey activities. These measures include:

- Standard detection-based mitigation measures, including use of visual and acoustic observation to detect marine mammals and shut down acoustic sources in certain circumstances;
- Time-area restrictions designed to avoid effects to certain species of marine mammals in times and/or places believed to be of greatest importance;
- Vessel strike avoidance measures; and
- Monitoring and reporting requirements.

Background

Section 101(a)(5)(A) of the MMPA (16 U.S.C. 1361 *et seq.*) directs the Secretary of Commerce (as delegated to NMFS) to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specified geographical region if certain findings are made, regulations are issued, and notice is provided to the public.

An authorization for incidental takings shall be granted if NMFS finds that the taking will have a negligible impact on the species or stock(s), will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses (where relevant), and if the permissible methods of taking and requirements pertaining to the mitigation, monitoring and reporting of such takings are set forth.

NMFS has defined ''negligible impact'' in 50 CFR 216.103 as an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival.

The MMPA states that the term ''take'' means to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal.

Except with respect to certain activities not pertinent here, the MMPA defines ''harassment'' as: Any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment); or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (Level B harassment).

National Environmental Policy Act

To comply with the National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. 4321 *et seq.*) and NOAA Administrative Order (NAO) 216–6A, NMFS must evaluate the proposed action (*i.e.,* the promulgation of regulations and subsequent issuance of incidental take authorizations) and alternatives with respect to potential impacts on the human environment.

In August 2017, BOEM produced a final Programmatic Environmental Impact Statement (PEIS) to evaluate potential significant environmental effects of geological and geophysical (G&G) activities on the Outer Continental Shelf (OCS) of the GOM, pursuant to requirements of NEPA. These activities include geophysical surveys in support of hydrocarbon exploration and development, as are described in the petition for ITR before NMFS. The PEIS is available online at: *www.boem.gov/Gulf-of-Mexico-Geological-and-Geophysical-Activities-Programmatic-EIS/.* NMFS participated in development of the PEIS as a cooperating agency and believes it is appropriate to adopt the analysis in order to assess the impacts to the human environment of issuance of the subject ITR and any subsequent LOAs. Information in the petition, BOEM's PEIS, and this document collectively provide the environmental information related to proposed issuance of this ITR for public review and comment.

Summary of Request

BOEM was formerly known as the Minerals Management Service (MMS) and, later, the Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE). On December 20, 2002, MMS petitioned NMFS for rulemaking under Section 101(a)(5)(A) of the MMPA to authorize take of sperm whales (*Physeter macrocephalus*) incidental to conducting geophysical surveys during hydrocarbon exploration and development activities in the GOM. On March 3, 2003, NMFS published a notice of receipt of MMS's application and requested comments and information from the public (68 FR 9991). MMS subsequently submitted a revised petition on September 30, 2004, to include a request for incidental take authorization of additional species of marine mammals. On April 18, 2011, BOEMRE submitted a revision to the petition, which incorporated updated information and analyses. NMFS published a notice of receipt of this revised petition on June 14, 2011 (76 FR 34656). In order to incorporate the best available information, BOEM submitted another revision to the petition on March 28, 2016, which was followed on October 17, 2016, by a revised version that was deemed adequate and complete based on NMFS's implementing regulations at 50 CFR 216.104. In the interim period, BOEM, with NMFS representing NOAA as a cooperating agency, prepared a PEIS for the GOM OCS Proposed G&G Activities.

On December 8, 2016 (81 FR 88664), we published a notice of receipt of the petition in the **Federal Register**, requesting comments and information related to the request. This 30-day comment period was extended to January 23, 2017 (81 FR 92788), for a total review period of 45 days. The comments and information received during this public review period informed development of the proposed ITR discussed in this document, and all comments received are available online at *www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-oil-and-gas.*

Geophysical surveys are conducted in support of hydrocarbon exploration and development in the GOM, typically by companies that provide such services to the oil and gas industry. Broadly, these surveys include (1) deep penetration surveys using large airgun arrays as the acoustic source, (2) shallow penetration surveys using a small airgun array, single airgun, or subbottom profiler as the acoustic source, and (3) high-resolution surveys, which may use a variety of acoustic sources. Generally speaking, these surveys may occur within Federal territorial waters and waters of the U.S. Exclusive Economic Zone (EEZ) (*i.e.,* to 200 nautical miles (nmi)) within the GOM, and corresponding with BOEM's Western, Central, and Eastern GOM OCS planning areas. The use of these acoustic sources is expected to produce underwater sound at levels that have the potential to result in harassment of marine mammals. Cetacean species with the potential to be present in the GOM are described below.

This proposed rule would establish a framework under the authority of the MMPA (16 U.S.C. 1361 *et seq.*) and NMFS's implementing regulations (50 CFR 216.101 *et seq.*) to allow for the authorization, through LOAs, of take of marine mammals incidental to the conduct of geophysical surveys for oil and gas activities in the GOM. The requested regulations would be valid for five years.

Description of the Specified Activity

Overview

The specified activity consists of geophysical surveys conducted by industry operators for a variety of reasons related to hydrocarbon exploration, development, and production. These operators are typically companies that provide geophysical services, such as data acquisition and processing, to the oil and gas industry, including exploration and production companies. The petition describes a five-year period of geophysical survey activity and provides estimates of the amount of effort by survey type and location. BOEM's PEIS (BOEM, 2017) describes a range of potential survey effort. The levels of effort in the petition (which form the basis for the modeling effort described later in the ''Estimated Take'' section) are the high-end estimates. Actual total amounts of effort by survey type and location would not be known in advance of receiving LOA requests from industry operators.

Geophysical surveys are conducted to obtain information on marine seabed and subsurface geology for a variety of reasons, including to: (1) Obtain data for hydrocarbon and mineral exploration and production; (2) aid in siting of oil and gas structures, facilities, and pipelines; (3) identify possible seafloor or shallow depth geologic hazards; and (4) locate potential archaeological resources and benthic habitats that should be avoided. In addition, geophysical survey data inform Federal government decisions. For example, BOEM uses such data for resource estimation and bid evaluation to ensure that the government receives a fair market value for OCS leases, as well as to help to evaluate worst-case discharge for potential oil-spill analysis and to evaluate sites for potential hazards prior to drilling.

Deep penetration seismic surveys using airgun arrays as an acoustic source (sound sources are described in the ''Detailed Description of Activities'' section) are a primary method of obtaining geophysical data used to characterize subsurface structure. These surveys are designed to illuminate deeper subsurface structures and formations that may be of economic interest as a reservoir for oil and gas exploitation. A deep penetration survey uses an acoustic source suited to provide data on geological formations that may be thousands of meters (m) beneath the seafloor, as compared with a shallow penetration or high resolution geophysical (HRG) survey that may be intended to evaluate shallow subsurface formations or the seafloor itself (*e.g.,* for hazards).

Deep penetration surveys may be two-dimensional (2D) or three-dimensional (3D) (see Figure 1–2 of the petition), and there are a variety of survey methodologies designed to provide the specific data of interest. 2D surveys are designed to acquire data over large areas (thousands of square miles) in order to screen for potential hydrocarbon prospectivity, and provide a cross-sectional image of the structure. In contrast, 3D surveys may use similar acoustic sources but are designed to cover smaller areas with greater resolution (*e.g.,* with closer survey line spacing), providing a volumetric image of underlying geological structures. Repeated 3D surveys are referred to as four-dimensional (4D), or time-lapse, surveys that assess the depletion of a reservoir.

Shallow penetration and high-resolution surveys are designed to highlight seabed and near-surface potential obstructions, archaeology, and geohazards that may have safety implications during rig installation or well and development facility siting. Shallow penetration surveys may use a small airgun array, single airgun, or subbottom profiler, while high-resolution surveys (which are limited to imaging the seafloor itself) may use single or multibeam echosounders or side-scan sonars.

Dates and Duration

The specified activities may occur at any time during the five-year period of validity of the proposed regulations. Actual dates and duration of individual surveys are not known. Survey activities are generally 24-hour operations. However, BOEM estimates that a typical seismic survey experiences approximately 20 to 30 percent of non-operational downtime due to a variety of factors, including technical or mechanical problems, standby for weather or other interferences, and implementation of mitigation measures.

Specified Geographical Region

The proposed survey activities would occur off the Gulf of Mexico coast of the United States, within BOEM's Western, Central, and Eastern GOM OCS planning areas (approximately within the U.S. EEZ; Figure 1). U.S. waters of the GOM include only the northern GOM. BOEM manages development of U.S. Federal OCS energy and mineral resources within OCS regions, which are divided into planning areas. Within planning areas are lease blocks, on which specific production activities may occur. Geophysical survey activities may occur on scales ranging from entire planning areas to multiple or specific lease blocks, or could occur at specific potential or existing facilities within a lease block.

In addition to general knowledge and other citations contained herein, this section relies upon the descriptions found in Sherman and Hempel (2009), Wilkinson *et al.* (2009), and BOEM (2017).

The GOM is a deep marginal sea—the largest semi-enclosed coastal sea of the western Atlantic—bordered by Cuba, Mexico, and the United States and encompassing more than 1.5 million square kilometers (km^2). The GOM is distinctive in physical oceanography and freshwater influx, with major, persistent currents and a high nutrient load. Oceanic water enters from the Yucatan Channel and exits through the Straits of Florida, creating the Loop Current. The Loop Current—the GOM's most dominant oceanographic feature—flows clockwise between Cuba and the Yucatan Peninsula, Mexico, and circulates into the eastern GOM before exiting as the Florida Current, where it ultimately joins the Gulf Stream in the Atlantic. Small-scale, ephemeral currents known as eddies form off the Loop Current and may enter the western GOM. The eastern edge of the Loop Current interacts with the shallow shelf to create zones of upwelling and onshore currents—nutrient-rich events promoting high phytoplankton growth and supporting high productivity.

The distribution of plankton in the deeper waters of the GOM, especially the northern and eastern parts of the Gulf, is controlled by the Loop Current (Mullin and Fulling, 2004). The temporal movement of all organisms, including marine mammals and their prey, may be affected by upwelling of nutrient rich cold water eddies (Davis *et al.,* 2002). However, habitat use appears to be more directly correlated with static features such as water depth, bottom gradient, and longitude (Mullin and Fulling, 2004). Temporal fluctuation near the surface can cause changes in diurnal movement patterns in squid, which prefer colder water, but does not substantially affect cetaceans feeding on squid in deeper waters.

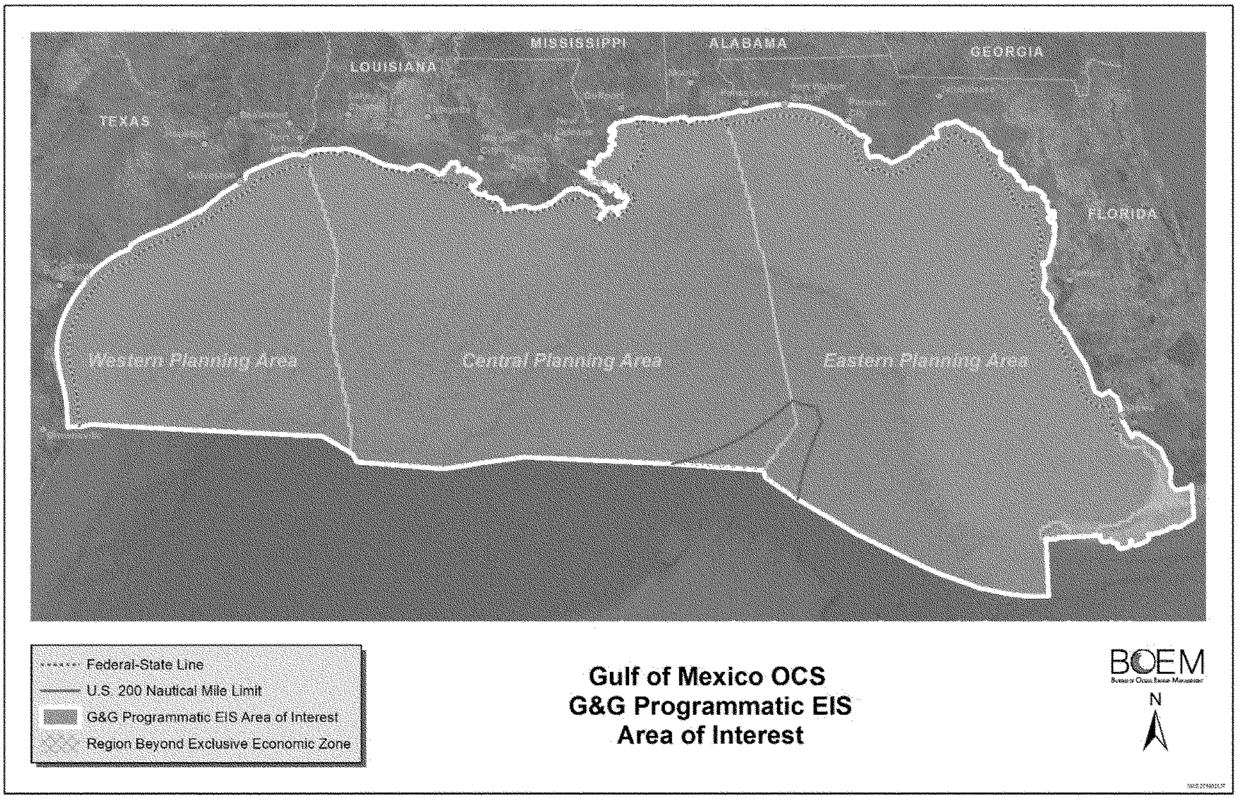


Figure 1. Specified Geographical Region.

The northern GOM is characterized as semi-tropical, with a seasonal temperature regime influenced mainly by tropical currents in the summer and continental influences during the winter. The GOM is topographically diverse, with an extensive continental shelf (comprising about 30 percent of the total area), a steep continental slope, and distinctive bathymetric and morphologic processes and features. These include the Flower Garden Banks, which are surface expressions of salt domes that host the northernmost coral reefs in the U.S. The northern GOM also has a small section of the larger abyssal plain of the greater GOM. The GOM has about 60 percent of U.S. tidal marshes, hosting significant nursery habitat for fish and other marine species. A major climatological feature is tropical storm activity, including hurricanes. Sea surface temperature ranges from 14–24 °C in the winter and 28–30 °C in the summer. The area is considered to be of moderately high productivity (referring to fixated carbon (*i.e.,* g C/m^2/yr), which relates to the carrying capacity of an ecosystem).

Muddy clay-silts and muddy sands dominate bottom substrates of the region offshore Texas and Louisiana, transitioning to sand, gravel, and shell from Alabama to Florida. The shelf off Florida is a carbonate limestone substrate overlain with sand and silt, supporting extensive seagrass beds, and interspersed with gravel-rock and coral reefs. The continental shelf in the western GOM is broadest (up to 135 miles) off Houston, Texas, and east to offshore the Atchafalaya Delta, Louisiana. It reaches its narrowest point (approximately 12 miles) near the mouth of the Mississippi River southeast of New Orleans, Louisiana. The continental shelf is narrow offshore Mobile Bay, Alabama, but broadens significantly offshore Florida to almost 200 miles wide.

Topography of the continental slope off the Florida panhandle is relatively smooth and featureless aside from the De Soto Canyon, whereas the slope off western Florida is distinguished by steep gradients and irregular topography. In the central and western GOM, the continental slope is characterized by canyons, troughs, mini-basins, and salt structures (*e.g.,* small diapiric domes) with higher relief than surrounding areas. The Sigsbee Escarpment defines the southern limit of the Texas-Louisiana slope and was formed by a large system of salt ridges that underlie the region. In addition to De Soto Canyon off the coast of Florida, the northern GOM contains four significant canyons on or near the Texas-Louisiana continental slope: Mississippi Canyon, located southwest of the Mississippi River Delta; Alaminos Canyon, located on the western end of the Sigsbee Escarpment; Keathley Canyon, also located on the western end of the Sigsbee Escarpment; and Rio Perdido Canyon, located between the Texas-Louisiana continental slope and the East Mexico continental slope.

The GOM is strongly influenced by freshwater input from several rivers, most importantly the Mississippi River and its tributary, the Atchafalaya River. The Mississippi River and its tributaries drain a large portion of the continental United States and carry large amounts of freshwater into the GOM along with sediment and a variety of nutrients and pollutants. The highest volume of freshwater from the Mississippi River flows into the GOM from May through November, when large volumes of turbid water become entrained in a westward-flowing longshore current. The delivery and deposition of increased loads of terrestrial organic material, including significant industrial and agricultural discharge, have often resulted in severe oxygen depletions in bottom waters and the appearance of a so-called ''dead zone,'' where large numbers of benthic fauna die. This is the largest zone of coastal hypoxia in the western hemisphere.

Wetlands in the GOM have experienced severe loss and degradation, due in part to interference with normal erosional/depositional processes, sea level rise, and coastal subsidence. Wetlands are converted to open water when accretion is insufficient to compensate for natural subsidence, while large areas of wetlands have been drained for industrial, urban, and agricultural development. Increasing salinity due to saltwater intrusion accompanies these changes, which further exacerbates the loss of coastal flora. This loss of wetlands ultimately increases erosion due to waves and tides, with the whole issue exacerbated by sea level rise.

The northern GOM hosts a vigorous complex of offshore hydrocarbon exploration, extraction, shipping, service, construction, and refining industries, resulting in additional impacts to coastal wetlands as well as large- and small-scale petroleum discharges and oil spills. Of particular note, in 2010 the *Macondo* discovery blowout and explosion aboard the *Deepwater Horizon* drilling rig (also known as the *Deepwater Horizon* explosion, oil spill, and response; hereafter referred to as the DWH oil spill) caused oil, natural gas, and other substances to flow into the GOM for 87 days before the well was sealed. Total oil discharge was estimated at 3.19 million barrels (134 million gallons), resulting in the largest marine oil spill in history (DWH NRDA Trustees, 2016). In addition, the response effort involved extensive application of dispersants at the seafloor and at the surface, and controlled burning of oil at the surface was also used extensively as a response technique. The oil, dispersant, and burn residue compounds present ecological concerns in the region. We discuss the impacts of the DWH oil spill on marine mammals in greater detail later in our ''Description of Marine Mammals in the Area of the Specified Activity'' section.

The GOM is also known for having many natural hydrocarbon seeps that contribute to a background level of chemicals in the environment. Chemosynthetic communities with aerobic bacterial components typically are associated with natural oil seeps. These naturally occurring seeps are common in deep slope waters, and there are hundreds of known, constant seeps that produce perennial slicks of oil at consistent locations (Kvenvolden and Cooper, 2003). DWH NRDA Trustees (2016) provided an estimate of the total amount of natural oil seepage in the GOM of between 9 and 23 million gallons per year. Although there is much uncertainty in attempting to estimate seepage rates (Kvenvolden and Cooper, 2003), it is clear that natural seepage is not comparable to the DWH oil spill release; about six to 15 times more oil was released from a single location in 87 days as is typically slowly released in a year from thousands of seeps across the entire GOM.

In addition to being a major area for activities associated with the oil and gas industry, the GOM hosts significant amounts of commercial fishing and tourism activities and has two of the world's busiest shipping fairways and top-ranking ports for container and passenger vessel traffic, all of which are noise-producing activities. The underwater environment is typically loud due to ambient sound, which is defined as environmental background sound levels lacking a single source or point (Richardson *et al.,* 1995). The sound level of a region is defined by the total acoustical energy being generated by known and unknown sources. These sources may include physical (*e.g.,* wind and waves, earthquakes, ice, atmospheric sound), biological (*e.g.,* sounds produced by marine mammals, fish, and invertebrates), and anthropogenic (*e.g.,* vessels, dredging, construction) sound. A number of sources contribute to ambient sound, including wind and waves, which are a main source of naturally occurring ambient sound for frequencies between 200 hertz (Hz) and 50 kilohertz (kHz) (Mitson, 1995) (for description of metrics related to underwater sound, please see the ''Description of Sound Sources'' section later in this document). In general, ambient sound levels tend to increase with increasing wind speed and wave height. Precipitation can become an important component of total sound at frequencies above 500 Hz, and possibly down to 100 Hz during quiet times. Marine mammals can contribute significantly to ambient sound levels, as can some fish and snapping shrimp. The frequency band for biological contributions is from approximately 12 Hz to over 100 kHz. Sources of ambient sound related to human activity include transportation (surface vessels), dredging and construction, oil and gas drilling and production, geophysical surveys, sonar, and explosions. Vessel noise typically dominates the total ambient sound for frequencies between 20 and 300 Hz. In general, the frequencies of anthropogenic sounds are below 1 kHz and, if higher frequency sound levels are created, they attenuate rapidly.

The sum of the various natural and anthropogenic sound sources that comprise ambient sound at any given location and time depends not only on the source levels (as determined by current weather conditions and levels of biological and human activity) but also on the ability of sound to propagate through the environment. In turn, sound propagation is dependent on the spatially and temporally varying properties of the water column and sea floor, and is frequency-dependent. As a result of the dependence on a large number of varying factors, ambient sound levels can be expected to vary widely over both coarse and fine spatial and temporal scales. Sound levels at a given frequency and location can vary by 10–20 decibels (dB) from day to day (Richardson *et al.,* 1995).

Estabrook *et al.* (2016) measured underwater noise at seven sites in the northern GOM, within three frequency bands (10–500 Hz (LF); 500–1,000 Hz (MF); 1,000–3,150 Hz (HF)). The authors found that the GOM is a spectrally, temporally, and spatially dynamic ambient noise environment, and that, while abiotic and other anthropogenic noise sources contributed significantly to the ambient noise environment, noise from geophysical surveys dominated the noise environment during the study period (2010–2012) and chronically elevated noise levels across several marine habitats. Specifically, although wind was a significant noise source at higher frequencies (*i.e.,* 500–3,550 Hz), these levels were relatively low compared to those of anthropogenic noise in the low-frequency band (10–500 Hz). Previous studies had identified anthropogenic sound as a major noise contributor in the GOM (*e.g.,* Newcomb *et al.,* 2003); however, Estabrook *et al.* (2016) found that sound levels from shipping activity were not nearly as pronounced as those from geophysical surveys, which, in many cases, persisted for months. As described below, typical airgun surveys fire pulses approximately every 10–20 seconds but, in addition, the resulting multipath propagation and reverberation from airgun pulses can exceed ambient levels during the interpulse interval (Guerra *et* *al.,* 2011; Guan *et al.,* 2015). Estabrook *et al.* (2016) found that, in some instances, there were near-continuous elevated noise levels and that airgun noise propagated over large spatial scales of several hundred kilometers. Background noise, considered to be the noise level that is present in the absence of notable anthropogenic, biological, and meteorological sound sources, was measured across all sites as follows: 102 dB (LF), 84 dB (MF), and 85 dB (HF). The median equivalent continuous sound pressure level across all sites was: 112 dB (LF), 90 dB (MF), and 93 dB (HF). Finally, the median equivalent continuous sound pressure level for a five-day interval when airgun pulses were present was: 124 dB (LF), 91 dB (MF), and 92 dB (HF).

Wiggins *et al.* (2016) also monitored the northern GOM soundscape over a comparable time period (2010–2013), conducting measurements at five locations and monitoring frequencies from 10–1,000 Hz. The authors made similar findings, *i.e.,* that average ambient noise levels at low frequencies in the northern GOM are among the highest measured in the world's oceans, and geophysical surveys dominate these high noise levels. In fact, Wiggins *et al.* (2016) found that during passage of a hurricane, low frequency sound pressure levels actually decreased due to the absence of survey activity. Although shipping noise was observed, the duration was typically shorter (approximately one hour versus more than 12 hours), and was masked by airgun noise at lower frequencies.

Detailed Description of Activities

An airgun is a device used to emit acoustic energy pulses into the seafloor, and generally consists of a steel cylinder that is charged with high-pressure air. There are different types of airguns; differences between types of airguns are generally in the mechanical parts that release the pressurized air, and the bubble and acoustic energy released are effectively the same. Airguns are typically operated at a firing pressure of 2,000 pounds per square inch (psi). Release of the compressed air into the water column generates a signal that reflects (or refracts) off the seafloor and/or subsurface layers having acoustic impedance contrast. Individual airguns are available in different volumetric sizes and, for deep penetration seismic surveys, are towed in arrays (*i.e.,* a certain number of airguns of varying sizes in a certain arrangement) designed according to a given company's method of data acquisition, seismic target, and data processing capabilities.

Airgun arrays are typically configured in subarrays of 6–12 airguns each. Towed hydrophone streamers (described below) may follow the array by 100–200 m and can be 5–12 kilometer (km) long. The airgun array and streamers are typically towed at a speed of approximately 4.5 to 5 knots (kn). BOEM notes that arrays used for deep penetration surveys typically have between 20–80 individual elements, with a total volume of 1,500–8,460 in^3. However, BOEM's permitting records show that during one recent year, over one-third of arrays in use had volumes greater than 8,000 in^3. The output of an airgun array is directly proportional to airgun firing pressure or to the number of airguns, and is expressed as the cube root of the total volume of the array.

Airguns are considered to be low-frequency acoustic sources, producing sound with energy in a frequency range from less than 10 Hz to 2 kHz (though there may be energy in the signal at frequencies up to 5 kHz), with most energy radiated at frequencies below 500 Hz. Frequencies of interest to industry are below approximately 100 Hz. The amplitude of the acoustic wave emitted from the source is equal in all directions (*i.e.,* omnidirectional) for a single airgun, but airgun arrays do possess some directionality due to phase delays between guns in different directions. Airgun arrays are typically tuned to maximize functionality for data acquisition purposes, meaning that sound transmitted in horizontal directions and at higher frequencies is minimized to the extent possible.

When fired, a brief (~0.1 second) pulse of sound is emitted by all airguns in an array nearly simultaneously, in order to increase the amplitude of the overall source pressure signal. The combined signal amplitude and directivity is dependent on the number and sizes of individual airguns and their geometric positions within the array. The airguns are silent during the intervening periods, with the array typically fired on a fixed distance (or shot point) interval. The intervals are optimized for water depth and the distance of important geological features below seafloor, but a typical interval in relatively deep water might be approximately every 10–20 s (or 25–50 m, depending on vessel speed). The return signal is recorded by a listening device, and later analyzed with computer interpretation and mapping systems used to depict the subsurface. There must be enough time between shots for the sound signals to propagate down to and reflect from the feature of interest, and then to propagate upward to be received on hydrophones or geophones. Reverberation of sound from previous shots must also be given time to dissipate. The receiving hydrophones can be towed behind or in front of the airgun array (may be towed from the source vessel or from a separate receiver vessel), or geophone receivers can be deployed on the seabed. Receivers may be displaced several kilometers horizontally away from the source, so horizontal propagation time is also considered in setting the interval between shots.

Sound levels for airgun arrays are typically modeled or measured at some distance from the source and a nominal source level then back-calculated. Because these arrays constitute a distributed acoustic source rather than a single point source (*i.e.,* the ''source'' is actually comprised of multiple sources with some pre-determined spatial arrangement), the highest sound levels measurable at any location in the water will be less than the nominal source level. A common analogy is to an array of light bulbs; at sufficient distance—in the far field—the array will appear to be a single point source of light but individual sources, each with less intensity than that of the whole, may be discerned at closer distances (Caldwell and Dragoset (2000) define the far field as greater than 250 m). Therefore, back-calculated source levels are not typically considered to be accurate indicators of the true maximum amplitude of the output in the far field, which is what is typically of concern in assessing potential impacts to marine mammals. In addition, the effective source level for sound propagating in near-horizontal directions (*i.e.,* directions likely to impact most marine mammals in the vicinity of an array) is likely to be substantially lower (*e.g.,* 15–24 dB; Caldwell and Dragoset, 2000) than the nominal source level applicable to downward propagation because of the directional nature of the sound from the airgun array. The horizontal propagation of sound is reduced by noise cancellation effects created when sound from neighboring airguns on the same horizontal plane partially cancel each other out.

Survey protocols generally involve a predetermined set of survey, or track, lines. The seismic acquisition vessel(s) (source vessel) will travel down a linear track for some distance until a line of data is acquired, then turn and acquire data on a different track. In some cases, data is acquired as the source vessel(s) turns continuously rather than moving on a linear track (*i.e.,* coil surveys). The spacing between track lines and the length of track lines can vary greatly, depending on the objectives of a survey.

In addition to the line over which data acquisition is desired, full-power operation may include run-in and run-out. Run-in is approximately 1 km of full-power source operation before starting a new line to ensure equipment is functioning properly, and run-out is additional full-power operation beyond the conclusion of a trackline (*e.g.,* half the distance of the acquisition streamer behind the source vessel, when used) to ensure that all data along the trackline are collected by the streamer. Line turns can require two to six hours when towed hydrophones are used, due to the long trailing streamers, but may be much faster when streamers are not used. Spacing and length of tracks varies by survey. Survey operations often involve the source vessel(s), supported by a chase vessel. Chase vessels typically support the source vessel(s) by protecting the long hydrophone streamer from damage (*e.g.,* from other vessels) (when used) and otherwise lending logistical support (*e.g.,* returning to port for fuel, supplies, or any necessary personnel transfers). Chase vessels do not deploy acoustic sources for data acquisition purposes; the only potential effects of the chase vessels are those associated with normal vessel operations.

The general activities described here could occur pre- or post-leasing and/or on- or off-lease. Pre-lease surveys are more likely to involve larger-scale activity designed to explore or evaluate geologic formations. Post-lease activities may also include deep penetration surveys, but would be expected to be smaller in spatial and temporal scale as they are associated with specific leased blocks. Shallow penetration and HRG surveys are more likely to be associated with specific leased blocks and/or facilities, with HRG surveys used along pipeline routes and to search for archaeological resources and/or benthic communities. Specific types of surveys are described below (summarized from the petition); for full detail please refer to sections 1.2 and 1.3 of the petition.

While these descriptions reflect existing technologies and current practice, new technologies and/or uses of existing technologies may come into practice during the period of validity of these proposed regulations. NMFS will evaluate any such developments on a case-specific basis to determine whether expected impacts on marine mammals are consistent with those described or referenced in this document and, therefore, whether any anticipated take incidental to use of those new technologies or practices is appropriately authorized under what would be the existing regulatory framework. We also note here that activities that may result in incidental take of marine mammals, and which would therefore appropriately require authorization under the MMPA, are not limited to those activities requiring permits from BOEM. Operators should be aware that there may be some activities previously unpermitted by BOEM, such as certain ancillary activities, that would appropriately be subject to the requirements of this proposed rule and they should consult NMFS regarding the need to obtain a LOA under this rule prior to conducting such activities. Unauthorized taking of marine mammals is a violation of the MMPA.

2D and 3D Surveys (Deep Penetration Surveys)—As discussed, deep penetration surveys use an airgun array(s) as the acoustic source and may be 2D or 3D (with repeated 3D surveys termed 4D). Surveys may be designed as either multi-source (*i.e.,* multiple arrays towed by one or more source vessel(s)) or single source. Surveys may also be differentiated by the way in which they record the return signals using hydrophones and/or geophones. Hydrophones may be towed in streamers behind a vessel (either the source vessel(s) or a separate vessel) or in some cases may be placed in boreholes (called vertical seismic profiling) or spaced at various depths on vertical cables in the water column. Sensors may also be incorporated into ocean-bottom cables (OBC) or autonomous ocean-bottom nodes (OBN) and placed on the seafloor—these surveys are referred to generally as ocean-bottom seismic (OBS). Autonomous nodes can be tethered to coated lines and deployed from ships or remotely-operated vehicles, with current technology allowing use in water depths to approximately 3,000 m. OBS surveys are most useful to acquire data in shallow water and obstructed areas, as well as for acquisition of four-component survey data (*i.e.,* including pressure and 3D linear acceleration collected via geophone). For OBS surveys, one or two vessels usually are needed to lay out and pick up cables, one ship is needed to record data, one ship tows an airgun array, and two smaller utility boats support survey operations. The size of the OBS receiver grid is usually limited by the amount of equipment available; however, to efficiently conduct a survey, approximately 500 nodes or 100 km of cable are needed.

We described previously the basic differences between 2D and 3D surveys. A typical 2D survey deploys a single array covering an area approximately 12.5–18 m long and 16–36 m wide behind the source vessel, whereas a 3D vessel may deploy multiple source arrays and/or streamers, with a potentially much larger width behind the vessel. A 3D vessel usually will tow 8–14 streamers (but as many as 24), each 3–8 km long. For example, an array containing ten streamers could have a total swath width behind the vessel of 675–1,350 m. Among 3D surveys in particular, there are a variety of survey designs employed to acquire the specific data of interest. These survey types may differ in the number of vessels used (for source or receiver), sound sources deployed, and the location or type of hydrophones. Conventional, single-vessel 3D surveys are referred to as narrow azimuth (NAZ) surveys. Other 3D survey techniques include wide-azimuth (WAZ), multi-azimuth (MAZ), rich-azimuth (RAZ), and full-azimuth (FAZ) surveys. Please see Figures 1–10 and 1–11 in the petition for depictions of these survey geometries.

In conventional 3D seismic surveys involving a single source vessel, only a subset of the reflected wave field can be obtained because of the narrow range of source-receiver azimuths (thus called NAZ surveys). Newer survey techniques, as well as improvements in data processing, provide better data quality than that achievable using traditional NAZ surveys, including better illumination, higher signal-to-noise ratios, and higher resolution. This is useful in imaging subsurface areas containing complex geologic structures, particularly those beneath salt bodies with irregular geometries.

Offset refers to the distance between a source and a particular receiver, while azimuth refers to the angles covered by the various directions between a source and individual receiving sensors. With NAZ surveys, the width (crossline dimension) of the nominal area imaged when the source is fired one time will be less than half the length (inline dimension). The aspect ratio (crossline divided by inline) of this nominal area is much less than 0.5 (see Figure 1–10 of the petition).

To achieve wider azimuthal coverage, multiple source vessels are deployed in order to achieve greater crossline dimension of the nominal area imaged. Different WAZ methods using multiple source vessels and, in some cases, multiple receiver vessels, are depicted in Figure 1–11 of the petition. A basic method used to acquire MAZ data involves a single source and streamer vessel, using conventional 3D survey methodology, covering transects on the same area multiple times along different azimuthal directions (Figure 1–11D of the petition). A combination of WAZ and MAZ geometries provides either RAZ or FAZ results. Acquisition of RAZ data requires using multiple passes of one source-and-streamer vessel and two source-only vessels. Making two passes at right angles to each other with a specific WAZ configuration would produce 180° azimuth (*i.e.,* FAZ) coverage. New survey designs will likely continue to be tested as the industry works to make WAZ, MAZ, RAZ, and FAZ shooting more efficient and less costly. Another development is synchronized discharge of airgun arrays being towed by different vessels (advances in data processing can separate the energy from synchronized sources using differences in source-to-receiver offset distances). While this increases the level of sound in the ensonified water volume, it also reduces the length of time that the water volume is ensonified.

In summary, 3D survey design involves a vessel with one or more acoustic sources covering an area of interest with relatively tight spatial configuration. In order to provide richer, more useful data, particularly in areas with more difficult geology, survey designs become more complicated with additional source and/or receiver vessels operating in potentially increasingly complicated choreographies. The time required to complete one pass of a trackline for a single NAZ vessel and the time required for one pass by a multi-vessel entourage conducting a WAZ survey will be essentially the same. Turn times will be somewhat longer during multi-vessel surveys to ensure that all vessels are properly aligned prior to beginning the next trackline. Turn times depend mostly on the vessels and the equipment they are towing (as in conventional 3D surveys); however, the number of vessels towing streamers in the entire entourage is the main determinant of the turn time. The MAZ technique, where multiple passes are made, increases the time needed for a survey in proportion to the number of passes that will be made within an area. The reduction in the number of passes is one of the most significant driving factors in continued efforts to design more efficient surveys. Coil surveys, described previously, reduce the total survey time due to elimination of the trackline-turn methodology.

Borehole Seismic Surveys—The placement of seismic sensors in a drilled well or borehole is another way data can be acquired. These surveys, typically referred to as vertical seismic profiles (VSP), provide information about geologic structure, lithology, and fluids that is intermediate between that obtained from sea surface surveys and well-log scale information (well logging is the process of recording various physical, chemical, electrical, or other properties of the rock/fluid mixtures penetrated by drilling a borehole). VSP surveying is conducted by placing receivers such as geophones at many (50–200) depths in a wellbore and recording both direct-arriving and reflection energy from an acoustic source. The acoustic source usually is a single airgun or small airgun array hung from a platform or deployed from a source vessel. The airguns used for VSPs may be the same or similar to those used for 2D and 3D towed-streamer surveys; however, the number of airguns and the total volume of an array used are less than those used for towed-streamer surveys. Less sound energy is required for VSP surveys because the seismic sensors are in a borehole, which is a much quieter environment than that for sensors in a towed streamer, and because the VSP sensors are located nearer to the targeted reflecting horizons. Some VSP surveys take less than a day, and most are completed in a few days. Borehole seismic surveys include 2D VSPs, 3D VSPs, checkshot surveys, and seismic while drilling (SWD).

Types of 2D VSPs are defined by source location, as follows: (1) Zero-offset VSPs involve a single source position that is close to the well (often deployed from a platform) compared to the depths where the sensors are placed (thereby causing the sensors to receive mostly vertically propagating energy); (2) offset VSPs involve a stationary vessel-based source position (or multiple positions) that is far enough away from the well that the recorded waveforms have a significant amount of horizontally-propagating energy; (3) walkaway VSPs involve a moving vessel and multiple source positions along a line away from the well; and (4) deviated-well VSPs involve source positions placed vertically above a well path. See Figure 1–12 of the petition for depictions.

3D VSPs involve use of multi-level sensor strings, allowing 1,500 to 3,000 m to be instrumented within a well. As with 2D VSPs, individual airguns and arrays used are generally similar to those used in towed-streamer surveys. The data acquisition design could involve typical 3D rectangular survey vessel track patterns, or spiral track patterns with the source vessel moving away from the well. For 3D VSPs, the distance from the well covered by the source vessel will approximately equal the depth of the well (see Figure 1–13 in the petition).

Checkshot surveys are similar to zero-offset VSPs but are less complex. The purpose of a checkshot survey is to estimate the velocity of sound in rocks penetrated by the well, and these surveys are typically conducted quickly. These surveys involve a single source typically hung from a platform and a sensor placed at a few depths in the well, where only the first energy arrival is recorded.

SWD refers to the acquisition of borehole data, using an airgun array as an acoustic source, while there is downtime from the actual drilling operation. SWD surveys are run intermittently for weeks up until the well completion depth.

Shallow Penetration/HRG Surveys—These surveys are conducted to provide data informing initial site evaluation, drilling rig emplacement, and platform or pipeline design and emplacement. Identification of geohazards (*e.g.,* gas hydrates, buried channels) is necessary to avoid drilling and facilities emplacement problems, and operators are required to identify and avoid archaeological resources and certain benthic communities. In most cases, conventional 2D and 3D deep penetration surveys do not have the correct resolution to provide the required information. Although HRG surveys may use a single airgun source, they generally use electromechanical sources such as side-scan sonars, shallow- and medium-penetration subbottom profilers, and single-beam echosounders or multibeam echosounders. Non-airgun HRG sources are often used in combination in order to acquire necessary data during a single deployment. HRG surveys are sometimes conducted using autonomous underwater vehicles (AUV) equipped with multiple acoustic sources.

HRG surveys may be conducted using airguns as the acoustic source. These typically use one or two airguns that are the same as those described for use in arrays during deep penetration surveys. However, the total volume is typically only approximately 40–400 in^3, the streamers are shorter, and the shot intervals are shorter. The intent is typically to image the shallow subsurface (less than 1,000 m below the seafloor). Including vessel turns at the end of lines, the time required to survey one OCS lease block is approximately 36 hours. These surveys are sometimes conducted using 3D techniques, *e.g.,* multiple sources and/or streamers.

Electromechanical sources are generally considered to be relatively mid- to high-frequency sources, and produce acoustic signals by creating an oscillatory overpressure through rapid vibration of a surface, using either electromagnetic forces or the piezoelectric effect of some materials. A vibratory source based on the piezoelectric effect is commonly referred to as a transducer, which may be designed to excite an acoustic wave of a specific frequency, often in a highly directive beam. The directional capability increases with increasing operating frequency.

Subbottom profiling surveys are typically used for high-resolution imaging of the shallow subsurface. These surveys may use a variety of acoustic sources, commonly referred to as ''boomers,'' ''sparkers,'' or ''chirps.'' A sparker uses electricity to vaporize water, creating collapsing bubbles that produce a broadband (50 Hz to 4 kHz), omnidirectional pulse of sound that can penetrate a few hundred meters into the subsurface. Short hydrophone arrays towed near the sparker receive the return signal; typically, the sparker is towed on one side of the vessel and the hydrophone array is towed on the other side. A boomer consists of a circular piston moved by electromagnetic force, generating a broadband acoustic pulse (300 Hz to 3 kHz, though adjustments to the applied electrical impulse may increase the frequency). Boomer systems can penetrate as deep as 200 m in soft sediments, though a more typical penetration may be 25–50 m. Boomer sources show some directionality, which increases with the acoustic frequency; at frequencies below 1 kHz they can usually be considered omnidirectional. Boomers are typically sled-mounted and towed behind the vessel, with short hydrophone arrays used to receive the return signal. The characteristics of the acoustic wave emitted by the boomer source are comparable to those emitted by the sparker source.

Chirp (Compressed High-Intensity Radiated Pulse) sources operate differently, sending a continuous sweep of frequencies (*e.g.,* 500 Hz to 24 kHz) approximately every 0.5 to 1 seconds. Some chirp systems work in multiple frequency bands simultaneously (*e.g.,* 3.5/12/200 kHz). Beamwidth will vary depending on the frequency, but is approximately 10–30°. Because this continuous sweep of frequencies provides a much wider range of information, chirp systems are able to create a much clearer, higher-resolution image while achieving the same or better depth of penetration. Chirps are typically towed behind the vessel or deployed on an AUV.

Side-scan sonars and echosounders do not penetrate the surface of the seabed, using reflections of sound pulses to locate, image, and aid in the identification of objects in the water column and on the seafloor, and to determine water depth. Echosounders typically emit short, single-frequency signals, with frequency decreasing as water depth increases. A deep-water system might operate at approximately 3–12 kHz, while a shallow-water system might operate at 200 kHz or greater. Multibeam echosounder systems use an array of transducers that project a fan-shaped beam under the hull of a vessel and perpendicular to the direction of motion, producing a swath of depth measurements to ensure full coverage of an area. Echosounders are typically hull-mounted or deployed on AUVs. Side-scan sonar systems produce shaded relief images of the ocean bottom by recording the intensity and timing of signals reflected off the seafloor, and consist of two transducers on the sides of the towed sonar body that are oriented perpendicularly to the towing direction. The signals are typically single-frequency, with a highly directional beam that is wide across-track and narrow in the direction of travel. Due to the transducer placement, side-scan sonars may not effectively image the area directly beneath the vessel and are often used in conjunction with echosounders. Side-scan sonars are typically high-frequency sources and therefore have a limited range (50–200 m). In deeper water, the source may be towed at greater depth or deployed on an AUV.

Representative Sound Sources

Because the specifics of acoustic sources to be used would not be known in advance of receiving LOA requests from industry operators, it is necessary to define representative acoustic source parameters, as well as representative survey patterns. BOEM determined realistic representative proxy sound sources and survey patterns, which are used in the modeling and more broadly to support the analysis, after discussions with individual geophysical companies.

Representative sources include a single airgun, an airgun array, and multiple electromechanical sources: Boomer, chirp, multibeam echosounder, and side-scan sonar. Two major survey types were considered: Large-area seismic and small-area, high-resolution geotechnical. Large-area seismic surveys are assumed to cover more than 1,000 mi² (2,590 km²) and include 2D, 3D NAZ, 3D WAZ, and coil types. Geotechnical study surveys are assumed to cover an area less than 100 mi² (259 km²) and use small airguns and/or high-frequency electromechanical sources installed on an AUV. VSP surveys, assuming a single source vessel with one 8,000 in³ array, were also modeled.

The nominal airgun sources used for analysis of the proposed action include a small single airgun (90 in³ Sercel airgun) towed at 4 m depth and a large airgun array (8,000 in³) towed at 8 m depth. Airguns are assumed to fire simultaneously at 2,000 psi. The airgun array was assumed to consist of 72 elements (Bolt 1900 LLXT airguns) arranged in six sub-arrays of 12 airguns each with 9 m in-line separations. Individual elements range from 40 to 250 in³. The layout of the modeled array (*i.e.,* airgun distribution in the horizontal plane) is shown in Figure 11 of Zeddies *et al.* (2015). For the single airgun, modeled source levels were 227.7 dB 0-peak (pk) sound pressure level (SPL) and 207.8 dB sound exposure level (SEL) (for description of metrics related to underwater sound, please see ''Description of Sound Sources,'' later in this document). Modeled source levels for the array range from 248.1 (broadside, *i.e.,* perpendicular to the tow direction) to 255.2 (endfire; *i.e.,* parallel to the tow direction) dB 0-pk SPL and from 225.7 (broadside) to 231.8 (endfire) dB SEL. Zeddies *et al.* (2015, 2017a), ''*Acoustic Propagation and Marine Mammal Exposure Modeling of Geological and Geophysical Sources in the Gulf of Mexico*'' and ''*Addendum to Acoustic Propagation and Marine Mammal Exposure Modeling of Geological and Geophysical Sources in the Gulf of Mexico,*'' are hereafter referred to as ''the modeling report.'' The reports are available online at: *www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-oil-and-gas.* Below, we outline the representative operational parameters of the different survey types that were used in the modeling simulations to predict the exposure of marine mammals to different received levels of sound.

Source vessels are assumed to travel at an average speed of 4.5–5 kn (*i.e.,* 200–220 linear km per day), and airgun arrays were assumed to be off during turns. The run-in and run-out sections were 1 km long. Each large-area survey (excluding coil surveys) was assumed to cover an area of 10 x 30 lease blocks, equivalent to 48 x 145 km or approximately 6,960 km². Coil surveys are assumed to cover a smaller area of 12 x 12 lease blocks, equivalent to 58 x 58 km or approximately 3,364 km².

2D surveys were simulated by assuming use of a single 8,000 in³ array, with transect lines offset laterally by 4.8 km. The production lines were filled in with a racetrack fill-in method, skipping two tracks on the left side turn (15 km wide turn) and transitioning onto the adjacent line on the right side turn (5 km wide turn) (see Figure 105 of the modeling report). The vessel speed was 4.5 kts and the shot interval was 21.6 s (approximately every 50 m).

3D NAZ surveys were simulated by assuming use of two source vessels towing identical arrays. Sources at each vessel produce seismic pulses simultaneously. Both vessels follow the same track, but were separated along the track by 6 km. The production lines were laterally spaced by 1 km (see Figure 106 of the modeling report). The production lines were filled via a racetrack fill-in method with eight loops in each racetrack (7–8 km wide turn). Forty-nine lines were required to fully cover the survey area. The vessel speed was 4.9 kn and the shot interval was 15 s (approximately every 37.5 m) for each vessel.

3D WAZ surveys were simulated by assuming use of four source vessels towing identical arrays. Sources at each vessel produce seismic pulses sequentially. The tracks of each vessel had the same geometry and had 1.2 km lateral offset. The vessels also had 500 m offset along the track (see Figure 107 of the modeling report). The production lines were filled in with a racetrack fill-in method with two loops in each racetrack (9.6 km wide turn). Forty lines were required to fully cover the survey area. The vessel speed was 4.5 kn, with individual vessel shot interval of 86.4 s (approximately every 200 m)—equivalent to 21.6 s for the group.

Coil surveys are performed by multiple vessels that sail a series of circular tracks with some angular separation while towing acoustic sources. These surveys were simulated by assuming use of four source vessels towing identical arrays. Sources at each vessel produce seismic pulses simultaneously. Tracks consist of a series of circles with 12.5 km diameter (see Figure 108 of the modeling report). Once each vessel completes a full circle, it advances to the next one along a tangential connection segment. The offset between the center of one circle and the next, either along-swath or between swaths, was 5 km. The full survey geometry consisted of two tracks with identical configuration with 1.2 km and 600 m offsets along X and Y directions, respectively. Two of the four vessels followed the first track with 180° separation; the other two vessels followed the second track with 180° separation relative to each other and 90° separation relative to the first pair. One hundred circles per vessel pair were required to fully cover the survey area. The vessel speed was 4.9 kn and the shot interval was 20 s (approximately every 50 m) for each vessel.

For small-area, high-resolution geotechnical surveys, we described the proxy single airgun source above. The representative boomer system was the Applied Acoustics AA301, based on a single plate with approximately 40 cm baffle diameter. The input energy for the AA301 boomer plate was up to 350 joules (J) per pulse or 1,000 J per second. The width of the pulse was 0.15–0.4 milliseconds (ms). A source verification study performed on a similar system by Martin *et al.,* (2012) showed that the broadband source level for the system was 203.3 dB root mean square (rms) SPL over a 0.2 ms window length and 172.6 dB SEL. These data were used for modeling the boomer source with a −4.6 dB correction applied to account for differences in input energy between the two systems.

As noted above, certain high-resolution acoustic sources may be deployed together and used concurrently. Here, the modeling assumes that a multibeam echosounder, side-scan sonar, and chirp subbottom profiler are operated concurrently and deployed on an AUV. Towing depth of the AUV was assumed to be 4 m below the sea surface when the water depth was less than 100 m and 40 m above the seafloor where water depth was more than 100 m. The representative multibeam echosounder (MBES) system was the Simrad EM2000 (manufactured by Kongsberg Maritime AS). According to manufacturer specifications, this device operates at 200 kHz and is equipped with a transducer head that produces a single beam 17° x 88° wide. The nominal source level was 203 dB rms SPL, with per-pulse SEL dependent on the pulse length (160–175 dB). Pulse width is 0.04–1.3 ms. The representative side-scan sonar is the EdgeTech 2200 IM, which works at two frequencies simultaneously (120 and 410 kHz). The beam angle produced by two side-mounted transducers was 70° x 0.8° at 120 kHz and 70° x 0.5° at 410 kHz. At 120 kHz, the estimated peak source level is 210 dB with pulse length of 8.3 ms; at 410 kHz these values are 216 dB and 2.4 ms. The chirp subbottom profiler uses the same side-scan sonar system, which is designed as a modular system for installation on an AUV, and adds the DW–424, a full spectrum chirp subbottom profiler that produces a sweep signal in the frequency range from 4 to 24 kHz. The projected beamwidth varies from 15° to 25° depending on the emitted frequency, with estimated source level of 200 dB and pulse length of 10 ms.

For these HRG surveys, the same survey pattern was assumed regardless of the source. Total survey area was assumed to be an area of 1 x 3 lease blocks, equivalent to 5 x 14.5 km or approximately 72.5 km². A single source vessel towing the appropriate source (*i.e.,* single airgun, boomer, or AUV with concurrently operated MBES, side-scan sonar, and chirp) was assumed. Production lines were laterally spaced 30 m (see Figure 109 of the modeling report) then filled in with a racetrack fill-in method where each racetrack has 20 loops (1.2 km wide turn). One hundred and sixty lines were required to fully cover the survey area. The vessel speed was 4 kn and, for surveys using the single airgun, the shot interval was 10 seconds(s) (approximately every 20 m).

Estimated Levels of Effort

As noted previously, actual total amounts of effort by survey type and location would not be known in advance of receiving LOA requests from industry operators. Therefore, BOEM provided projections of survey level of effort for the different survey types for a 10-year period (note that this proposed rule covers only a 5-year period). In order to construct a realistic scenario for future geophysical survey effort, BOEM evaluated recent trends in permit applications as well as industry estimates of future survey activity. BOEM also accounted for restrictions under the Gulf of Mexico Energy Security Act (GOMESA; Pub. L. 109–432), which precludes leasing, pre-leasing, or any related activity (though not geophysical surveys that have been permitted) in the GOM east of 86°41′ W, in BOEM's Eastern Planning Area (EPA) and within 125 mi (201 km) of Florida, or in BOEM's Central Planning Area (CPA) and within 100 mi of Florida (and according to certain other detailed stipulations). These leasing restrictions, which will to some degree influence geophysical survey effort, are in place until June 30, 2022.

In order to provide some spatial resolution to the projections of survey effort and to provide reasonably similar areas within which acoustic modeling might be conducted, the geographic region was divided into seven zones, largely on the basis of water depth, seabed slope, and defined BOEM planning area boundaries. Shelf regions typically extend from shore to approximately 100–200 m water depths where bathymetric relief is gradual (off Florida's west coast, the shelf extends approximately 150 km). The slope starts where the seabed relief is steeper and extends into deeper water; in the GOM water deepens from 100–200 m to 1,500–2,500 m over as little as a 50 km horizontal distance. As the slope ends, water depths become more consistent, though depths can vary from 2,000–3,300 m. Three primary bathymetric areas were defined as shelf (0–200 m water depth), slope (200–2,000 m), and deep (>2,000 m).

Available information regarding cetacean density in the GOM (*e.g.,* Roberts *et al.,* 2016) shows that, in addition to water depth, animal distribution tends to vary from east to west in the GOM and appears correlated with the width of shelf and slope areas from east to west. The western region is characterized by a relatively narrow shelf and moderate-width slope. The central region has a moderate-width shelf and moderate-width slope, and the eastern region has a wide shelf and a very narrow slope. Therefore, BOEM's western, central, and eastern planning area divisions provide appropriate longitudinal separations for the shelf and slope areas. Due to relative consistency in both physical properties and predicted animal distribution, the deep area was not subdivided. As shown in Figure 2, Zones 1–3 represent the shelf area (from east to west), Zones 4–6 represent the slope area (from east to west), and Zone 7 is the deep area (note that other features of Figure 2 are described in the "Estimated Take" section). Table 1 displays BOEM's 10-year estimated levels of effort, estimated as 24-hr survey days, including annual totals by survey type and by zone for deep penetration and shallow penetration surveys, respectively.

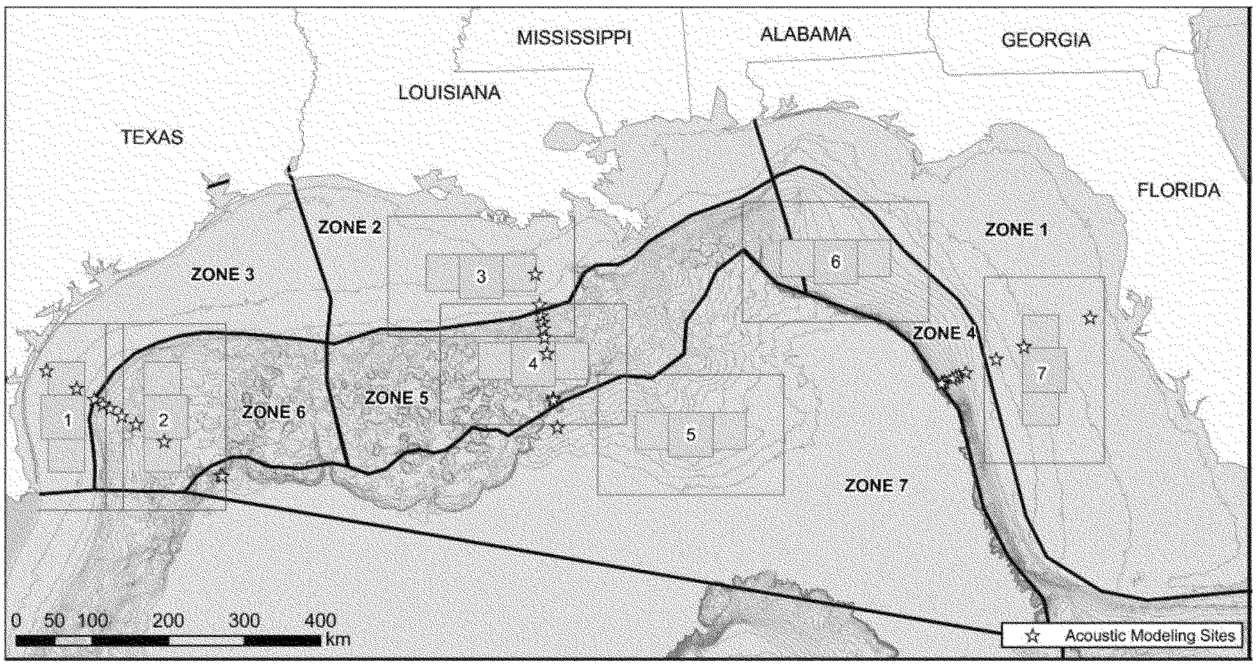


Figure 110 in Zeddies *et al.* (2015)

Figure 2. Gulf of Mexico Modeling Zones.

TABLE 1—PROJECTED LEVELS OF EFFORT IN 24-HR SURVEY DAYS FOR TEN YEARS, BY ZONE AND SURVEY TYPE [1]

Year	Zone [2]	2D [3]	3D NAZ [3]	3D WAZ [3]	Coil [3]	VSP [3]	Total (deep) [3]	Shallow hazards [4]	Boomer [4]	HRG [4]	Total (shallow) [4]
1	1	0	0	0	0	0	0	0	0	1	1
	2	0	243	0	0	0	243	2	0	19	21
	3	0	30	0	0	0	30	0	0	4	4
	4	0	0	0	0	0	0	0	0	0	0
	5	56	389	192	82	2	721	0	0	26	26
	6	0	186	49	21	0	256	0	0	10	10
	7	69	515	248	106	2	940	0	0	34	34
Total		125	1,363	489	209	4	2,190	2	0	94	96
2	1	0	0	0	0	0	0	0	0	1	1
	2	0	364	43	19	0	426	2	0	19	21
	3	0	0	0	0	0	0	0	0	4	4
	4	33	0	0	0	0	33	0	0	0	0
	5	0	389	192	82	2	665	0	0	26	26
	6	0	99	0	0	0	99	0	0	11	11
	7	30	502	241	103	2	878	0	0	34	34
Total		63	1,354	476	204	4	2,101	2	0	95	96

TABLE 1—PROJECTED LEVELS OF EFFORT IN 24-HR SURVEY DAYS FOR TEN YEARS, BY ZONE AND SURVEY TYPE [1]—Continued

Year	Zone [2]	2D [3]	3D NAZ [3]	3D WAZ [3]	Coil [3]	VSP [3]	Total (deep) [3]	Shallow hazards [4]	Boomer [4]	HRG [4]	Total (shallow) [4]
3	1	0	0	0	0	0	0	0	0	1	1
	2	0	243	0	0	0	243	2	0	18	20
	3	0	0	0	0	0	0	0	0	4	4
	4	0	0	0	0	0	0	0	0	1	1
	5	0	342	160	69	2	573	0	0	27	27
	6	0	186	49	21	0	256	0	0	12	12
	7	0	456	208	89	2	755	0	0	36	36
Total		0	1,227	417	179	4	1,827	2	0	99	101
4	1	0	0	0	0	0	0	0	0	0	0
	2	0	364	43	19	0	426	2	1	16	19
	3	0	30	0	0	0	30	0	0	3	3
	4	66	61	21	9	0	157	0	0	1	1
	5	28	247	96	41	2	414	0	0	27	27
	6	0	99	0	0	0	99	0	0	12	12
	7	94	380	140	60	2	676	0	0	36	36
Total		188	1,181	300	129	4	1,802	2	1	95	98
5	1	0	0	0	0	0	0	0	0	0	0
	2	0	243	0	0	0	243	0	0	20	20
	3	0	0	0	0	0	0	0	0	3	3
	4	0	92	0	0	0	92	0	0	0	0
	5	0	295	192	82	2	571	2	1	25	28
	6	0	99	0	0	0	99	0	0	13	13
	7	0	467	241	103	3	814	3	2	34	39
Total		0	1,196	433	185	5	1,819	5	3	95	103
6	1	0	0	0	0	0	0	0	0	0	0
	2	0	364	43	19	0	426	0	0	18	18
	3	0	0	0	0	0	0	0	0	2	2
	4	0	92	0	0	0	92	0	0	1	1
	5	0	247	160	69	2	478	0	0	30	30
	6	0	186	49	21	0	256	0	0	13	13
	7	0	421	208	89	3	721	0	0	40	40
Total		0	1,310	460	198	5	1,973	0	0	104	104
7	1	0	0	0	0	0	0	0	0	0	0
	2	0	243	0	0	0	243	0	0	16	16
	3	0	30	0	0	0	30	0	0	2	2
	4	33	61	21	9	0	124	0	0	1	1
	5	28	247	160	69	2	506	0	0	32	32
	6	0	99	0	0	0	99	0	0	13	13
	7	64	380	220	94	3	761	0	0	43	43
Total		125	1,060	401	172	5	1,763	0	0	107	107
8	1	0	0	0	0	0	0	0	0	0	0
	2	0	364	43	19	0	426	0	0	16	16
	3	0	0	0	0	0	0	0	0	2	2
	4	11	61	0	0	0	72	0	0	1	1
	5	9	247	128	55	2	441	0	0	35	35
	6	0	99	0	0	0	99	0	0	13	13
	7	21	380	160	69	3	633	0	0	46	46
Total		41	1,151	331	143	5	1,671	0	0	113	113
9	1	0	0	0	0	0	0	0	0	0	0
	2	0	243	0	0	0	243	0	0	16	16
	3	0	0	0	0	0	0	0	0	2	2
	4	0	61	0	0	0	61	0	0	1	1
	5	0	200	192	82	2	476	0	0	35	35
	6	0	99	0	0	0	99	0	0	14	14
	7	0	321	241	103	3	668	0	0	47	47
Total		0	924	433	185	5	1,547	0	0	115	115
10	1	0	0	0	0	0	0	0	0	0	0
	2	0	364	43	19	0	426	0	0	13	13
	3	0	30	0	0	0	30	0	0	2	2
	4	5	61	0	0	0	66	0	0	1	1
	5	0	200	160	69	2	431	0	0	37	37
	6	0	99	0	0	0	99	0	0	14	14
	7	5	321	200	86	3	615	0	0	49	49

TABLE 1—PROJECTED LEVELS OF EFFORT IN 24-HR SURVEY DAYS FOR TEN YEARS, BY ZONE AND SURVEY TYPE [1]—Continued

Year	Zone [2]	2D [3]	3D NAZ [3]	3D WAZ [3]	Coil [3]	VSP [3]	Total (deep) [3]	Shallow hazards [4]	Boomer [4]	HRG [4]	Total (shallow) [4]
Total		10	1,075	403	174	5	1,667	0	0	116	116

[1] Projected levels of effort in 24-hr survey days.
[2] Zones follow the zones depicted in Figure 2.
[3] Deep penetration survey types include 2D, which uses one source vessel with one large array (8,000 in^3); 3D NAZ, which uses two source vessels using one large array each; 3D WAZ and coil, each of which uses four source vessels using one large array each (but with differing survey design); and VSP, which uses one source vessel with a large array. ''Deep'' refers to survey type, not to water depth.
[4] Shallow penetration/HRG survey types include shallow hazards surveys, assumed to use a single 90 in^3 airgun, subbottom profiling using a boomer, and high-resolution surveys using the MBES, side-scan sonar, and chirp systems concurrently. ''Shallow'' refers to survey type, not to water depth.

Table 2 provides a summary of the projected levels of effort. Very little effort is predicted in the EPA, with no deep penetration surveys expected in Zone 1 and an annual average of 63 survey days predicted in Zone 4. Similarly, very little overall effort is expected in western shelf waters. The vast majority of effort is expected to occur in the CPA, in all water depths. For deep penetration surveys, 3D NAZ is expected to be the most common survey type (in terms of total survey says) with approximately 65 percent of the total. 3D WAZ surveys represent approximately 22 percent of total survey days. Shallow penetration surveys overall represent an insignificant addition to the projected deep penetration effort, reflecting the smaller amount of effort associated with these survey types.

Year 1 provides an example of what might be a high-effort year in the GOM, while Year 9 is representative of a low-effort year. A moderate level of effort in the GOM, according to these projections, would be similar to the level of effort projected for Year 4. However, per-zone ranges can provide a different outlook than does an assessment of total year projected effort across zones. For example, in the ''high'' effort annual scenario (Year 1; considering total projected survey days across zones), there are 263 projected survey days in Zone 2, while the ''moderate'' effort annual scenario (Year 4) projects 446 survey days in Zone 2. Projected levels of effort presented here represent expected maxima, and it is possible that actual levels of effort will be lower, whether due to effects of the economy on industry activities or other reasons. Please see Figure 3.2–1 of BOEM's PEIS (BOEM, 2017) for projected potential ranges of survey activity. The ranges of projected activity level include an upper bound based on industry capacity in the GOM and a lower bound that accounts for a number of things that could affect these activities (*e.g.,* marketplace changes, adjustment of schedules for closures).

TABLE 2—SUMMARY OF PROJECTED LEVELS OF EFFORT IN 24-HR SURVEY DAYS

Zone/region	Deep penetration surveys			Shallow penetration/HRG surveys		
	Min	Mean	Max	Min	Mean	Max
1 (Shelf east)	0	0	0	0	0	1
2 (Shelf central)	243	304	426	13	18	21
3 (Shelf west)	0	11	30	2	3	4
4 (Slope east)	0	63	157	0	1	1
5 (Slope central)	414	480	721	26	30	37
6 (Slope west)	99	133	256	10	13	14
7 (Deep)	615	678	940	34	40	49
Total	1,547	1,669	2,190	96	105	116

Proposed mitigation, monitoring, and reporting measures are described in detail later in this document (please see ''Proposed Mitigation'' and ''Proposed Monitoring and Reporting'').

Description of Marine Mammals in the Area of the Specified Activity

Sections 3 and 4 of the petition summarize available information regarding status and trends, distribution and habitat preferences, and behavior and life history of the potentially affected species. We refer the reader to these descriptions, to descriptions of the affected environment in Appendix E of BOEM's PEIS, as well as to NMFS's Stock Assessment Reports (SAR; *www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessments*), incorporated here by reference, instead of reprinting the information. Additional general information about these species (*e.g.,* physical and behavioral descriptions) may be found on NMFS's website (*www.fisheries.noaa.gov/find-species*), the U.S. Navy's Marine Resource Assessment for the GOM (DoN, 2007a) (available online at: *www.navfac.navy.mil/products_and_services/ev/products_and_services/marine_resources/marine_resource_assessments.html*), or Würsig (2017).

Table 3 lists all species with expected potential for occurrence in the Gulf of Mexico and summarizes information related to the population or stock. For taxonomy, we follow Committee on Taxonomy (2017). While no mortality or serious injury is anticipated or proposed for authorization, potential biological removal (PBR; defined in the MMPA as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population) and annual serious injury and mortality from anthropogenic sources are included here as gross indicators of the status of the species and other threats (as described in NMFS's SARs).

Species that could potentially occur in the proposed survey areas, but are not reasonably expected to have potential to be affected by the specified activity, are described briefly but omitted from further analysis. These include extralimital species, which are species that do not normally occur in a given area but for which there are one or more occurrence records that are considered beyond the normal range of the species. For status of species, we provide information regarding U.S. regulatory status under the MMPA and Endangered Species Act (ESA).

Marine mammal abundance estimates presented in this document represent the total number of individuals that make up a given stock or the total number estimated within a particular study area. NMFS's stock abundance estimates for most species represent the total estimate of individuals within the geographic area, if known, that comprises that stock. All managed stocks in this region are assessed in NMFS's U.S. Atlantic SARs (*e.g.,* Hayes *et al.,* 2017). All values presented in Table 3 are the most recent available at the time of publication and are available in the 2016 SARs (Hayes *et al.,* 2017) or draft 2017 SARs (*www.fisheries.noaa.gov/national/marine-mammal-protection/draft-marine-mammal-stock-assessment-reports*).

In some cases, species are treated as guilds. In general ecological terms, a guild is a group of species that have similar requirements and play a similar role within a community. However, for purposes of stock assessment or abundance prediction, certain species may be treated together as a guild because they are difficult to distinguish visually and many observations are ambiguous. For example, NMFS's GOM SARs assess stocks of *Mesoplodon* spp. and *Kogia* spp. as guilds. Here, we consider beaked whales and *Kogia* spp. as guilds. In the following discussion, reference to ''beaked whales'' includes the Cuvier's, Blainville's, and Gervais beaked whales, and reference to ''*Kogia* spp.'' includes both the dwarf and pygmy sperm whale.

Twenty-one species (with 25 managed stocks) have the potential to co-occur with the proposed survey activities. Extralimital species or stocks unlikely to co-occur with survey activity include 31 estuarine bottlenose dolphin stocks (discussed below), the blue whale (*Balaenoptera musculus*), fin whale (*B. physalus*), sei whale (*B. borealis*), minke whale (*B. acutorostrata*), humpback whale (*Megaptera novaeangliae*), North Atlantic right whale (*Eubalaena glacialis*), and the Sowerby's beaked whale (*Mesoplodon bidens).* All mysticete species listed here are considered only of accidental occurrence in GOM and are generally historically known only from a very small number of strandings and/or sightings (Würsig *et al.,* 2000; Würsig, 2017). The blue whale is known from two stranding records, the fin whale from five strandings and rare sightings, and the sei whale from five strandings (Würsig, 2017). Although North Atlantic right whales are well known from the east coast of Florida, that area represents the southern limit of their range; Würsig (2017) reports one stranding and one sighting of two whales in the GOM. Occasional minke whale strandings and rare sightings near the Florida Keys show a winter-spring pattern, which may be indicative of northward-migrating whales from the Caribbean becoming disoriented (Würsig *et al.,* 2000). In 1997, a single group of six humpback whales was observed approximately 250 km east of the Mississippi River delta in deep water; however, this sighting as well as other occasional strandings and rare sighting records are believed to represent vagrants from the Caribbean (Würsig *et al.,* 2000). A Sowerby's beaked whale was found stranded in western Florida in 1984, a record representing the lowest known latitude for the species (Bonde and O'Shea, 1989). We also note here that Hildebrand *et al.* (2015) report acoustic detections of an ''as yet unidentified species of beaked whale'' from three sites. At the three sites—Mississippi Canyon, Green Canyon, and Dry Tortugas—vocal encounters of the unknown species represented four, three, and 0.1 percent of total beaked whale vocal encounters. The same acoustic echolocation signature was previously reported near Hawaii (but without simultaneous visual and acoustic detection), and would presumably be a species with tropical distribution (Hildebrand *et al.,* 2012; McDonald *et al.,* 2009). Nothing else is known of this potential new species.

Roberts *et al.* (2016) developed a stratified density model for the fin whale in the GOM, on the basis of one observation during an aerial survey in the early 1990s. None of the other extralimital species listed here were observed during NMFS shipboard or aerial survey effort from 1992–2009. The fin whale is the second-most frequently reported mysticete in the GOM (after the Bryde's whale), though with only a handful of stranding and sighting records, and is considered here as a rare and likely accidental migrant. As noted by the model authors, while the probability of a chance encounter is not zero, the single sighting during NMFS survey effort should be considered extralimital (Roberts *et al.,* 2015a).

Estuarine stocks of bottlenose dolphin primarily inhabit inshore waters of bays, sounds, and estuaries (BSE), and stocks are defined throughout waters adjacent to the specified geographical region. However, estuarine stock ranges are generally described as including coastal waters (*i.e.,* waters adjacent to shore, barrier islands, or presumed outer bay boundaries and outside of typical inshore ranges) to approximately 1–3 km. For example, bottlenose dolphins that were captured in Texas and outfitted with radio transmitters largely remained within the bays, with three individuals tracked to 1 km offshore (Lynn and Würsig, 2002). Radio-tracking of dolphins in the St. Joseph Bay, Florida area showed that most dolphins stayed within the bay and that, although some individuals ranged more than 40 km along the coastline from the study site, they never ventured outside of immediate nearshore waters (Balmer *et al.,* 2008). More recently, dolphins captured in Barataria Bay, Louisiana were fitted with satellite-linked transmitters, showing that most dolphins remained within the bay, while those that entered nearshore coastal waters remained within 1.75 km (Wells *et al.,* 2017). Therefore, these stocks would not generally be expected to be impacted by the described geophysical surveys. If a deep penetration seismic survey were occurring in nearshore Federal waters (*i.e.,* at least 3 miles from shore but 9 miles from shore off Texas and Florida), it is possible that a dolphin belonging to a BSE stock could be affected. However, such surveys are expected to be rare in such shallow waters, and given the fact that BSE dolphins in sheltered inshore waters would largely not be impacted by noise generated offshore, we believe that impacts from the described activities that could potentially be considered as a ''take'' (as defined by the MMPA) should be considered discountable.

In addition, the West Indian manatee (*Trichechus manatus latirostris*) may be found in coastal waters of the GOM. However, manatees are managed by the U.S. Fish and Wildlife Service and are not considered further in this document.

TABLE 3—MARINE MAMMALS POTENTIALLY PRESENT IN THE SPECIFIED GEOGRAPHICAL REGION

Common name	Scientific name	Stock	ESA/ MMPA status; strategic (Y/N) [1]	NMFS stock abundance (CV, N_{min}, most recent abundance survey) [2 8]	Predicted mean (CV)/maximum abundance [3]	PBR	Annual M/SI (CV) [4]
Order Cetartiodactyla—Cetacea—Superfamily Mysticeti (baleen whales)							
Family Balaenopteridae (rorquals):							
Bryde's whale	*Balaenoptera edeni*	Gulf of Mexico	-[5]; Y	33 (1.07; 16; 2009)	44 (0.27)/n/a	0.03	0.7
Superfamily Odontoceti (toothed whales, dolphins, and porpoises)							
Family Physeteridae:							
Sperm whale	*Physeter macrocephalus*	GOM	E/D; Y	763 (0.38; 560; 2009)	2,128 (0.08)/2,234	1.1	0
Family Kogiidae:							
Pygmy sperm whale	*Kogia breviceps*	GOM	-; N	186 (1.04; 90; 2009) [6]	2,234 (0.19)/6,117 [6]	0.9	0.3 (1.0)
Dwarf sperm whale	*K. sima*	GOM	-; N				
Family Ziphiidae (beaked whales):							
Cuvier's beaked whale.	*Ziphius cavirostris*	GOM	-; N	74 (1.04; 36; 2009)	2,910 (0.16)/3,958 [6]	0.4	0
Gervais beaked whale.	*Mesoplodon europaeus*	GOM	-; N	149 (0.91; 77; 2009) [6]		0.8	0
Blainville's beaked whale.	*M. densirostris*	GOM	-; N				
Family Delphinidae:							
Rough-toothed dolphin.	*Steno bredanensis*	GOM	-; N	624 (0.99; 311; 2009)	4,853 (0.19)/n/a	3	0.8 (1.0)
Common bottlenose dolphin.	*Tursiops truncatus truncatus.*	GOM Oceanic	-; N	5,806 (0.39; 4,230; 2009)	138,602 (0.06)/ 192,176 [6].	42	6.5 (0.65)
		GOM Continental Shelf	-; N	51,192 (0.10; 46,926; 2011–12).		469	0.8
		GOM Coastal, Eastern	-; N	12,388 (0.13; 11,110; 2011–12).		111	1.6
		GOM Coastal, Northern	-; N	7,185 (0.21; 6,044; 2011–12).		60	0.4
		GOM Coastal, Western	-; N	20,161 (0.17; 17,491; 2011–12).		175	0.6
Clymene dolphin	*Stenella clymene*	GOM	-; N	129 (1.00; 64; 2009)	11,000 (0.16)/ 12,115.	0.6	0
Atlantic spotted dolphin.	*S. frontalis*	GOM	-; N	37,611 (0.28; 29,844; 2000–01) [7].	47,488 (0.13)/ 85,108.	Undet.	42 (0.45)
Pantropical spotted dolphin.	*S. attenuata attenuata*	GOM	-; N	50,880 (0.27; 40,699; 2009).	84,014 (0.06)/ 108,764.	407	4.4
Spinner dolphin	*S. longirostris longirostris*	GOM	-; N	11,441 (0.83; 6,221; 2009).	13,485 (0.24)/ 31,341.	62	0
Striped dolphin	*S. coeruleoalba*	GOM	-; N	1,849 (0.77; 1,041; 2009)	4,914 (0.17)/5,323	10	0
Fraser's dolphin	*Lagenodelphis hosei*	GOM	-; N	726 (0.7; 427; 1996–2001) [7].	1,665 (0.73)/n/a	Undet.	0
Risso's dolphin	*Grampus griseus*	GOM	-; N	2,442 (0.57; 1,563; 2009)	3,137 (0.10)/4,153	16	7.9 (0.85)
Melon-headed whale	*Peponocephala electra*	GOM	-; N	2,235 (0.75; 1,274; 2009)	6,733 (0.30)/7,105	13	0
Pygmy killer whale	*Feresa attenuata*	GOM	-; N	152 (1.02; 75; 2009)	2,126 (0.30)/n/a	0.8	0
False killer whale	*Pseudorca crassidens*	GOM	-; N	777 (0.56; 501; 2003–04) [7].	3,204 (0.36)/n/a	Undet.	0
Killer whale	*Orcinus orca*	GOM	-; N	28 (1.02; 14; 2009)	185 (0.41)/n/a	0.1	0
Short-finned pilot whale.	*Globicephala macrorhynchus.*	GOM	-; N	2,415 (0.66; 1,456; 2009)	1,981 (0.18)/n/a	15	0.5 (1.0)

[1] ESA status: Endangered (E)/MMPA status: Depleted (D). A dash (-) indicates that the species is not listed under the ESA or designated as depleted under the MMPA. Under the MMPA, a strategic stock is one for which the level of direct human-caused mortality exceeds PBR or which is determined to be declining and likely to be listed under the ESA within the foreseeable future. Any species or stock listed under the ESA is automatically designated under the MMPA as depleted and as a strategic stock.

[2] NMFS marine mammal stock assessment reports online at: *www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessments.* CV is coefficient of variation; N_{min} is the minimum estimate of stock abundance.

[3] This information represents species- or guild-specific abundance predicted by habitat-based cetacean density models (Roberts *et al.,* 2016). These models provide the best available scientific information regarding predicted density patterns of cetaceans in the U.S. Gulf of Mexico, and we provide the corresponding abundance predictions as a point of reference. Total abundance estimates were produced by computing the mean density of all pixels in the modeled area and multiplying by its area.

[4] These values, found in NMFS's SARs, represent annual levels of human-caused mortality plus serious injury from all sources combined (*e.g.,* commercial fisheries, ship strike). A CV associated with estimated mortality due to commercial fisheries is presented in some cases.

[5] NMFS has proposed to list the GOM Bryde's whale as an endangered species under the ESA (81 FR 88639; December 8, 2016).

[6] Abundance estimates are in some cases reported for a guild or group of species when those species are difficult to differentiate at sea. Similarly, the habitat-based cetacean density models produced by Roberts *et al.* (2016) are based in part on available observational data which, in some cases, is limited to genus or guild in terms of taxonomic definition. NMFS's SARs present pooled abundance estimates for *Kogia* spp. and *Mesoplodon* spp., while Roberts *et al.* (2016) produced density models to genus level for *Kogia* spp. and as a guild for beaked whales (*Ziphius cavirostris* and *Mesoplodon* spp.). Finally, Roberts *et al.* (2016) produced a density model for bottlenose dolphins that does not differentiate between oceanic, shelf, and coastal stocks.

[7] NMFS's abundance estimates for these species are greater than eight years old and not considered current. PBR is therefore considered undetermined, as there is no current minimum abundance estimate for use in calculation. We nevertheless present the most recent abundance estimate.

[8] We note that Dias and Garrison (2016) present abundance estimates for oceanic stocks that were calculated for use in DWH oil spill injury quantification. For most stocks, these estimates are based on pooled observations from shipboard surveys conducted in 2003, 2004, and 2009 and corrected for detection bias. Estimates for beaked whales and *Kogia* spp. were based on density estimates derived from passive acoustic data collection (Hildebrand *et al.,* 2012). The abundance estimate for Bryde's whales incorporated the results of additional shipboard surveys conducted in 2007, 2010, and 2012. Here we retain NMFS's official SARs information for comparison with model-predicted abundance (Roberts *et al.,* 2016).

For the majority of species potentially present in the specified geographical region, NMFS has designated only a single generic stock (*i.e.,* ''Gulf of Mexico'') for management purposes, although there is currently no information to differentiate the stock from the Atlantic Ocean stock of the same species, nor information on whether more than one stock may exist in the GOM (Hayes *et al.,* 2017).

During aerial and ship-based cetacean surveys, the most commonly sighted species in the GOM are bottlenose dolphins, pantropical spotted dolphins, Atlantic spotted dolphins, Risso's dolphins, sperm whales, and *Kogia* spp. (Baumgartner *et al.,* 2001; Mullin and Fulling, 2004; Mullin *et al.,* 2004, Maze-Foley and Mullin, 2006; Mullin, 2007; Dias and Garrison, 2016). Short-finned pilot whales, striped dolphins, Clymene dolphins, spinner dolphins, and beaked whales are somewhat commonly observed during surveys and have different rates of detection (Mullin *et al.,* 2004; Mullin and Fulling, 2004; Dias and Garrison, 2016). Rarely recorded species include melon-headed whales, false killer whales, killer whales, and pygmy killer whales (Dias and Garrison, 2016). Bryde's whales are also infrequently seen and are the only species of baleen whale recurrently seen in the GOM (Baumgartner *et al.,* 2001; Mullin and Fulling, 2004; Mullin *et al.,* 2004, Maze-Foley and Mullin, 2006; Mullin, 2007; Dias and Garrison, 2016). Fraser's dolphins are present in the GOM, but there are very few detections during marine mammal surveys (Mullin and Fulling, 2004; Dias and Garrison, 2016).

For the bottlenose dolphin, NMFS defines an oceanic stock, a continental shelf stock, and three coastal stocks. As in the northwestern Atlantic Ocean, there are two general bottlenose dolphin ecotypes: ''coastal'' and ''offshore.'' These ecotypes are genetically and morphologically distinct (Hoelzel *et al.,* 1998; Waring *et al.,* 2016), though ecotype distribution is not clearly defined and the stocks are delineated primarily on the basis of management rather than ecological boundaries. The offshore ecotype is assumed to correspond to the oceanic stock, with the stock boundary (and thus the de facto delineation of offshore and coastal ecotypes) defined as the 200-m isobath. All genetic samples collected during 1994–2008 in waters greater than 200 m were of the offshore ecotype (Waring *et al.,* 2016). The continental shelf stock is defined as between two typical survey strata: the 20- and 200-m isobaths. While the shelf stock is assumed to consist primarily of coastal ecotype dolphins, offshore ecotype dolphins may also be present. There is expected to be some overlap with the three coastal stocks as well, though the degree is unknown and it is not thought that significant mixing or interbreeding occurs between them (Waring *et al.,* 2016). The coastal stocks are defined as being in waters between the shore, barrier islands, or presumed outer bay boundaries out to the 20-m isobath and, as a working hypothesis, NMFS has assumed that dolphins occupying habitats with dissimilar climatic, coastal, and oceanographic characteristics might be restricted in their movements between habitats, thus constituting separate stocks (Waring *et al.,* 2016). Shoreward of the 20-m isobath, the eastern coastal stock extends from Key West, FL to 84° W longitude; the northern coastal stock from 84° W longitude to the Mississippi River delta; and the western coastal stock from the Mississippi River delta to the Mexican border. The latter is assumed to be a trans-boundary stock, though no information is available regarding abundance in Mexican waters. Genetic studies have shown significant differentiation between inshore stocks and the adjacent coastal stock (Sellas *et al.,* 2005) and among dolphins living in coastal and shelf waters (Waring *et al.,* 2016), suggesting that despite spatial overlap there may be mechanisms reducing interbreeding among coastal stocks and between coastal stocks and BSE stocks (Waring *et al.,* 2016). Continued studies are necessary to examine the current stock boundaries delineated in coastal, shelf, and oceanic waters (Waring *et al.,* 2016).

In Table 3 above, we report two sets of abundance estimates: those from NMFS's SARs and those predicted by Roberts *et al.* (2016)—for the latter we provide both the annual mean and the monthly maximum (where applicable). Please see footnotes 2–3 for more detail. NMFS's SAR estimates are typically generated from the most recent shipboard and/or aerial surveys conducted. GOM oceanography is dynamic, and the spatial scale of the GOM is small relative to the ability of most cetacean species to travel. As an example, no groups of Fraser's dolphins were observed during dedicated cetacean abundance surveys during 2003–2004 or 2009, yet NMFS states that it is probable that Fraser's dolphins were present in the northern GOM but simply not encountered, and therefore declines to present an abundance estimate of zero (Waring *et al.,* 2013). U.S. waters only comprise about 40 percent of the entire GOM, and 65 percent of GOM oceanic waters are south of the U.S. EEZ. Studies based on abundance and distribution surveys restricted to U.S. waters are unable to detect temporal shifts in distribution beyond U.S. waters that might account for any changes in abundance within U.S. waters. NMFS's SAR estimates also typically do not incorporate correction for detection bias. Therefore, they should generally be considered as underestimates, especially for cryptic or long-diving species (*e.g.,* beaked whales, *Kogia* spp., sperm whales). Dias and Garrison (2016) state, for example, that current abundance estimates for *Kogia* spp. may be considerably underestimated due to the cryptic behavior of these species and difficulty of detection in Beaufort sea state greater than one, and density estimates for certain species derived from long-term passive acoustic monitoring are much higher than are estimates derived from visual observations (Mullin and Fulling, 2004; Mullin, 2007; Hildebrand *et al.,* 2012).

The Roberts *et al.* (2016) abundance estimates represent the output of predictive models derived from multi-year observations and associated environmental parameters and which incorporate corrections for detection bias. Incorporating more data over multiple years of observation can yield different results in either direction, as the result is not as readily influenced by fine-scale shifts in species habitat preferences or by the absence of a species in the study area during a given year. NMFS's abundance estimates show substantial year-to-year variability in some cases. For example, NMFS-reported estimates for the Clymene dolphin vary by a maximum factor of more than 100 (2009 estimate of 129 versus 1996–2001 estimate of 17,355), indicating that it may be more appropriate to use the model prediction versus a point estimate, as the model incorporates data from 1992–2009. The latter factor—incorporation of correction for detection bias—should systematically result in greater abundance predictions. For these reasons, we expect that the Roberts *et al.* (2016) estimates are generally more realistic and, for these purposes, represent the best available information. For purposes of assessing estimated exposures relative to abundance—used in this case to understand the scale of the predicted takes compared to the population—we generally believe that the Roberts *et al.* (2016) abundance predictions are most appropriate because they were used to generate the exposure estimates and therefore provide the most relevant comparison. Roberts *et al.* (2016) represents the best available scientific information regarding marine mammal occurrence and distribution in the Gulf of Mexico.

As a further illustration of the distinction between the SARs and model-predicted abundance estimates, the current NMFS stock abundance estimates for most GOM species are based on direct observations from shipboard surveys conducted in 2009 (from the 200-m isobath to the edge of the U.S. EEZ) and not corrected for detection bias, whereas the exposure estimates presented herein for those species are based on the abundance predicted by a density surface model informed by observations from surveys conducted over approximately 20 years and covariates associated at the observation level. To directly compare the estimated exposures predicted by the outputs of the Roberts *et al.* (2016) model to NMFS's SAR abundance would therefore not be meaningful.

Biologically Important Areas (BIA)—As part of our description of the environmental baseline, we discuss any known areas of importance as marine mammal habitat. These areas may include designated critical habitat for ESA-listed species (as defined by section 3 of the ESA) or other known areas not formally designated pursuant to any statute or other law. Important areas may include areas of known importance for reproduction, feeding, or migration, or areas where small and resident populations are known to occur.

Although there is no designated critical habitat for marine mammal species in the specified geographical region, BIAs for marine mammals are recognized. For example, the GOM Bryde's whale is a very small population that is genetically distinct from other Bryde's whales and not genetically diverse within the GOM (Rosel and Wilcox, 2014). Further, the species is typically observed only within a narrowly circumscribed area within the eastern GOM. Therefore, this area is described as a year-round BIA by LaBrecque *et al.* (2015). Although survey effort has covered all oceanic waters of the U.S. GOM, whales were observed only between approximately the 100- and 300-m isobaths in the eastern GOM from the head of the De Soto Canyon (south of Pensacola, Florida) to northwest of Tampa Bay, Florida (Maze-Foley and Mullin, 2006; Waring *et al.,* 2016; Rosel and Wilcox, 2014; Rosel *et al.,* 2016). NOAA subsequently conducted a status review of the GOM Bryde's whale. The review, described in a technical memorandum (Rosel *et al.* (2016)), expanded this description by stating that, due to the depth of some sightings, the area is more appropriately defined to the 400-m isobath and westward to Mobile Bay, Alabama, in order to provide some buffer around the deeper sightings and to include all sightings in the northeastern GOM. However, the recorded Bryde's whale shipboard and aerial survey sightings between 1989 and 2015 have mainly fallen within the BIA described by LaBreque *et al.* (2015).

LaBrecque *et al.* (2015) also described eleven year-round BIAs for small and resident BSE bottlenose dolphin populations in the GOM. Additional study would likely allow for identification of additional BIAs associated with other GOM BSE dolphin stocks.

Unusual Mortality Events (UME)—A UME is defined under Section 410(6) of the MMPA as ''a stranding that is unexpected; involves a significant die-off of any marine mammal population; and demands immediate response.'' From 1991 to the present, there have been twelve formally recognized UMEs affecting marine mammals in the region and involving species under NMFS's jurisdiction. These have primarily impacted coastal bottlenose dolphins, with multiple UMEs determined to have resulted from biotoxins and one from infectious disease. None of these involve ongoing investigation. Most significantly, a UME affecting multiple cetacean species in the northern GOM occurred from 2010–2014.

The northern GOM UME was determined to have begun in March 2010 and extended through July 2014. The event included all cetaceans stranded during this time in Alabama, Mississippi, and Louisiana and all cetaceans other than bottlenose dolphins stranded in the Florida Panhandle (Franklin County through Escambia County), with a total of 1,141 cetaceans stranded or reported dead offshore. For reference, the same area experienced a normal average of 75 strandings per year from 2002–09 (Litz *et al.,* 2014). The majority of stranded animals were bottlenose dolphins, though at least ten additional species were reported as well. Since not all cetaceans that die wash ashore where they may be found, the number reported stranded is likely a fraction of the total number of cetaceans that died during the UME. There was also an increase in strandings of stillborn and newborn dolphins (Colegrove *et al.,* 2016).

The UME investigation and the *Deepwater Horizon* Natural Resource Damage Assessment (described below) determined that the DWH oil spill is the most likely explanation of the persistent, elevated stranding numbers in the northern GOM after the 2010 spill. The evidence to date supports that exposure to hydrocarbons released during the DWH oil spill was the most likely explanation of adrenal and lung disease in dolphins, which has contributed to increased deaths of dolphins living within the oil spill footprint and increased fetal loss. The longest and most prolonged stranding cluster was in Barataria Bay, Louisiana in 2010–11, followed by Mississippi and Alabama in 2011, consistent with timing and spatial distribution of oil, while the number of deaths was not elevated for areas that were not as heavily oiled.

However, increased dolphin strandings occurred in Louisiana and Mississippi before the DWH oil spill, and identified stranding clusters within the UME suggest that the event may involve different additional contributing factors varying by location, time, and population (Venn-Watson *et al.,* 2015a). Some previous GOM cetacean UMEs had included environmental influences (*e.g.,* low salinity due to heavy rainfall and associated runoff of land-based pesticides, low temperatures) as possible contributing factors (Litz *et al.,* 2014). Low air and water temperatures occurred in the spring of 2010 throughout the GOM prior to and during the start of the UME, and a portion of the pre-spill atypical strandings occurred in Lake Pontchartrain, Louisiana, concurrent with lower than average salinity (Mullin *et al.,* 2015). Therefore, a large part of the pre-spill increased dolphin strandings may have been due to a combination of cold temperatures and low salinity (Litz *et al.,* 2014).

Subsequent health assessments of live dolphins from Barataria Bay and comparison to a reference population found significantly increased adrenal disease, lung disease, and poor health, while histological evaluations of samples from dead stranded animals from within and outside the UME area found that UME animals were more likely to have lung and adrenal lesions and to have primary bacterial pneumonia, which caused or contributed significantly to death (Schwacke *et al.,* 2014a, 2014b; Venn-Watson *et al.,* 2015b). In order to diagnose health, dolphin capture-release health assessments were conducted in Barataria Bay, during which physical examinations, including weighing and morphometric measurements, were conducted, routine biological samples (*e.g.,* blood, tissue) were obtained, and animals were examined with ultrasound. Veterinarians then reviewed the findings and determined an overall prognosis for each animal (*e.g.,* favorable outcome expected, outcome uncertain, unfavorable outcome expected). Almost half of the examined animals were given a guarded or worse prognosis, and 17 percent were not expected to survive (Schwacke *et al.,* 2014a).

The prevalence of brucellosis and morbillivirus infections was low and biotoxin levels were low or below the detection limit, meaning that these were not likely primary causes of the UME (Venn-Watson *et al.,* 2015b; Fauquier *et al.,* 2017). Subsequent study found that persistent organic pollutants (*e.g.,* polychlorinated biphenyls), which are associated with endocrine disruption and immune suppression when present in high levels, are likely not a primary contributor to the poor health conditions and increased mortality observed in these GOM populations (Balmer *et al.,* 2015). The chronic adrenal gland and lung diseases identified in stranded UME dolphins are consistent with exposure to petroleum compounds (Venn-Watson *et al.,* 2015b). Colegrove *et al.* (2016) found that the increase in perinatal strandings resulted from late-term pregnancy failures and development of *in utero* infections likely caused by chronic illnesses in mothers who were exposed to oil.

While the number of dolphin mortalities in the area decreased after the peak from March 2010–July 2014, it does not indicate that the effects of the oil spill on these populations have ended. Researchers still saw evidence of chronic lung disease and adrenal impairment four years after the spill (in July 2014) and saw evidence of failed pregnancies in 2015 (Smith *et al.,* 2017). These follow-up studies found a yearly mortality rate for Barataria Bay dolphins of roughly 13 percent (as compared to annual mortality rates of 5 percent or less that have been previously reported for other dolphin populations), and found that only 20 percent of pregnant dolphins produced viable calves (compared with 83 percent in a reference population) (Lane *et al.,* 2015; McDonald *et al.,* 2017). Research into the long-term health effects of the spill on marine mammal populations is ongoing. For more information on the UME, please visit *www.nmfs.noaa.gov/pr/health/mmume/cetacean_gulfofmexico.htm.*

Prior UMEs averaged six months in duration and involved significantly fewer mortalities. In most of these relatively localized events, dolphin morbillivirus or brevetoxicosis was confirmed or suspected as a causal factor (Litz *et al.,* 2014). One other recent UME occurred during 2011–12 for bottlenose dolphins in Texas. Investigators were not able to determine a cause for the UME, though findings included lung infection, poor body condition, and discoloring of teeth. No connection has been identified between this event and the 2010–14 event described above. For more information on UMEs, please visit: *www.fisheries.noaa.gov/national/marine-life-distress/marine-mammal-unusual-mortality-events.*

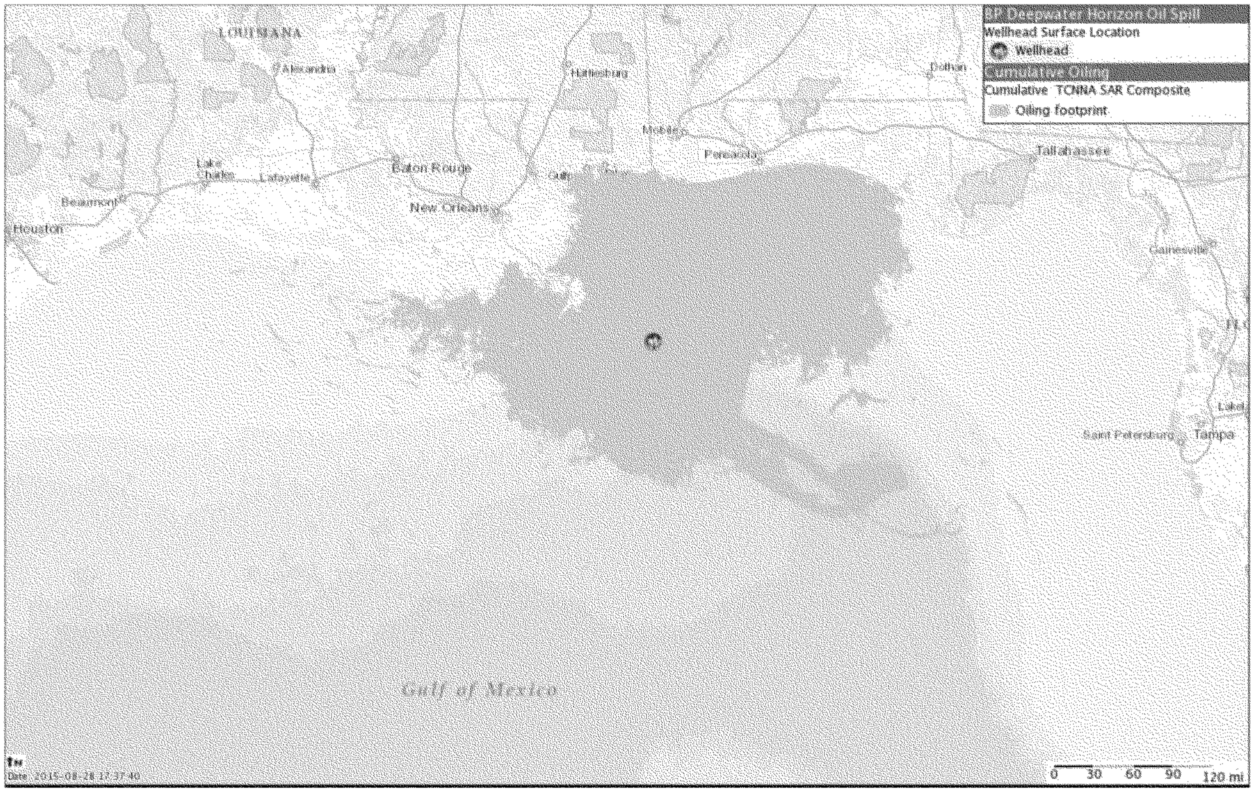
Deepwater Horizon Oil Spill

We introduced the DWH oil spill—which includes the impacts of the spill as well as the response efforts—previously in our description of the ''Specified Geographical Region.'' Here we provide additional description of the potential effects of the spill on the marine mammals that may be affected by the activities that are the subject of this proposed rule. The summary provided below is an incorporation by reference of relevant information from DWH NRDA Trustees (2016) and DWH MMIQT (2015); more detail on the DWH oil spill and its effects on marine mammals is available in these documents. Additional technical reports relating to the assessment of marine mammal injury due to the DWH oil spill are available online at: *www.doi.gov/deepwaterhorizon/adminrecord.* A brief overview of injury assessment activities and associated findings is provided by Wallace *et al.,* (2017).

On April 20, 2010, the *Deepwater Horizon* offshore drilling platform, a semi-submersible exploratory drilling rig operating on the exploratory *Macondo* well (within BOEM's Mississippi Canyon lease block), exploded and subsequently sank in 1,522 m of water in the GOM, approximately 81 km off the coast of Louisiana. This incident resulted in the release of an estimated 3.19 million barrels (134 million gallons) of oil from the compromised well. In addition, approximately 1.84 million gallons of chemical dispersants were applied to the waters of the spill area. The release of oil continued for 87 days, with an average of more than 1.5 million gallons of fresh oil entering the ocean per day—essentially creating a new major oil spill every day for nearly 3 months, equivalent to the 1989 *Exxon Valdez* oil spill re-occurring in the same location every week for the duration. Response techniques included deployment of containment booms, physical removal of oil, controlled burning of oil on the surface, major releases of fresh water to keep the oil offshore, beach and fishery closures, construction of berms, wildlife rehabilitation and relocation (*e.g.,* Wilkin *et al.,* 2017), and application of chemical dispersants on the surface and at the wellhead on the seafloor (with the goal of breaking the oil into small droplets). For more information about the DWH oil spill, please visit *response.restoration.noaa.gov/deepwater-horizon-oil-spill* and *www.deepwaterhorizoneconomicsettlement.com/docs.php.*

An estimated 7.7 billion standard cubic feet of natural gas was released in association with the oil; bacteria proliferated, consumed the gas, and died. Mucus produced by bacteria, as well as some of the bacterial mass itself, agglomerated with brown-colored oil droplets and settled through the water column—this phenomenon is referred to as ''marine oil snow.'' Oil, released from the well-head approximately 1,500 m deep, moved with currents, creating a plume of oil within the deep sea; oil and associated ''marine oil snow'' also settled on the sea floor. More buoyant oil traveled up through the water column and formed large surface slicks; at its maximum extent, oil covered over 40,000 km^2 of ocean. Cumulatively, over the course of the spill, oil was detected on over 112,000 km^2 of ocean. Figure 3 shows the cumulative area of detectable surface oil slick during the DWH oil spill. Currents, winds, and tides carried these surface oil slicks to shore, fouling more than 2,100 km of shoreline, including beaches, bays, estuaries, and marshes from eastern Texas to the Florida Panhandle. In addition, some lighter oil compounds evaporated from the slicks, exposing air-breathing organisms like marine mammals to noxious fumes at the sea surface. Air pollution resulted from compounds in the oil that evaporated into the air and from fires purposely started to burn off oil at the ocean surface. The oil released during the event was a complex mixture containing thousands of individual chemical compounds—many of which are known to be toxic to biota—which then changed as they were subject to natural processes such as mixing with air and water, microbial degradation, and exposure to sunlight. DWH oil has a specific chemical signature that, together with other lines of evidence, allowed investigators to determine which oil-derived contaminants found in the environment originated from the spill.

Dispersants are chemicals that reduce the tension between oil and water, leading to the formation of oil droplets that more readily disperse within the water column. A main purpose of using dispersants is to enhance the rate at which bacteria degrade the oil in order to prevent oil slicks from fouling sensitive shoreline habitats. The large-scale use of dispersants raised concerns about the potential for toxic effects of dispersed oil in the water column, as well as the potential for hypoxia due to bacterial consumption of dispersed oil. The surface application of dispersants increased exposure of near-surface biota, such as marine mammals, to oil that re-entered the water column.



Source: DWH NRDA Trustees, 2016.

Figure 3. Cumulative Area of Detectable Oil Slick, DWH Oil Spill.

The DWH oil spill was subject to the provisions of the Oil Pollution Act (OPA) of 1990 (33 U.S.C. 2701 *et seq.*), which addresses prevention, response, and compensation for oil pollution incidents in navigable waters, adjoining shorelines, and the U.S. EEZ. Under the authority of OPA, a council of Federal and state trustees was established, on behalf of the public, to assess natural resource injuries resulting from the incident and work to make the environment and public whole for those injuries. As required under OPA, the trustees conducted a natural resource damage assessment (NRDA), finding that the injuries resulting from the DWH oil spill affected such a wide array of linked resources over such an enormous area that the effects must be described as constituting an ecosystem-level injury. OPA regulations (15 CFR part 990) establish a process for conducting a NRDA that require, in part, the assessment of potential injuries to relevant resources, here including marine mammals and habitats they rely upon. OPA regulations define injury as an observable or measurable adverse change in a natural resource that may occur directly or indirectly. Types of injuries include adverse changes in survival, growth, and reproduction; health, physiology and biological condition; behavior; community composition; ecological processes and functions; and physical and chemical habitat quality or structure.

The injury assessment first requires a determination of whether an incident injured natural resources. Trustees must establish that a pathway existed from the oil discharge to the resource, confirm that resources were exposed to the discharge, and evaluate the adverse effects that occurred as a result of the exposure (or response activities). Subsequently, the assessment requires injury quantification (including degree and spatiotemporal extent), essentially by comparing the post-event conditions with the pre-event baseline. For a fuller overview of the injury assessment process in this case, please see Takeshita *et al.* (2017). Because of the vast scale of the incident, the trustees evaluated injuries to a set of representative habitats, communities, species, and ecological processes, with studies conducted at many scales. Key findings are as follows: (1) Oil flowed within deep ocean water currents hundreds of miles away from the well and moved upwards and across a very large area of the ocean surface, affecting vast areas overall (*e.g.,* approximately 112,000 km^2 of ocean surface; 2,100 km of shoreline; and between 1,000–1,900 km^2 of seafloor), including every type of habitat occupied by marine mammals in the northern GOM as well as habitat for all stocks of marine mammals in the northern GOM; (2) the oil that was released was toxic to a wide range of organisms, including marine mammals; (3) oil came into contact with and injured a wide range of organisms, including marine mammals; (4)

response activities had collateral impacts on the environment; and (5) exposure to oil and response activities resulted in extensive injuries to multiple habitats, species, and ecological functions, across broad geographic regions. Critical pathways of exposure for marine mammals included the contaminated water column, where they swim and capture prey; the surface slick at the air to water interface, where they breathe, rest, and swim; and contaminated sediment, where they forage and capture prey. Response workers and scientists witnessed 85 instances of marine mammals (with a total of 1,394 individuals) swimming in surface oil or with oil on their bodies; these instances represented a minimum of 11 species, including dolphins, sperm whales, *Kogia* spp., and a beaked whale.

The marine mammal injury assessment synthesized data from NRDA field studies, stranded carcasses collected by the Southeast Marine Mammal Stranding Network, historical data on marine mammal populations, NRDA toxicity testing studies, and the published literature. DWH oil was found to cause problems with the regulation of stress hormone secretion from adrenal cells and kidney cells, which will affect an animal's ability to regulate body functions and respond appropriately to stressful situations, thus leading to reduced fitness. Bottlenose dolphins living in habitats contaminated with DWH oil showed signs of adrenal dysfunction, and dead, stranded dolphins from areas contaminated with DWH oil had smaller adrenal glands (Schwacke *et al.,* 2014a; Venn-Watson *et al.,* 2015b). Limited cetacean exposure studies have demonstrated that bottlenose dolphins may sustain liver damage and that bottlenose dolphins and sperm whales may develop skin lesions (Engelhardt, 1983). Field and laboratory studies and other data analysis were designed to explicitly examine other potential explanations for marine mammal injuries, including biotoxins, infectious diseases, human and fishery interactions, and other unrelated potential contaminants. Each of these other factors was ruled out as a primary cause for the high prevalence of adverse health effects, reproductive failures, and disease in stranded animals. When all of the data are considered together, the DWH oil spill is the only reasonable cause for the full suite of observed adverse health effects.

Findings related to bottlenose dolphins living in heavily oiled nearshore habitats were described previously in the UME discussion. Due to the difficulty of investigating marine mammals in pelagic environments and across the entire region impacted by the event, the injury assessment focused on health assessments conducted on bottlenose dolphins in nearshore habitats (*i.e.,* Barataria Bay and Mississippi Sound) and used these populations as case studies for extrapolating to coastal and oceanic populations that received similar or worse exposure to DWH oil, with appropriate adjustments made for differences in behavior, anatomy, physiology, life histories, and population dynamics among species. Based on direct observation, injuries were quantified for four BSE stocks of bottlenose dolphin, *e.g.,* for the Barataria Bay stock, the DWH oil spill caused 35 percent (CI 15–49) excess mortality, 46 percent (CI 21–65) excess failed pregnancies, and a 37 percent (CI 14–57) higher likelihood that animals would have adverse health effects. The process for assigning a health prognosis (Schwacke *et al.,* 2014a) was described previously in the UME discussion. Two dolphins having received the lowest grade died within 6 months, and the percentage of the population with the two lowest prognoses (17 percent poor and grave) essentially predicted the percentage of dolphins that disappeared and presumably died the following year based on photo-identification surveys.

Investigators then used a population modeling approach to capture the overlapping and synergistic relationships among the three metrics for injury, and to quantify the entire scope of DWH marine mammal injury to populations into the future, expressed as ''lost cetacean years'' due to the DWH oil spill (which represents years lost due to premature mortality as well as the resultant loss of reproductive output). This approach allowed for consideration of long-term impacts resulting from immediate losses and reproductive failures in the few years following the spill, as well as expected persistent impacts on survival and reproduction for exposed animals well into the future (Takeshita *et al.,* 2017). For example, lost cetacean years were estimated for the Barataria Bay stock of bottlenose dolphins, leading to an estimated 51 percent (CI 32–72) maximum reduction in population size and a time to recovery of 39 years (CI 24–80) in the absence of potential benefits of restoration activities. For a more detailed overview of the injury quantification for these stocks and their post-DWH population trajectory, please see Schwacke *et al.* (2017), and for full details of the overall injury quantification, see DWH MMIQT (2015).

To calculate the increase in percent mortality for the shelf and oceanic marine mammal stocks, the Barataria Bay percent mortality was applied to the percentage of animals in each stock that was exposed to oil. This percentage was calculated assuming that animals experiencing a level of cumulative surface oiling similar to or greater than that in Barataria Bay would have been likely to suffer a similar or greater degree and magnitude of injury. This is likely a conservative estimate of impacts, because: (1) Shelf and oceanic species experienced long exposures (up to 90 days) to very high concentrations of fresh oil and a diverse suite of response activities, while estuarine dolphins were not exposed until later in the spill period and to weathered oil products at lower water concentrations; (2) oceanic cetaceans dive longer and to deeper depths, and it is possible that the types of lung injuries observed in estuarine dolphins may be more severe for oceanic cetaceans; and (3) cetaceans in deeper waters were exposed to very high concentrations of volatile gas compounds at the water's surface near the wellhead.

As an example of the calculation, 47 percent of the spinner dolphin stock range in the northern GOM experienced oiling equal to or greater than Barataria Bay, and, therefore, was assumed to have experienced a rate of mortality increase equal to that calculated for Barataria Bay (35 percent). Thus, the entire northern GOM spinner dolphin stock is assumed to have experienced a 16 percent mortality increase ($0.35 \times 0.47 = 0.16$). Similarly, the percentage of females with reproductive failure in Barataria Bay and Mississippi Sound (46 percent; stocks pooled for sample size considerations) is considered to be the best estimate of excess failed pregnancies for other marine mammals in the oil spill footprint, and the percentage of the population with a guarded or worse health prognosis—compared with dolphins sampled in a healthy reference population—from Barataria Bay (37 percent) was applied to other stocks.

The population modeling approach used in the injury quantification allows consideration of long-term impacts resulting from individual losses, adverse reproductive effects, and persistent impacts on survival for exposed animals. The model was run using baseline mortality and reproductive parameters to determine what the population trajectory of each stock would have been if the DWH spill had not happened. The same model was then run a second time, with estimates for excess mortality, reproductive failures, and adverse health effects due to the DWH oil spill. The number of years predicted for the DWH oil-impacted population to recover (without active restoration) is the number of years until the DWH oil-injured population trajectory reaches 95 percent of the baseline population trajectory, reported as years to recovery. The output from the population model also predicts the largest proportional decrease in population size (*i.e.,* the difference between the two population trajectories when the DWH oil-impacted trajectory is at its lowest point). A separate population model is run for each stock, with inputs for the models restricted to the available data for each stock. For inputs without empirical data, the values are extrapolated from other stocks or incorporate additional modeling efforts. For bottlenose dolphins, uncertainty in model output was evaluated by drawing from the distributions for model input parameters to execute 10,000 simulations, producing distributions for each of the model outputs. For other species, because there was insufficient information to construct informed input parameter distributions, only a single model scenario was run using point estimates for input parameter values and simulations were not conducted to explore the effects of uncertainty in the model parameters.

The results of these calculations for each affected shelf and oceanic stock, and for northern and western coastal stocks of bottlenose dolphin, are presented in Table 4. The eastern coastal stock of bottlenose dolphin was considered to be not affected by the DWH oil spill, as the cumulative footprint of oil did not overlap the stock's range. Results for BSE dolphin stocks are not presented here. No analysis was performed for Fraser's dolphins or killer whales; although they are present in the GOM, sightings are rare and there were no historical sightings in the oil spill footprint during the surveys used in the quantification process. These stocks were likely injured, but no information is available on which to base a quantification effort.

TABLE 4—SUMMARY OF MODELED EFFECTS OF DWH OIL SPILL

Common name	% Population exposed to oil (95% CI)	% Population killed (95% CI)	% Females with reproductive failure (95% CI)	% Population with adverse health effects (95% CI)	% Maximum population reduction (95% CI)	Years to recovery (95% CI)[b]
Bryde's whale	48 (23–100)	17 (7–24)	22 (10–31)	18 (7–28)	−22	69
Sperm whale	16 (11–23)	6 (2–8)	7 (3–10)	6 (2–9)	−7	21
Kogia spp.	15 (8–29)	5 (2–7)	7 (3–10)	6 (2–9)	−6	11
Beaked whales	12 (7–22)	4 (2–6)	5 (3–8)	4 (2–7)	−6	10
Rough-toothed dolphin	41 (16–100)	14 (6–20)	19 (9–26)	15 (6–23)	−17	54
Bottlenose dolphin, oceanic	10 (5–10)	3 (1–5)	5 (2–6)	4 (1–6)	−4	n/a
Bottlenose dolphin, northern coastal	82 (55–100)	38 (26–58)	37 (17–53)	30 (11–47)	−50 (32–73)	39 (23–76)
Bottlenose dolphin, western coastal	23 (16–32)	1 (1–2)	10 (5–15)	8 (3–13)	−5 (3–9)	n/a
Shelf dolphins[a]	13 (9–19)	4 (2–6)	6 (3–8)	5 (2–7)	−3	n/a
Clymene dolphin	7 (3–15)	2 (1–4)	3 (2–5)	3 (1–4)	−3	n/a
Pantropical spotted dolphin	20 (15–26)	7 (3–10)	9 (4–13)	7 (3–11)	−9	39
Spinner dolphin	47 (24–91)	16 (7–23)	21 (10–30)	17 (6–27)	−23	105
Striped dolphin	13 (8–22)	5 (2–7)	6 (3–9)	5 (2–8)	−6	14
Risso's dolphin	8 (5–13)	3 (1–4)	3 (2–5)	3 (1–4)	−3	n/a
Melon-headed whale	15 (6–36)	5 (2–7)	7 (3–10)	6 (2–9)	−7	29
Pygmy killer whale	15 (7–33)	5 (2–8)	7 (3–10)	6 (2–9)	−7	29
False killer whale	18 (7–48)	6 (3–9)	8 (4–12)	7 (3–11)	−9	42
Short-finned pilot whale	6 (4–9)	2 (1–3)	3 (1–4)	2 (1–3)	−3	n/a

Modified from DWH NRDA Trustees (2016).
CI = confidence interval. No CI was calculated for population reduction or years to recovery for shelf or oceanic stocks.
[a] "Shelf dolphins" includes Atlantic spotted dolphins and the shelf stock of bottlenose dolphins (20–200 m water depth). These two species were combined because the abundance estimate used in population modeling was derived from aerial surveys and the species could not generally be distinguished from the air.
[b] It is not possible to calculate YTR for stocks with maximum population reductions of less than or equal to 5 percent.

Coastal and oceanic marine mammals were injured by exposure to oil from the DWH spill; nearly all of the stocks that overlap with the oil spill footprint have demonstrable, quantifiable injuries, and the remaining stocks (for which there is no quantifiable injury) were also likely injured, though there is not currently enough information to make a determination. Injuries included elevated mortality rates, reduced reproduction, and disease. Due to these effects, affected populations may require decades to recover absent successful efforts at restoration (*e.g.,* DWH NRDA Trustees, 2017). Tens of thousands of marine mammals were exposed to the DWH surface slick, where they inhaled, aspirated, ingested, and came into contact with oil components (Dias *et al.,* 2017). The oil's physical and toxic effects damaged tissues and organs, leading to a constellation of adverse health effects, including reproductive failure, adrenal disease, lung disease, and poor body condition, as observed in bottlenose dolphins (De Guise *et al.,* 2017; Kellar *et al.,* 2017). Coastal and estuarine bottlenose dolphin populations were some of the most severely injured (Hohn *et al.,* 2017; Rosel *et al.,* 2017; Thomas *et al.,* 2017), as described previously in relation to the UME, but oceanic species were also exposed and experienced increased mortality, increased reproductive failure, and a higher likelihood of other adverse health effects.

Due to the scope of the spill, the magnitude of potentially injured populations, and the difficulties and limitations of working with marine mammals, it is impossible to quantify injury without uncertainty. Wherever possible, the quantification results represent ranges of values that encapsulate the uncertainty inherent in the underlying datasets. The population model outputs shown in Table 4 best represent the temporal magnitude of the injury and the potential recovery time from the injury.

Aside from the heavily impacted stocks of bottlenose dolphin, two species of particular concern are the sperm whale and Bryde's whale. For the Bryde's whale, it was estimated that 48 percent of the population was impacted by DWH oil, resulting in an estimated 22 percent maximum decline in population size that will require 69 years to recovery. However, small populations are highly susceptible to stochastic, or unpredictable, processes and genetic effects that can reduce productivity and resiliency to perturbations. The population models do not account for these effects, and, therefore, the capability of the Bryde's whale population to recover from this injury is unknown. For the sperm whale, a 7 percent maximum decline in population size requiring 21 years to recovery was predicted. However, little is known about the fate and transport of DWH deep-sea oil plumes in relation to deep-diving marine mammals, such as sperm whales, and the results should be viewed with caution. Other stocks with particularly concerning results include the rough-toothed dolphin and spinner dolphin (Table 4).

In the absence of active (and effective) restoration, marine mammal stocks across the northern GOM will take many years to recover (Table 4). Marine mammals are slow to reach reproductive maturity, only give birth to a single offspring every 3 to 5 years, and are generally long lived (with lifespans up to 80 years). Two populations of killer whales suffered losses of 33 and 41 percent in the year following the *Exxon Valdez* oil spill in Alaska, and recovery of both populations has been unexpectedly slow (Matkin *et al.,* 2008). Persistent pollutant exposure (Ylitalo *et al.,* 2001), decline of a primary prey source (Ver Hoef and Frost, 2003), and disruption of social groups (Matkin *et al.,* 2008; Wade *et al.,* 2012) may be contributing factors. Populations of dolphins depleted as the result of tuna fishery bycatch in the eastern tropical Pacific also demonstrated slower than expected rates of recovery, which may be due in part to the continued effects of stressful interactions with the fishery (Gerrodette and Forcada, 2005). The ability of the stocks to recover and the length of time required for that recovery are tied to the carrying capacity of the habitat, and to the degree of other population pressures. We treat the effects of the DWH oil spill as part of the environmental baseline in considering the likely resilience of these populations to the effects of the activities considered in this proposed regulatory framework.

In addition to injuries from direct exposure to DWH oil, marine mammal habitat was degraded. Exposure to oil at or near the surface occurred in an area of high biological abundance and high productivity during a time of year (spring and summer) that corresponds with peaks in seasonal productivity in the northern GOM. Developing fish larvae exposed to the surface slick suffered almost 100 percent mortality, and oil concentrations at different levels in the water column exceeded levels known to cause mortality and sub-lethal effects to fish—this is expected to have caused the loss of millions to billions of fish that would have reached one year of age. However, though damage to fish and invertebrate populations was likely significant during the time oil was present, populations of directly affected fish and invertebrate species appear not to have suffered a lasting impact. Although marine mammals were harmed through the effects of DWH oil on plankton, fish, and invertebrate populations, it is difficult to interpret any long-term impacts on marine mammal populations resulting from significant short-term impacts on prey populations. Prey reductions, when they occur, can have cascading effects on larger species. Animals in the wild live in a dynamic relationship with their environment and available resources, balancing energy expenditures and nutritional uptake in order to survive, remain healthy, and reproduce. Any impact that shifts that balance by diminishing food resources or requiring unusual expenditures of energy—whether to acquire prey, avoid predators, fight disease and infection, or successfully reproduce—is inherently harmful to the species. Additionally, as noted previously, injury due to the DWH oil spill is considered an ecosystem-level event, which will impact marine mammals in particular due to their long lives and position as apex predators reliant upon a healthy ecosystem (*e.g.,* Moore, 2008; Bossart, 2011).

Marine Mammal Hearing

Hearing is the most important sensory modality for marine mammals underwater, and exposure to anthropogenic sound can have deleterious effects. To appropriately assess the potential effects of exposure to sound, it is necessary to understand the frequency ranges marine mammals are able to hear. Current data indicate that not all marine mammal species have equal hearing capabilities (*e.g.,* Richardson *et al.,* 1995; Wartzok and Ketten, 1999; Au and Hastings, 2008). To reflect this, Southall *et al.* (2007) recommended that marine mammals be divided into functional hearing groups based on directly measured or estimated hearing ranges on the basis of available behavioral response data, audiograms derived using auditory evoked potential techniques, anatomical modeling, and other data. Note that no direct measurements of hearing ability have been successfully completed for mysticetes (*i.e.,* low-frequency cetaceans). Subsequently, NMFS (2016) described generalized hearing ranges for these marine mammal hearing groups. Generalized hearing ranges were chosen based on the approximately 65 dB threshold from the normalized composite audiograms, with an exception for lower limits for low-frequency cetaceans where the result was deemed to be biologically implausible and the lower bound from Southall *et al.* (2007) retained. The functional groups and the associated frequencies are indicated below (note that these frequency ranges correspond to the range for the composite group, with the entire range not necessarily reflecting the capabilities of every species within that group):

- Low-frequency cetaceans (mysticetes): Generalized hearing is estimated to occur between approximately 7 Hz and 35 kHz, with best hearing estimated to be from 100 Hz to 8 kHz;
- Mid-frequency cetaceans (larger toothed whales, beaked whales, and most delphinids): Generalized hearing is estimated to occur between approximately 150 Hz and 160 kHz, with best hearing from 10 to less than 100 kHz;
- High-frequency cetaceans (porpoises, river dolphins, and members of the genera *Kogia* and *Cephalorhynchus;* including two members of the genus *Lagenorhynchus,* on the basis of recent echolocation data and genetic data): Generalized hearing is estimated to occur between approximately 275 Hz and 160 kHz.

For more detail concerning these groups and associated frequency ranges, please see NMFS (2016) for a review of available information. Twenty-one species of cetacean have the reasonable potential to co-occur with the proposed survey activities. Please refer to Table 3. Of the cetacean species that may be present, one is classified as a low-frequency cetacean (*i.e.,* the Bryde's whale), 18 are classified as mid-frequency cetaceans (*i.e.,* all delphinid and ziphiid species and the sperm whale), and two are classified as high-frequency cetaceans (*i.e., Kogia* spp.).

Potential Effects of the Specified Activity on Marine Mammals and Their Habitat

This section includes a summary and discussion of the ways that components of the specified activity may impact marine mammals and their habitat. The ''Estimated Take'' section later in this document includes a quantitative analysis of the number of individuals that are expected to be taken by this activity. The ''Negligible Impact Analysis and Determination'' section considers the content of this section and the material it references, the ''Estimated Take'' section, and the ''Proposed Mitigation'' section, to draw conclusions regarding the likely impacts of these activities on the reproductive success or survivorship of individuals and how those impacts on individuals are likely to impact marine mammal species or stocks. In the following discussion, we provide general background information on sound before considering potential effects to marine mammals from the specified activities (*i.e.,* sound, ship strike, and contaminants).

Background on Sound and Acoustic Metrics

This section contains a brief technical background on sound, on the characteristics of certain sound types, and on metrics used in this proposal inasmuch as the information is relevant to other sections of this document. For general information on sound and its interaction with the marine environment, please see, *e.g.,* Au and Hastings (2008); Richardson *et al.* (1995); Urick (1983).

Sound travels in waves, the basic components of which are frequency, wavelength, velocity, and amplitude. Frequency is the number of pressure waves that pass by a reference point per unit of time and is measured in Hz or cycles per second. Wavelength is the distance between two peaks or corresponding points of a sound wave (length of one cycle). Higher frequency sounds have shorter wavelengths than lower frequency sounds, and typically attenuate (decrease) more rapidly, except in certain cases in shallower water. Amplitude is the height of the sound pressure wave or the ''loudness'' of a sound and is typically described using the relative unit of the dB. A sound pressure level (SPL) in dB is described as the ratio between a measured pressure and a reference pressure (for underwater sound, this is 1 microPascal (μPa)), and is a logarithmic unit that accounts for large variations in amplitude; therefore, a relatively small change in dB corresponds to large changes in sound pressure. The source level (SL) represents the SPL referenced at a distance of 1 m from the source (referenced to 1 μPa), while the received level is the SPL at the listener's position (referenced to 1 μPa).

When underwater objects vibrate or activity occurs, sound-pressure waves are created. These waves alternately compress and decompress the water as the sound wave travels. Underwater sound waves radiate in a manner similar to ripples on the surface of a pond and may be either directed in a beam or beams or may radiate in all directions (omnidirectional sources), as is nominally the case for sound produced by airguns (though when grouped in arrays there is some directionality). The compressions and decompressions associated with sound waves are detected as changes in pressure by aquatic life and man-made sound receptors such as hydrophones.

Sounds are often considered to fall into one of two general types: Pulsed and non-pulsed (defined in the following). The distinction between these two sound types is important because they have differing potential to cause physical effects, particularly with regard to hearing (*e.g.,* Ward, 1997 in Southall *et al.,* 2007). Please see Southall *et al.* (2007) for an in-depth discussion of these concepts. The distinction between these two sound types is not always obvious, as certain signals share properties of both pulsed and non-pulsed sounds. A signal near a source could be categorized as a pulse, but due to propagation effects as it moves farther from the source, the signal duration becomes longer (*e.g.,* Greene and Richardson, 1988).

Pulsed sound sources (*e.g.,* airguns, explosions, gunshots, sonic booms, impact pile driving) produce signals that are brief (typically considered to be less than one second), broadband, atonal transients (ANSI, 1986, 2005; Harris, 1998; NIOSH, 1998; ISO, 2003) and occur either as isolated events or repeated in some succession. Pulsed sounds are all characterized by a relatively rapid rise from ambient pressure to a maximal pressure value followed by a rapid decay period that may include a period of diminishing, oscillating maximal and minimal pressures, and generally have an increased capacity to induce physical injury as compared with sounds that lack these features.

Non-pulsed sounds can be tonal, narrowband, or broadband, brief or prolonged, and may be either continuous or intermittent (ANSI, 1995; NIOSH, 1998). Some of these non-pulsed sounds can be transient signals of short duration but without the essential properties of pulses (*e.g.,* rapid rise time). Examples of non-pulsed sounds include those produced by vessels, aircraft, machinery operations such as drilling or dredging, vibratory pile driving, and active sonar systems. The duration of such sounds, as received at a distance, can be greatly extended in a highly reverberant environment.

Root mean square (rms) is the quadratic mean sound pressure over the duration of an impulse. Root mean square is calculated by squaring all of the sound amplitudes, averaging the squares, and then taking the square root of the average (Urick, 1983). Root mean square accounts for both positive and negative values; squaring the pressures makes all values positive so that they may be accounted for in the summation of pressure levels (Hastings and Popper, 2005). The length of the time window used for the purpose of the rms SPL calculation can be selected using different approaches. This value is commonly defined as the 90 percent energy pulse duration, containing the central 90 percent (from 5 to 95 percent of the total) of the cumulative square pressure (or sound exposure level) of the pulse. However, as was the case in the modeling performed for this effort, a fixed time window may be used. Here, a sliding window was used to calculate rms SPL values for a series of fixed window lengths within the pulse. The maximum value of rms SPL over all time window positions is taken to represent the rms SPL of the pulse. This measurement is often used in the context of discussing behavioral effects, in part because behavioral effects, which often result from auditory cues, may be better expressed through averaged units than by peak pressures.

Energy equivalent SPL (denoted L_{eq}) is the measure of the average amount of energy carried by a time-dependent pressure wave over a period of time. The L_{eq} is numerically equal to the rms SPL of a steady sound that has the same total energy as the sound measured over the given time window. Conceptually, the difference between the two metrics is that the rms SPL is computed over short time periods, usually one second or less, and tracks the fluctuations of a non-steady acoustic signal, whereas the L_{eq} reflects the average SPL of an acoustic signal over tens of seconds or longer.

Sound exposure level (SEL; represented as dB re 1 μPa^2-s) represents the total energy in a stated frequency band over a stated time interval or event, and considers both intensity and duration of exposure. The per-pulse SEL is calculated over the time window containing the entire pulse (*i.e.,* 100 percent of the acoustic energy). SEL is a cumulative metric; it can be accumulated over a single pulse, or calculated over periods containing multiple pulses. Cumulative SEL represents the total energy accumulated by a receiver over a defined time window or during an event.

Peak sound pressure (also referred to as zero-to-peak sound pressure or 0-pk) is the maximum instantaneous sound pressure measurable in the water at a specified distance from the source, and is represented in the same units as the rms sound pressure. Another common metric is peak-to-peak sound pressure (pk-pk), which is the algebraic difference between the peak positive and peak negative sound pressures. Peak-to-peak pressure is typically approximately 6 dB higher than peak pressure (Southall *et al.,* 2007).

Airguns produce pulsed signals, with energy in a frequency range from about 10–2,000 Hz, and most energy radiated at frequencies below 200 Hz. Larger airguns, with larger internal air volume, produce higher broadband sound levels with sound energy spectrum shifted toward the lower frequencies. The amplitude of the acoustic wave emitted from the source is equal in all directions (*i.e.,* omnidirectional), but when used in arrays, airguns do possess some directionality due to different phase delays between guns in different directions. Airgun arrays are typically tuned to maximize functionality for data acquisition purposes, meaning that more sound energy is focused downwardly than horizontally, and sound transmitted in horizontal directions and at higher frequencies is minimized to the extent possible.

Acoustic sources used for HRG surveys generally produce higher frequency signals with highly directional beam patterns. These sources are generally considered to be intermittent, with typically brief signal durations, and temporal characteristics that more closely resemble those of impulsive sounds than non-impulsive sounds. Boomers generate a high-amplitude broadband (100 Hz–10 kHz) acoustic pulse with high downward directivity, though may be considered omnidirectional at frequencies below 1 kHz. Subbottom profiler systems generally project a chirp pulse spanning an operator-selectable frequency band, usually between 1 to 20 kHz, with a single beam directed vertically down. Multibeam echosounders use an array of transducers that project a high-frequency, fan-shaped beam under the hull of a survey ship and perpendicular to the direction of motion. Side-scan sonars use two transducers to project high-frequency beams that are usually wide in the vertical plane (50°–70°) and very narrow in the horizontal plane (less than a few degrees).

Vessel noise, produced largely by cavitation of propellers and by machinery inside the hull, is considered a non-pulsed sound. Sounds emitted by survey vessels are low frequency and continuous, but would be widely dispersed in both space and time. Survey vessel traffic is of low density compared to traffic associated with commercial shipping, industry support vessels, or commercial fishing vessels, and would therefore be expected to represent an insignificant incremental increase in the total amount of anthropogenic sound input to the marine environment. For these reasons, we do not consider vessel traffic noise further in this analysis.

Potential Effects of Underwater Sound

Note that, in the following discussion, we refer in many cases to a review article concerning studies of noise-induced hearing loss conducted from 1996–2015 (*i.e.,* Finneran, 2015). For study-specific citations, please see that work. Anthropogenic sounds cover a broad range of frequencies and sound levels and can have a range of highly variable impacts on marine life, from none or minor to potentially severe responses, depending on received levels, duration of exposure, behavioral context, and various other factors. The potential effects of underwater sound from active acoustic sources can potentially result in one or more of the following: Temporary or permanent hearing impairment, non-auditory physical or physiological effects, behavioral disturbance, stress, and masking (Richardson *et al.,* 1995; Gordon *et al.,* 2004; Nowacek *et al.,* 2007; Southall *et al.,* 2007; Götz *et al.,* 2009). The degree of effect is intrinsically related to the signal characteristics, received level, distance from the source, and duration of the sound exposure. In general, sudden, high level sounds can cause hearing loss, as can longer exposures to lower level sounds. Temporary or permanent loss of hearing will occur almost exclusively for noise within an animal's hearing range. We first describe specific manifestations of acoustic effects before providing discussion specific to the use of airgun arrays.

Richardson *et al.* (1995) described zones of increasing intensity of effect that might be expected to occur, in relation to distance from a source and assuming that the signal is within an animal's hearing range. First is the area within which the acoustic signal would be audible (potentially perceived) to the animal, but not strong enough to elicit any overt behavioral or physiological response. The next zone corresponds with the area where the signal is audible to the animal and of sufficient intensity to elicit behavioral or physiological responsiveness. Third is a zone within which, for signals of high intensity, the received level is sufficient to potentially cause discomfort or tissue damage to auditory or other systems. Overlaying these zones to a certain extent is the area within which masking (*i.e.,* when a sound interferes with or masks the ability of an animal to detect a signal of interest that is above the absolute hearing threshold) may occur; the masking zone may be highly variable in size.

We describe more severe effects (*i.e.,* certain non-auditory physical or physiological effects) only briefly as we do not expect that use of airgun arrays are reasonably likely to result in such effects (see below for further discussion). Potential effects from impulsive sound sources can range in severity from effects such as behavioral disturbance or tactile perception to physical discomfort, slight injury of the internal organs and the auditory system, or mortality (Yelverton *et al.,* 1973). Non-auditory physiological effects or injuries that theoretically might occur in marine mammals exposed to high level underwater sound or as a secondary effect of extreme behavioral reactions (*e.g.,* change in dive profile as a result of an avoidance reaction) caused by exposure to sound include neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage (Cox *et al.,* 2006; Southall *et al.,* 2007; Zimmer and Tyack, 2007; Tal *et al.,* 2015). The survey activities considered here do not involve the use of devices such as explosives or mid-frequency tactical sonar that are associated with these types of effects.

When a live or dead marine mammal swims or floats onto shore and is incapable of returning to sea, the event is termed a ''stranding'' (16 U.S.C. 1421h(3)). Marine mammals are known to strand for a variety of reasons, such as infectious agents, biotoxicosis, starvation, fishery interaction, ship strike, unusual oceanographic or weather events, sound exposure, or combinations of these stressors sustained concurrently or in series (*e.g.,* Geraci *et al.,* 1999). However, the cause or causes of most strandings are unknown (*e.g.,* Best, 1982). Combinations of dissimilar stressors may combine to kill an animal or dramatically reduce its fitness, even though one exposure without the other would not be expected to produce the same outcome (*e.g.,* Sih *et al.,* 2004). For further description of specific stranding events see, *e.g.,* Southall *et al.,* 2006, 2013; Jepson *et al.,* 2013; Wright *et al.,* 2013.

Use of military tactical sonar has been implicated in multiple investigated stranding events, although one stranding event was contemporaneous with and reasonably associated spatially with the use of seismic airguns. This event occurred in the Gulf of California, coincident with seismic reflection profiling by the R/V *Maurice Ewing* operated by Columbia University's Lamont-Doherty Earth Observatory and involved two Cuvier's beaked whales (Hildebrand, 2004). The vessel had been firing an array of 20 airguns with a total volume of 8,500 in^3 (Hildebrand, 2004; Taylor *et al.,* 2004). Most known stranding events have involved beaked whales, though a small number have involved deep-diving delphinids or sperm whales (*e.g.,* Mazzariol *et al.,* 2010; Southall *et al.,* 2013). In general, long duration (~1 second) and high-intensity sounds (235 dB SPL) have been implicated in stranding events (Hildebrand, 2004). With regard to beaked whales, mid-frequency sound is typically implicated (when causation can be determined) (Hildebrand, 2004). Although seismic airguns create predominantly low-frequency energy, the signal does include a mid-frequency component.

Threshold Shift—Marine mammals exposed to high-intensity sound, or to lower-intensity sound for prolonged periods, can experience hearing threshold shift (TS), which is the loss of hearing sensitivity at certain frequency ranges (Finneran, 2015). TS can be permanent (PTS), in which case the loss of hearing sensitivity is not fully recoverable, or temporary (TTS), in which case the animal's hearing threshold would recover over time (Southall *et al.*,, 2007). Repeated sound exposure that leads to TTS could cause PTS. In severe cases of PTS, there can be total or partial deafness, while in most cases the animal has an impaired ability to hear sounds in specific frequency ranges (Kryter, 1985).

When PTS occurs, there is physical damage to the sound receptors in the ear (*i.e.,* tissue damage), whereas TTS represents primarily tissue fatigue and is reversible (Southall *et al.,* 2007). In addition, other investigators have suggested that TTS is within the normal bounds of physiological variability and tolerance and does not represent physical injury (*e.g.,* Ward, 1997). Therefore, NMFS does not consider TTS to constitute auditory injury.

Relationships between TTS and PTS thresholds have not been studied in marine mammals, and there is no PTS data for cetaceans, but such relationships are assumed to be similar to those in humans and other terrestrial mammals. PTS typically occurs at exposure levels at least several decibels above (a 40-dB threshold shift approximates PTS onset; *e.g.,* Kryter *et al.,* 1966; Miller, 1974) that inducing mild TTS (a 6-dB threshold shift approximates TTS onset; *e.g.,* Southall *et al.* 2007). Based on data from terrestrial mammals, a precautionary assumption is that the PTS thresholds for impulse sounds (such as airgun pulses as received close to the source) are at least 6 dB higher than the TTS threshold on a peak-pressure basis and PTS cumulative sound exposure level thresholds are 15 to 20 dB higher than TTS cumulative sound exposure level thresholds (Southall *et al.,* 2007). Given the higher level of sound or longer exposure duration necessary to cause PTS as compared with TTS, it is considerably less likely that PTS could occur.

For mid-frequency cetaceans in particular, potential protective mechanisms may help limit onset of TTS or prevent onset of PTS. Such mechanisms include dampening of hearing, auditory adaptation, or behavioral amelioration (*e.g.,* Nachtigall and Supin, 2013; Miller *et al.,* 2012; Finneran *et al.,* 2015; Popov *et al.,* 2016; Nachtigall *et al.,* 2017).

TTS is the mildest form of hearing impairment that can occur during exposure to sound (Kryter, 1985). While experiencing TTS, the hearing threshold rises, and a sound must be at a higher level in order to be heard. In terrestrial and marine mammals, TTS can last from minutes or hours to days (in cases of strong TTS). In many cases, hearing sensitivity recovers rapidly after exposure to the sound ends. Few data on sound levels and durations necessary to elicit mild TTS have been obtained for marine mammals.

Marine mammal hearing plays a critical role in communication with conspecifics, and interpretation of environmental cues for purposes such as predator avoidance and prey capture. Depending on the degree (elevation of threshold in dB), duration (*i.e.,* recovery time), and frequency range of TTS, and the context in which it is experienced, TTS can have effects on marine mammals ranging from discountable to serious. For example, a marine mammal may be able to readily compensate for a brief, relatively small amount of TTS in a non-critical frequency range that occurs during a time where ambient noise is lower and there are not as many competing sounds present. Alternatively, a larger amount and longer duration of TTS sustained during time when communication is critical for successful mother/calf interactions could have more serious impacts.

Finneran *et al.* (2015) measured hearing thresholds in three captive bottlenose dolphins before and after exposure to ten pulses produced by a seismic airgun in order to study TTS induced after exposure to multiple pulses. Exposures began at relatively low levels and gradually increased over a period of several months, with the highest exposures at peak SPLs from 196 to 210 dB and cumulative (unweighted) SELs from 193–195 dB. No substantial TTS was observed. In addition, behavioral reactions were observed that indicated that animals can learn behaviors that effectively mitigate noise exposures (although exposure patterns must be learned, which is less likely in wild animals than for the captive animals considered in the study). The authors note that the failure to induce more significant auditory effects was likely due to the intermittent nature of exposure, the relatively low peak pressure produced by the acoustic source, and the low-frequency energy in airgun pulses as compared with the frequency range of best sensitivity for dolphins and other mid-frequency cetaceans.

Currently, TTS data only exist for four species of cetaceans (bottlenose dolphin, beluga whale (*Delphinapterus leucas*), harbor porpoise (*Phocoena phocoena*), and Yangtze finless porpoise (*Neophocoena asiaeorientalis*)) exposed to a limited number of sound sources (*i.e.,* mostly tones and octave-band noise) in laboratory settings (Finneran, 2015). In general, harbor porpoises have a lower TTS onset than other measured cetacean species (Finneran, 2015). Additionally, the existing marine mammal TTS data come from a limited number of individuals within these species. There are no data available on noise-induced hearing loss for mysticetes.

Critical questions remain regarding the rate of TTS growth and recovery after exposure to intermittent noise and the effects of single and multiple pulses. Data at present are also insufficient to construct generalized models for recovery and determine the time necessary to treat subsequent exposures as independent events. More information is needed on the relationship between auditory evoked potential and behavioral measures of TTS for various stimuli. For summaries of data on TTS in marine mammals or for further discussion of TTS onset thresholds, please see Southall *et al.* (2007), Finneran and Jenkins (2012), Finneran (2015), and NMFS (2016).

Behavioral Effects—Behavioral disturbance may include a variety of effects, including subtle changes in behavior (*e.g.,* minor or brief avoidance of an area or changes in vocalizations), more conspicuous changes in similar behavioral activities, and more sustained and/or potentially severe reactions, such as displacement from or abandonment of high-quality habitat. Behavioral responses to sound are highly variable and context-specific and any reactions depend on numerous intrinsic and extrinsic factors (*e.g.,* species, state of maturity, experience, current activity, reproductive state, auditory sensitivity, time of day), as well as the interplay between factors (*e.g.,* Richardson *et al.,* 1995; Wartzok *et al.,* 2003; Southall *et al.,* 2007; Weilgart, 2007; Archer *et al.,* 2010). Behavioral reactions can vary not only among individuals but also within an individual, depending on previous experience with a sound source, context, and numerous other factors (Ellison *et al.,* 2012), and can vary depending on characteristics associated with the sound source (*e.g.,* whether it is moving or stationary, number of sources, distance from the source). Please see Appendices B–C of Southall *et al.* (2007) for a review of studies involving marine mammal behavioral responses to sound.

Habituation can occur when an animal's response to a stimulus wanes with repeated exposure, usually in the absence of unpleasant associated events (Wartzok *et al.,* 2003). Animals are most likely to habituate to sounds that are predictable and unvarying. It is important to note that habituation is appropriately considered as a ''progressive reduction in response to stimuli that are perceived as neither aversive nor beneficial,'' rather than as, more generally, moderation in response to human disturbance (Bejder *et al.,* 2009). The opposite process is sensitization, when an unpleasant experience leads to subsequent responses, often in the form of avoidance, at a lower level of exposure. As noted, behavioral state may affect the type of response. For example, animals that are resting may show greater behavioral change in response to disturbing sound levels than animals that are highly motivated to remain in an area for feeding (Richardson *et al.,* 1995; NRC, 2003; Wartzok *et al.,* 2003). Controlled experiments with captive marine mammals have showed pronounced behavioral reactions, including avoidance of loud sound sources (Ridgway *et al.,* 1997). Observed responses of wild marine mammals to loud pulsed sound sources (typically airguns or acoustic harassment devices) have been varied but often consist of avoidance behavior or other behavioral changes suggesting discomfort (Morton and Symonds, 2002; see also Richardson *et al.,* 1995; Nowacek *et al.,* 2007). However, many delphinids approach acoustic source vessels with no apparent discomfort or obvious behavioral change (*e.g.,* Barkaszi *et al.,* 2012).

Available studies show wide variation in response to underwater sound; therefore, it is difficult to predict specifically how any given sound in a particular instance might affect marine mammals perceiving the signal. If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or population. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant (*e.g.,* Lusseau and Bejder, 2007; Weilgart, 2007; NRC, 2005). However, there are broad categories of potential response, which we describe in greater detail here, that include alteration of dive behavior, alteration of foraging behavior, effects to breathing, interference with or alteration of vocalization, avoidance, and flight.

Changes in dive behavior can vary widely, and may consist of increased or decreased dive times and surface intervals as well as changes in the rates of ascent and descent during a dive (*e.g.,* Frankel and Clark, 2000; Ng and Leung, 2003; Nowacek *et al.;* 2004; Goldbogen *et al.,* 2013a, 2013b). Variations in dive behavior may reflect interruptions in biologically significant activities (*e.g.,* foraging) or they may be of little biological significance. The impact of an alteration to dive behavior resulting from an acoustic exposure depends on what the animal is doing at the time of the exposure and the type and magnitude of the response.

Disruption of feeding behavior can be difficult to correlate with anthropogenic sound exposure (but see discussion of impacts to sperm whale foraging behavior below and in ''Proposed Mitigation''), so it is usually inferred by observed displacement from known foraging areas, the appearance of secondary indicators (*e.g.,* bubble nets or sediment plumes), or changes in dive behavior. As for other types of behavioral response, the frequency, duration, and temporal pattern of signal presentation, as well as differences in species sensitivity, are likely contributing factors to differences in response in any given circumstance (*e.g.,* Croll *et al.,* 2001; Nowacek *et al.;* 2004; Madsen *et al.,* 2006a; Yazvenko *et al.,* 2007). A determination of whether foraging disruptions incur fitness consequences would require information on or estimates of the energetic requirements of the affected individuals and the relationship between prey availability, foraging effort and success, and the life history stage of the animal.

Visual tracking, passive acoustic monitoring, and movement recording tags were used to quantify sperm whale behavior prior to, during, and following exposure to airgun arrays at received levels in the range 140–160 dB at distances of 7–13 km, following a phase-in of sound intensity and full array exposures at 1–13 km (Madsen *et al.,* 2006a; Miller *et al.,* 2009). Sperm whales did not exhibit horizontal avoidance behavior at the surface. However, foraging behavior may have been affected. The sperm whales exhibited 19 percent less vocal (buzz) rate during full exposure relative to post exposure, and the whale that was approached most closely had an extended resting period and did not resume foraging until the airguns had ceased firing. The remaining whales continued to execute foraging dives throughout exposure; however, swimming movements during foraging dives were 6 percent lower during exposure than control periods (Miller *et al.,* 2009). These data raise concerns that airgun surveys may impact foraging behavior in sperm whales, although more data are required to understand whether the differences were due to exposure or natural variation in sperm whale behavior (Miller *et al.,* 2009). We discuss these findings in greater detail under ''Proposed Mitigation.''

Variations in respiration naturally vary with different behaviors and alterations to breathing rate as a function of acoustic exposure can be expected to co-occur with other behavioral reactions, such as a flight response or an alteration in diving. However, respiration rates in and of themselves may be representative of annoyance or an acute stress response. Various studies have shown that respiration rates may either be unaffected or could increase, depending on the species and signal characteristics, again highlighting the importance in understanding species differences in the tolerance of underwater noise when determining the potential for impacts resulting from anthropogenic sound exposure (*e.g.,* Kastelein *et al.,* 2001, 2005, 2006; Gailey *et al.,* 2007; Gailey *et al.,* 2016).

Marine mammals vocalize for different purposes and across multiple modes, such as whistling, echolocation click production, calling, and singing. Changes in vocalization behavior in response to anthropogenic noise can occur for any of these modes and may result from a need to compete with an increase in background noise or may reflect increased vigilance or a startle response. For example, in the presence of potentially masking signals, humpback whales and killer whales have been observed to increase the length of their songs (Miller *et al.,* 2000; Fristrup *et al.,* 2003; Foote *et al.,* 2004), while right whales have been observed to shift the frequency content of their calls upward while reducing the rate of calling in areas of increased anthropogenic noise (Parks *et al.,* 2007). In some cases, animals may cease sound production during production of aversive signals (Bowles *et al.,* 1994).

Cerchio *et al.* (2014) used passive acoustic monitoring to document the presence of singing humpback whales off the coast of northern Angola and to opportunistically test for the effect of seismic survey activity on the number of singing whales. Two recording units were deployed between March and December 2008 in the offshore environment; numbers of singers were counted every hour. Generalized Additive Mixed Models were used to assess the effect of survey day (seasonality), hour (diel variation), moon phase, and received levels of noise (measured from a single pulse during each ten minute sampled period) on singer number. The number of singers significantly decreased with increasing received level of noise, suggesting that humpback whale communication was disrupted to some extent by the survey activity.

Castellote *et al.* (2012) reported acoustic and behavioral changes by fin whales in response to shipping and airgun noise. Acoustic features of fin whale song notes recorded in the Mediterranean Sea and northeast Atlantic Ocean were compared for areas with different shipping noise levels and traffic intensities and during an airgun survey. During the first 72 hours of the survey, a steady decrease in song received levels and bearings to singers indicated that whales moved away from the acoustic source and out of the study area. This displacement persisted for a time period well beyond the 10-day duration of airgun activity, providing evidence that fin whales may avoid an area for an extended period in the presence of increased noise. The authors hypothesize that fin whale acoustic communication is modified to compensate for increased background noise and that a sensitization process may play a role in the observed temporary displacement.

Seismic pulses at average received levels of 131 dB re 1 μPa^2-s caused blue whales to increase call production (Di Iorio and Clark, 2010). In contrast, McDonald *et al.* (1995) tracked a blue whale with seafloor seismometers and reported that it stopped vocalizing and changed its travel direction at a range of 10 km from the acoustic source vessel (estimated received level 143 dB pk-pk). Blackwell *et al.* (2013) found that bowhead whale call rates dropped significantly at onset of airgun use at sites with a median distance of 41–45 km from the survey. Blackwell *et al.* (2015) expanded this analysis to show that whales actually increased calling rates as soon as airgun signals were detectable before ultimately decreasing calling rates at higher received levels (*i.e.,* 10-minute cumulative sound exposure level (cSEL) of ~127 dB). Overall, these results suggest that bowhead whales may adjust their vocal output in an effort to compensate for noise before ceasing vocalization effort and ultimately deflecting from the acoustic source (Blackwell *et al.,* 2013, 2015). These studies demonstrate that even low levels of noise received far from the source can induce changes in vocalization and/or behavior for mysticetes.

Avoidance is the displacement of an individual from an area or migration path as a result of the presence of a sound or other stressors, and is one of the most obvious manifestations of disturbance in marine mammals (Richardson *et al.,* 1995). For example, gray whales are known to change direction—deflecting from customary migratory paths—in order to avoid noise from airgun surveys (Malme *et al.,* 1984). Humpback whales showed avoidance behavior in the presence of an active airgun array during observational studies and controlled exposure experiments in western Australia (McCauley *et al.,* 2000a). Avoidance may be short-term, with animals returning to the area once the noise has ceased (*e.g.,* Bowles *et al.,* 1994; Goold, 1996; Stone *et al.,* 2000; Morton and Symonds, 2002; Gailey *et al.,* 2007). Longer-term displacement is possible, however, which may lead to changes in abundance or distribution patterns of the affected species in the affected region if habituation to the presence of the sound does not occur (*e.g.,* Bejder *et al.,* 2006; Teilmann *et al.,* 2006).

Forney *et al.* (2017) detail the potential effects of noise on marine mammal populations with high site fidelity, including displacement and auditory masking, noting that a lack of observed response does not imply absence of fitness costs and that apparent tolerance of disturbance may have population-level impacts that are less obvious and difficult to document. As we discuss in describing our proposed mitigation later in this document, avoidance of overlap between disturbing noise and areas and/or times of particular importance for sensitive species may be critical to avoiding population-level impacts because (particularly for animals with high site fidelity) there may be a strong motivation to remain in the area despite negative impacts. Forney *et al.* (2017) state that, for these animals, remaining in a disturbed area may reflect a lack of alternatives rather than a lack of effects. The authors discuss several case studies, including western Pacific gray whales, which are a small population of mysticetes believed to be adversely affected by oil and gas development off Sakhalin Island, Russia (Weller *et al.,* 2002; Reeves *et al.,* 2005). Western gray whales display a high degree of interannual site fidelity to the area for foraging purposes, and observations in the area during airgun surveys has shown the potential for harm caused by displacement from such an important area (Weller *et al.,* 2006; Johnson *et al.,* 2007). As we discuss below in ''Proposed Mitigation,'' similar concerns exist in relation to the potential for survey activity in the resident habitat of the GOM's small population of Bryde's whales. Forney *et al.* (2017) also discuss beaked whales, noting that anthropogenic effects in areas where they are resident could cause severe biological consequences, in part because displacement may adversely affect foraging rates, reproduction, or health, while an overriding instinct to remain could lead to more severe acute effects.

A flight response is a dramatic change in normal movement to a directed and rapid movement away from the perceived location of a sound source. The flight response differs from other avoidance responses in the intensity of the response (*e.g.,* directed movement, rate of travel). Relatively little information on flight responses of marine mammals to anthropogenic signals exist, although observations of flight responses to the presence of predators have occurred (Connor and Heithaus, 1996). The result of a flight response could range from brief, temporary exertion and displacement from the area where the signal provokes flight to, in extreme cases, marine mammal strandings (Evans and England, 2001). However, it should be noted that response to a perceived predator does not necessarily invoke flight (Ford and Reeves, 2008), and whether individuals are solitary or in groups may influence the response.

Behavioral disturbance can also impact marine mammals in more subtle ways. Increased vigilance may result in costs related to diversion of focus and attention (*i.e.,* when a response consists of increased vigilance, it may come at the cost of decreased attention to other critical behaviors such as foraging or resting). These effects have generally not been demonstrated for marine mammals, but studies involving fish and terrestrial animals have shown that increased vigilance may substantially reduce feeding rates (*e.g.,* Beauchamp and Livoreil, 1997; Fritz *et al.,* 2002; Purser and Radford, 2011). In addition, chronic disturbance can cause population declines through reduction of fitness (*e.g.,* decline in body condition) and subsequent reduction in reproductive success, survival, or both (*e.g.,* Harrington and Veitch, 1992; Daan *et al.,* 1996; Bradshaw *et al.,* 1998). However, Ridgway *et al.* (2006) reported that increased vigilance in bottlenose dolphins exposed to sound over a five-day period did not cause any sleep deprivation or stress effects.

Many animals perform vital functions, such as feeding, resting, traveling, and socializing, on a diel cycle (24-hour cycle). Disruption of such functions resulting from reactions to stressors such as sound exposure are more likely to be significant if they last more than one diel cycle or recur on subsequent days (Southall *et al.,* 2007). Consequently, a behavioral response lasting less than one day and not recurring on subsequent days is not considered particularly severe unless it could directly affect reproduction or survival (Southall *et al.,* 2007). Note that there is a difference between multi-day substantive behavioral reactions and multi-day anthropogenic activities. For example, just because an activity lasts for multiple days does not necessarily mean that individual animals are either exposed to activity-related stressors for multiple days or, further, exposed in a manner resulting in sustained multi-day substantive behavioral responses.

Stone (2015a) reported data from at-sea observations during 1,196 airgun surveys from 1994 to 2010. When large arrays of airguns (considered to be 500 in^3 or more) were firing, lateral displacement, more localized avoidance, or other changes in behavior were evident for most odontocetes. However, significant responses to large arrays were found only for the minke whale and fin whale. Behavioral responses observed included changes in swimming or surfacing behavior, with indications that cetaceans remained near the water surface at these times. Cetaceans were recorded as feeding less often when large arrays were active. Behavioral observations of gray whales during an airgun survey monitored whale movements and respirations pre-, during-, and post-seismic survey (Gailey *et al.,* 2016). Behavioral state and water depth were the best 'natural' predictors of whale movements and respiration and, after considering natural variation, none of the response variables were significantly associated with survey or vessel sounds.

Stress Responses—An animal's perception of a threat may be sufficient to trigger stress responses consisting of some combination of behavioral responses, autonomic nervous system responses, neuroendocrine responses, or immune responses (*e.g.,* Seyle, 1950; Moberg, 2000). In many cases, an animal's first and sometimes most economical (in terms of energetic costs) response is behavioral avoidance of the potential stressor. Autonomic nervous system responses to stress typically involve changes in heart rate, blood pressure, and gastrointestinal activity. These responses have a relatively short duration and may or may not have a significant long-term effect on an animal's fitness.

Neuroendocrine stress responses often involve the hypothalamus-pituitary-adrenal system. Virtually all neuroendocrine functions that are affected by stress—including immune competence, reproduction, metabolism, and behavior—are regulated by pituitary hormones. Stress-induced changes in the secretion of pituitary hormones have been implicated in failed reproduction, altered metabolism, reduced immune competence, and behavioral disturbance (*e.g.,* Moberg, 1987; Blecha, 2000). Increases in the circulation of glucocorticoids are also equated with stress (Romano *et al.,* 2004).

The primary distinction between stress (which is adaptive and does not normally place an animal at risk) and "distress" is the cost of the response. During a stress response, an animal uses glycogen stores that can be quickly replenished once the stress is alleviated. In such circumstances, the cost of the stress response would not pose serious fitness consequences. However, when an animal does not have sufficient energy reserves to satisfy the energetic costs of a stress response, energy resources must be diverted from other functions. This state of distress will last until the animal replenishes its energetic reserves sufficiently to restore normal function.

Relationships between these physiological mechanisms, animal behavior, and the costs of stress responses are well-studied through controlled experiments and for both laboratory and free-ranging animals (*e.g.,* Holberton *et al.,* 1996; Hood *et al.,* 1998; Jessop *et al.,* 2003; Krausman *et al.,* 2004; Lankford *et al.,* 2005). Stress responses due to exposure to anthropogenic sounds or other stressors and their effects on marine mammals have also been reviewed (Fair and Becker, 2000; Romano *et al.,* 2002b) and, more rarely, studied in wild populations (*e.g.,* Romano *et al.,* 2002a). For example, Rolland *et al.* (2012) found that noise reduction from reduced ship traffic in the Bay of Fundy was associated with decreased stress in North Atlantic right whales. These and other studies lead to a reasonable expectation that some marine mammals will experience physiological stress responses upon exposure to acoustic stressors and that it is possible that some of these would be classified as "distress." In addition, any animal experiencing TTS would likely also experience stress responses (NRC, 2003).

Auditory Masking—Sound can disrupt behavior through masking, or interfering with, an animal's ability to detect, recognize, or discriminate between acoustic signals of interest (*e.g.,* those used for intraspecific communication and social interactions, prey detection, predator avoidance, navigation) (Richardson *et al.,* 1995; Erbe *et al.,* 2016). Masking occurs when the receipt of a sound is interfered with by another coincident sound at similar frequencies and at similar or higher intensity, and may occur whether the sound is natural (*e.g.,* snapping shrimp, wind, waves, precipitation) or anthropogenic (*e.g.,* shipping, sonar, seismic exploration) in origin. The ability of a noise source to mask biologically important sounds depends on the characteristics of both the noise source and the signal of interest (*e.g.,* signal-to-noise ratio, temporal variability, direction), in relation to each other and to an animal's hearing abilities (*e.g.,* sensitivity, frequency range, critical ratios, frequency discrimination, directional discrimination, age or TTS hearing loss), and existing ambient noise and propagation conditions.

Under certain circumstances, marine mammals experiencing significant masking could also be impaired from maximizing their performance fitness in survival and reproduction. Therefore, when the coincident (masking) sound is man-made, it may be considered harassment when disrupting or altering critical behaviors. It is important to distinguish TTS and PTS, which persist after the sound exposure, from masking, which occurs during the sound exposure. Because masking (without resulting in TS) is not associated with abnormal physiological function, it is not considered a physiological effect, but rather a potential behavioral effect.

The frequency range of the potentially masking sound is important in determining any potential behavioral impacts. For example, low-frequency signals may have less effect on high-frequency echolocation sounds produced by odontocetes but are more likely to affect detection of mysticete communication calls and other potentially important natural sounds such as those produced by surf and some prey species. The masking of communication signals by anthropogenic noise may be considered as a reduction in the communication space of animals (*e.g.,* Clark *et al.,* 2009; Matthews *et al.,* 2016) and may result in energetic or other costs as animals change their vocalization behavior (*e.g.,* Miller *et al.,* 2000; Foote *et al.,* 2004; Parks *et al.,* 2007; Di Iorio and Clark, 2009; Holt *et al.,* 2009). Masking can be reduced in situations where the signal and noise come from different directions (Richardson *et al.,* 1995), through amplitude modulation of the signal, or through other compensatory behaviors (Houser and Moore, 2014). Masking can be tested directly in captive species (*e.g.,* Erbe, 2008), but in wild populations it must be either modeled or inferred from evidence of masking compensation. There are few studies addressing real-world masking sounds likely to be experienced by marine mammals in the wild (*e.g.,* Branstetter *et al.,* 2013).

Masking affects both senders and receivers of acoustic signals and can potentially have long-term chronic effects on marine mammals at the population level as well as at the individual level. Low-frequency ambient sound levels have increased by as much as 20 dB (more than three times in terms of SPL) in the world's ocean from pre-industrial periods, with most of the increase from distant commercial shipping (Hildebrand, 2009). All anthropogenic sound sources, but especially chronic and lower-frequency signals (*e.g.,* from vessel traffic), contribute to elevated ambient sound levels, thus intensifying masking.

Ship Strike

Vessel collisions with marine mammals, or ship strikes, can result in death or serious injury of the animal. Wounds resulting from ship strike may include massive trauma, hemorrhaging, broken bones, or propeller lacerations (Knowlton and Kraus, 2001). An animal at the surface may be struck directly by a vessel, a surfacing animal may hit the bottom of a vessel, or an animal just below the surface may be cut by a vessel's propeller. Superficial strikes may not kill or result in the death of the animal. These interactions are typically associated with large whales, which are occasionally found draped across the bulbous bow of large commercial ships upon arrival in port. Although smaller cetaceans are more maneuverable in relation to large vessels than are large whales, they may also be susceptible to strike. The severity of injuries typically depends on the size and speed of the vessel, with the probability of death or serious injury increasing as vessel speed increases (Knowlton and Kraus, 2001; Laist *et al.,* 2001; Vanderlaan and Taggart, 2007; Conn and Silber, 2013). Impact forces increase with speed, as does the probability of a strike at a given distance (Silber *et al.,* 2010; Gende *et al.,* 2011).

Pace and Silber (2005) also found that the probability of death or serious injury increased rapidly with increasing vessel speed. Specifically, the predicted probability of serious injury or death increased from 45 to 75 percent as vessel speed increased from 10 to 14 kn, and exceeded 90 percent at 17 kn. Higher speeds during collisions result in greater force of impact, but higher speeds also appear to increase the chance of severe injuries or death through increased likelihood of collision by pulling whales toward the vessel (Clyne, 1999; Knowlton *et al.,* 1995). In a separate study, Vanderlaan and Taggart (2007) analyzed the probability of lethal mortality of large whales at a given speed, showing that the greatest rate of change in the probability of a lethal injury to a large whale as a function of vessel speed occurs between 8.6 and 15 kn. The chances of a lethal injury decline from approximately 80 percent at 15 kn to approximately 20 percent at 8.6 kn. At speeds below 11.8 kn, the chances of lethal injury drop below 50 percent, while the probability asymptotically increases toward 100 percent above 15 kn.

In an effort to reduce the number and severity of strikes of the endangered North Atlantic right whale, NMFS implemented speed restrictions in 2008 (73 FR 60173; October 10, 2008). These restrictions require that vessels greater than or equal to 65 ft (19.8 m) in length travel at less than or equal to 10 kn near key port entrances and in certain areas of right whale aggregation along the U.S. eastern seaboard. Conn and Silber (2013) estimated that these restrictions reduced total ship strike mortality risk levels by 80 to 90 percent.

For vessels used in geophysical survey activities, vessel speed while towing gear is typically only 4–5 kn. At these speeds, both the possibility of striking a marine mammal and the possibility of a strike resulting in serious injury or mortality are discountable. At average transit speed, the probability of serious injury or mortality resulting from a strike is less than 50 percent. However, the likelihood of a strike actually happening is again unlikely. Ship strikes, as analyzed in the studies cited above, generally involve commercial shipping, which is much more common in both space and time than is geophysical survey activity. Jensen and Silber (2004) summarized ship strikes of large whales worldwide from 1975–2003 and found that most collisions occurred in the open ocean and involved large vessels (*e.g.,* commercial shipping). Commercial fishing vessels were responsible for three percent of recorded collisions, while no such incidents were reported for geophysical survey vessels during that time period.

It is possible for ship strikes to occur while traveling at slow speeds. For example, a hydrographic survey vessel traveling at low speed (5.5 kn) while conducting mapping surveys off the central California coast struck and killed a blue whale in 2009. The State of California determined that the whale had suddenly and unexpectedly surfaced beneath the hull, with the result that the propeller severed the whale's vertebrae, and that this was an unavoidable event. The strike represented the only such incident in approximately 540,000 hours of similar coastal mapping activity ($p = 1.9 \times 10^{-6}$; 95% CI = $0 - 5.5 \times 10^{-6}$; NMFS, 2013). In addition, a research vessel reported a fatal strike in 2011 of a dolphin in the Atlantic, demonstrating that it is possible for strikes involving smaller cetaceans to occur. In that case, the incident report indicated that an animal apparently was struck by the vessel's propeller as it was intentionally swimming near the vessel. While indicative of the type of unusual events that cannot be ruled out, neither of these instances represents a circumstance that would be considered reasonably foreseeable or that would be considered preventable.

Although the likelihood of vessels associated with geophysical surveys striking a marine mammal are low, we require a robust ship strike avoidance protocol (see ''Proposed Mitigation''), which we believe eliminates any foreseeable risk of ship strike. We anticipate that vessel collisions involving seismic data acquisition vessels towing gear, while not impossible, represent unlikely, unpredictable events for which there are no preventive measures. Given the required mitigation measures, the relatively slow speeds of vessels towing gear, the presence of bridge crew watching for obstacles at all times (including marine mammals), the presence of marine mammal observers, and the small number of seismic survey cruises relative to commercial ship traffic, we believe that the possibility of ship strike is discountable and, further, that were a strike of a large whale to occur, it would be unlikely to result in serious injury or mortality. No incidental take resulting from ship strike is anticipated or proposed for authorization, and this potential effect of the specified activity will not be discussed further in the following analysis.

Other Potential Impacts

Here, we briefly address the potential risks due to entanglement and contaminant spills. We are not aware of any records of marine mammal entanglement in towed arrays such as those considered here, and we address measures designed to eliminate the potential for entanglement in gear used by OBS surveys in ''proposed Mitigation.'' The discharge of trash and debris is prohibited (33 CFR 151.51–77) unless it is passed through a machine that breaks up solids such that they can pass through a 25-mm mesh screen. All other trash and debris must be returned to shore for proper disposal with municipal and solid waste. Some personal items may be accidentally lost overboard. However, U.S. Coast Guard and Environmental Protection Act regulations require operators to become proactive in avoiding accidental loss of solid waste items by developing waste management plans, posting informational placards, manifesting trash sent to shore, and using special precautions such as covering outside trash bins to prevent accidental loss of solid waste. Any permits issued by BOEM would include guidance for the handling and disposal of marine trash and debris, similar to BSEE's Notice to Lessees 2015–G03 (''Marine Trash and Debris Awareness and Elimination'') (BSEE, 2015; BOEM, 2017). We believe entanglement risks are essentially eliminated by the proposed requirements, and entanglement risks are not discussed further in this document.

Marine mammals could be affected by accidentally spilled diesel fuel from a vessel associated with proposed survey activities. Quantities of diesel fuel on the sea surface may affect marine mammals through various pathways: Surface contact of the fuel with skin and other mucous membranes, inhalation of concentrated petroleum vapors, or ingestion of the fuel (direct ingestion or by the ingestion of contaminated prey) (*e.g.,* Geraci and St. Aubin, 1980, 1985, 1990). However, the likelihood of a fuel spill during any particular geophysical survey is considered to be remote, and the potential for impacts to marine mammals would depend greatly on the size and location of a spill and meteorological conditions at the time of the spill. Spilled fuel would rapidly spread to a layer of varying thickness and break up into narrow bands or windrows parallel to the wind direction. The rate at which the fuel spreads would be determined by the prevailing conditions such as temperature, water currents, tidal streams, and wind speeds. Lighter, volatile components of the fuel would evaporate to the atmosphere almost completely in a few days. Evaporation rate may increase as the fuel spreads because of the increased surface area of the slick. Rougher seas, high wind speeds, and high temperatures also tend to increase the rate of evaporation and the proportion of fuel lost by this process (Scholz *et al.,* 1999). We do not anticipate potentially meaningful effects to marine mammals as a result of any contaminant spill resulting from the proposed survey activities, and contaminant spills resulting from the specified activity are not discussed further in this document.

Anticipated Effects on Marine Mammal Habitat

Physical Disturbance—Sources of seafloor disturbance related to geophysical surveys that may impact marine mammal habitat include placement of anchors, nodes, cables, sensors, or other equipment on or in the seafloor for various activities. Equipment deployed on the seafloor has the potential to cause direct physical damage and could affect bottom-associated fish resources. Several NTLs detail the mitigation measures used to prevent adverse impacts (''Biologically-sensitive Underwater Features and Areas'' (NTL 2009–G39), ''Deepwater Benthic Communities'' (NTL 2009–G40), and ''Shallow Hazards Program'' (NTL 2008–G05) (MMS, 2008; 2009a; 2009b)).

Placement of equipment, such as nodes, on the seafloor could damage areas of hard bottom where direct contact with the seafloor occurs and could crush epifauna (organisms that live on the seafloor or surface of other organisms). Damage to unknown or unseen hard bottom could occur, but because of the small area covered by most bottom-founded equipment, the patchy distribution of hard bottom habitat, BOEM's review process, and BOEM's application of avoidance conditions of approval, contact with unknown hard bottom is expected to be rare and impacts minor. Seafloor disturbance in areas of soft bottom can cause loss of small patches of epifauna and infauna due to burial or crushing, and bottom-feeding fishes could be temporarily displaced from feeding areas. Overall, any effects of physical damage to habitat are expected to be minor and temporary.

Effects to Prey—Sound may affect marine mammals through impacts on the abundance, behavior, or distribution of prey species (*e.g.,* crustaceans, cephalopods, fish, zooplankton). Marine mammal prey varies by species, season, and location and, for some, is not well documented. Here, we describe studies regarding the effects of noise on known marine mammal prey.

Fish utilize the soundscape and components of sound in their environment to perform important functions such as foraging, predator avoidance, mating, and spawning (*e.g.,* Zelick *et al.,* 1999; Fay, 2009). Depending on their hearing anatomy and peripheral sensory structures, which vary among species, fishes hear sounds using pressure and particle motion sensitivity capabilities and detect the motion of surrounding water (Fay *et al.,* 2008). The potential effects of airgun noise on fishes depends on the overlapping frequency range, distance from the sound source, water depth of exposure, and species-specific hearing sensitivity, anatomy, and physiology. Key impacts to fishes may include behavioral responses, hearing damage, barotrauma (pressure-related injuries), and mortality.

Fish react to sounds which are especially strong and/or intermittent low-frequency sounds, and behavioral responses such as flight or avoidance are the most likely effects. Short duration, sharp sounds can cause overt or subtle changes in fish behavior and local distribution. The reaction of fish to airguns depends on the physiological state of the fish, past exposures, motivation (*e.g.,* feeding, spawning, migration), and other environmental factors. Hastings and Popper (2005) identified several studies that suggest fish may relocate to avoid certain areas of sound energy. Several studies have demonstrated that airgun sounds might affect the distribution and behavior of some fishes, potentially impacting foraging opportunities or increasing energetic costs (*e.g.,* Fewtrell and McCauley, 2012; Pearson *et al.,* 1992; Skalski *et al.,* 1992; Santulli *et al.,* 1999; Paxton *et al.,* 2017). However, some studies have shown no or slight reaction to airgun sounds (*e.g.,* Pena *et al.,* 2013; Wardle *et al.,* 2001; Jorgenson and Gyselman, 2009; Cott *et al.,* 2012). More commonly, though, the impacts of noise on fish are temporary. Investigators reported significant, short-term declines in commercial fishing catch rate of gadid fishes during and for up to five days after survey operations, but the catch rate subsequently returned to normal (Engas et al, 1996; Engas and Lokkeborg, 2002); other studies have reported similar findings (Hassel *et al.,* 2004). However, even temporary effects to fish distribution patterns can impact their ability to carry out important life-history functions (Paxton *et al.,* 2017).

SPLs of sufficient strength have been known to cause injury to fish and fish mortality and, in some studies, fish auditory systems have been damaged by airgun noise (McCauley *et al.,* 2003; Popper *et al.,* 2005; Song *et al.,* 2008). However, in most fish species, hair cells in the ear continuously regenerate and loss of auditory function likely is restored when damaged cells are replaced with new cells. Halvorsen *et al.* (2012a) showed that a TTS of 4–6 dB was recoverable within 24 hours for one species. Impacts would be most severe when the individual fish is close to the source and when the duration of exposure is long. No mortality occurred to fish in any of these studies.

Injury caused by barotrauma can range from slight to severe and can cause death, and is most likely for fish with swim bladders. Barotrauma injuries have been documented during controlled exposure to impact pile driving (an impulsive noise source, as are airguns) (Halvorsen *et al.,* 2012b; Casper *et al.,* 2013). For geophysical surveys, the sound source is constantly moving, and most fish would likely avoid the sound source prior to receiving sound of sufficient intensity to cause physiological or anatomical damage.

Invertebrates appear to be able to detect sounds (Pumphrey, 1950; Frings and Frings, 1967) and are most sensitive to low-frequency sounds (Packard *et al.,* 1990; Budelmann and Williamson, 1994; Lovell *et al.,* 2005; Mooney *et al.,* 2010). Available data suggest that cephalopods are capable of sensing the particle motion of sounds and detect low frequencies up to 1–1.5 kHz, depending on the species, and so are likely to detect airgun noise (Kaifu *et al.,* 2008; Hu *et al.,* 2009; Mooney *et al.,* 2010; Samson *et al.,* 2014). Cephalopods have a specialized sensory organ inside the head called a statocyst that may help an animal determine its position in space (orientation) and maintain balance (Budelmann, 1992). Packard *et al.* (1990) showed that cephalopods were sensitive to particle motion, not sound pressure, and Mooney *et al.* (2010) demonstrated that squid statocysts act as an accelerometer through which particle motion of the sound field can be detected. Auditory injuries (lesions occurring on the statocyst sensory hair cells) have been reported upon controlled exposure to low-frequency sounds, suggesting that cephalopods are particularly sensitive to low-frequency sound (Andre *et al.,* 2011; Sole *et al.,* 2013). Behavioral responses, such as inking and jetting, have also been reported upon exposure to low-frequency sound (McCauley *et al.,* 2000b; Samson *et al.,* 2014).

Impacts to benthic communities from impulsive sound generated by active acoustic sound sources are not well documented. There are no published data that indicate whether threshold shift injuries or effects of auditory masking occur in benthic invertebrates, and there are little data to suggest whether sounds from seismic surveys would have any substantial impact on invertebrate behavior (Hawkins *et al.,* 2014), though some studies have indicated showed no short-term or long-term effects of airgun exposure (*e.g.,* Andriguetto-Filho *et al.,* 2005; Payne *et al.,* 2007; 2008; Boudreau *et al.,* 2009). Exposure to airgun signals was found to significantly increase mortality in scallops, in addition to causing significant changes in behavioral patterns during exposure (Day *et al.,* 2017). However, the implications of this finding are not straightforward, as the authors state that the observed levels of mortality were not beyond naturally occurring rates.

There is little information concerning potential impacts of noise on zooplankton populations. However, one recent study (McCauley *et al.,* 2017) investigated zooplankton abundance, diversity, and mortality before and after exposure to airgun noise, finding that the exposure resulted in significant depletion for more than half the taxa present and that there were two to three times more dead zooplankton after airgun exposure compared with controls for all taxa. The majority of taxa present were copepods and cladocerans; for these taxa, the range within which effects on abundance were detected was up to approximately 1.2 km. In order to have significant impacts on *r*-selected species such as plankton, the spatial or temporal scale of impact must be large in comparison with the ecosystem concerned (McCauley *et al.,* 2017). Therefore, the large scale of effect observed here is of concern—particularly where repeated noise exposure is expected—and further study is warranted.

Prey species exposed to sound might move away from the sound source, experience TTS, experience masking of biologically relevant sounds, or show no obvious direct effects. Mortality from decompression injuries is possible in close proximity to a sound, but only limited data on mortality in response to airgun noise exposure are available (Hawkins *et al.,* 2014). The most likely impacts for most prey species in a given area would be temporary avoidance of the area. Surveys using towed airgun arrays move through an area relatively quickly, limiting exposure to multiple impulsive sounds. In all cases, sound levels would return to ambient once a survey ends and the noise source is shut down and, when exposure to sound ends, behavioral and/or physiological responses are expected to end relatively quickly (McCauley *et al.,* 2000b). The duration of fish avoidance of a given area after survey effort stops is unknown, but a rapid return to normal recruitment, distribution, and behavior is anticipated. While the potential for disruption of spawning aggregations or schools of important prey species can be meaningful on a local scale, the mobile and temporary nature of most surveys and the likelihood of temporary avoidance behavior suggest that impacts would be minor.

Acoustic Habitat—Acoustic habitat is the soundscape—which encompasses all of the sound present in a particular location and time, as a whole—when considered from the perspective of the animals experiencing it. Animals produce sound for, or listen for sounds produced by, conspecifics (communication during feeding, mating, and other social activities), other animals (finding prey or avoiding predators), and the physical environment (finding suitable habitats, navigating). Together, sounds made by animals and the geophysical environment (*e.g.,* produced by earthquakes, lightning, wind, rain, waves) make up the natural contributions to the total acoustics of a place. These acoustic conditions, termed acoustic habitat, are one attribute of an animal's total habitat.

Soundscapes are also defined by, and acoustic habitat influenced by, the total contribution of anthropogenic sound. This may include incidental emissions from sources such as vessel traffic, or may be intentionally introduced to the marine environment for data acquisition purposes (as in the use of airgun arrays). Anthropogenic noise varies widely in its frequency content, duration, and loudness and these characteristics greatly influence the potential habitat-mediated effects to marine mammals (please also see the previous discussion on masking in the ''Acoustic Effects'' subsection), which may range from local effects for brief periods of time to chronic effects over large areas and for long durations. Depending on the extent of effects to habitat, animals may alter their communications signals (thereby potentially expending additional energy) or miss acoustic cues (either conspecific or adventitious). Problems arising from a failure to detect cues are more likely to occur when noise stimuli are chronic and overlap with biologically relevant cues used for communication, orientation, and predator/prey detection (Francis and Barber, 2013). For more detail on these concepts see, *e.g.,* Barber *et al.,* 2009; Pijanowski *et al.,* 2011; Francis and Barber, 2013; Lillis *et al.,* 2014.

The term ''listening area'' refers to the region of ocean over which sources of sound can be detected by an animal at the center of the space. Loss of communication space concerns the area over which a specific animal signal, used to communicate with conspecifics in biologically-important contexts (*e.g.,* foraging, mating), can be heard, in noisier relative to quieter conditions (Clark *et al.,* 2009). Lost listening area concerns the more generalized contraction of the range over which animals would be able to detect a variety of signals of biological importance, including eavesdropping on predators and prey (Barber *et al.,* 2009). Such metrics do not, in and of themselves, document fitness consequences for the marine animals that live in chronically noisy environments. Long-term population-level consequences mediated through changes in the ultimate survival and reproductive success of individuals are difficult to study, and particularly so underwater. However, it is increasingly well documented that aquatic species rely on qualities of natural acoustic habitats, with researchers quantifying reduced detection of important ecological cues (*e.g.,* Francis and Barber, 2013; Slabbekoorn *et al.,* 2010) as well as survivorship consequences in several species (*e.g.,* Simpson *et al.,* 2014; Nedelec *et al.,* 2015).

Specific to the GOM and the activities considered here, Matthews *et al.* (2016, 2017) developed a first-order cumulative and chronic effects assessment for noise produced by oil and gas exploration activities in the U.S. GOM. The 2016 report was originally presented as Appendix K in BOEM (2017), with an addendum to the report produce in 2017; both are available online at: *www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-oil-and-gas.* Here, we summarize the study and its findings (referred to here as ''the CCE report''). For full methodological details and results, please see the report.

As discussed previously in this section, direct exposure to the pulses produced by airguns can result in acute impacts at close ranges. However, low-frequency dominant airgun noise undergoes multiple reflections at the ocean bottom and surface and refraction through the water column, both of which cause prolonged decay time of the original acoustic signals (Urick, 1984). Extended decay time can lead to high sound levels lasting from one impulse to the onset of the next, elevating ambient noise levels (Guan *et al.,* 2015). In addition, low-frequency energy from airgun surveys, with access to conductive propagation conditions (*e.g.,* deeper waters), has been documented to travel long distances, contributing to increased background noise over very large areas (Nieukirk *et al.,* 2012). Implications for acoustic masking and reduced communication space resulting from noise produced by airgun surveys are expected to be particularly heightened for animals that actively produce low frequency sounds or whose hearing is attuned to lower frequencies. Bryde's whales are the only GOM species classified within the low-frequency hearing group, producing calls that span a low frequency range that directly overlaps the dominant energies produced by airguns. However, impacts associated with cumulative noise within the frequencies of the Matthews *et al.* (2016) study (10–5,000 Hz), are relevant to the majority of cetacean species in the GOM. In the addendum to the CCE report (Matthews *et al.,* 2017), the same methods for calculating changes in communication space were applied to sperm whales (based on male sperm whale slow-clicks; Madsen *et al.,* 2002b).

Acoustic modeling was conducted for ten locations (''receiver sites'') within the study area to examine aggregate noise produced over a full year. The locations of the receiver sites are given in Table 5 and shown in the map of Figure 4. These sites were chosen to reflect areas of biological importance to cetaceans, (*e.g.,* LaBrecque *et al.,* 2015), areas of high densities of cetaceans (Roberts *et al.,* 2016), and areas of key biological diversity (*e.g.,* National Marine Sanctuaries). The study area was divided into six ''activity zones'' (Figure 4) (note that these zones are different from those used for acoustic exposure modeling and described below in the ''Estimated Take'' section).

TABLE 5—MODELED RECEIVER SITE LOCATIONS, WATER DEPTHS, AND SELECTION BASIS

Site	Receiver site	Latitude	Longitude	Water depth (m)	Selection basis
1	Western GOM	27.01606° N	95.7405° W	842	Higher density cryptic deep diving and social pelagic cetaceans.
2	Florida Escarpment	25.95807° N	84.6956° W	693	Higher density multiple cetacean species shelf break and slope.
3	Midwestern GOM	27.43300° N	92.1200° W	830	Higher density multiple cetacean species shelf break and slope.
4	Sperm whale site	24.34771° N	83.7727° W	1,053	Higher density sperm whales and cryptic deep diving cetaceans.
5	Deep offshore	27.64026° N	87.0285° W	3,050	Location of NOAA noise reference station.
6	Mississippi Canyon	28.15455° N	89.3971° W	1,106	Higher density sperm whales and cryptic deep diving cetaceans.
7	Bryde's whale site	28.74043° N	85.7302° W	212	Bryde's whale biologically important area.

TABLE 5—MODELED RECEIVER SITE LOCATIONS, WATER DEPTHS, AND SELECTION BASIS—Continued

Site	Receiver site	Latitude	Longitude	Water depth (m)	Selection basis
8	De Soto Canyon	29.14145° N	87.1762° W	919	Higher density sperm whales and cryptic deep diving cetaceans.
9	Flower Garden Banks National Marine Sanctuary.	27.86713° N	93.8259° W	88	National Marine Sanctuary.
10	Bottlenose dolphin site	29.40526° N	93.3247° W	12	Bottlenose dolphin biologically important area.

Note that ''closure areas'' depicted in Figure 4 represent those described in Chapter 2.8 of BOEM (2017), which are in some cases different from those described in this document (see the ''Proposed Mitigation'' section). Matthews *et al.* (2016, 2017) analyzed multiple scenarios, including a baseline scenario (referred to in the CCE report as ''Alternative A'') in which no geophysical surveys are conducted and noise consists of natural sounds and a minimum estimate of commercial vessel noise; a survey activity scenario (referred to in the CCE report as ''Alternative C'') in which projected activities were uniformly distributed throughout the study area, with the exception of the coastal waters restriction from February to May (as described below in the ''Proposed Mitigation'' section); and a closure scenario (referred to in the CCE report as ''Alternative F1'') in which no activities are conducted in the restriction areas, 25 percent of the activity that would have occurred in the restriction areas is redistributed into non-restriction areas of the same activity zone (Figure 4), and 75 percent of the activities that would have occurred in the restriction areas are not conducted at all. Matthews *et al.* (2016, 2017) also assessed additional scenarios not relevant to this proposed rulemaking; these are not discussed here.

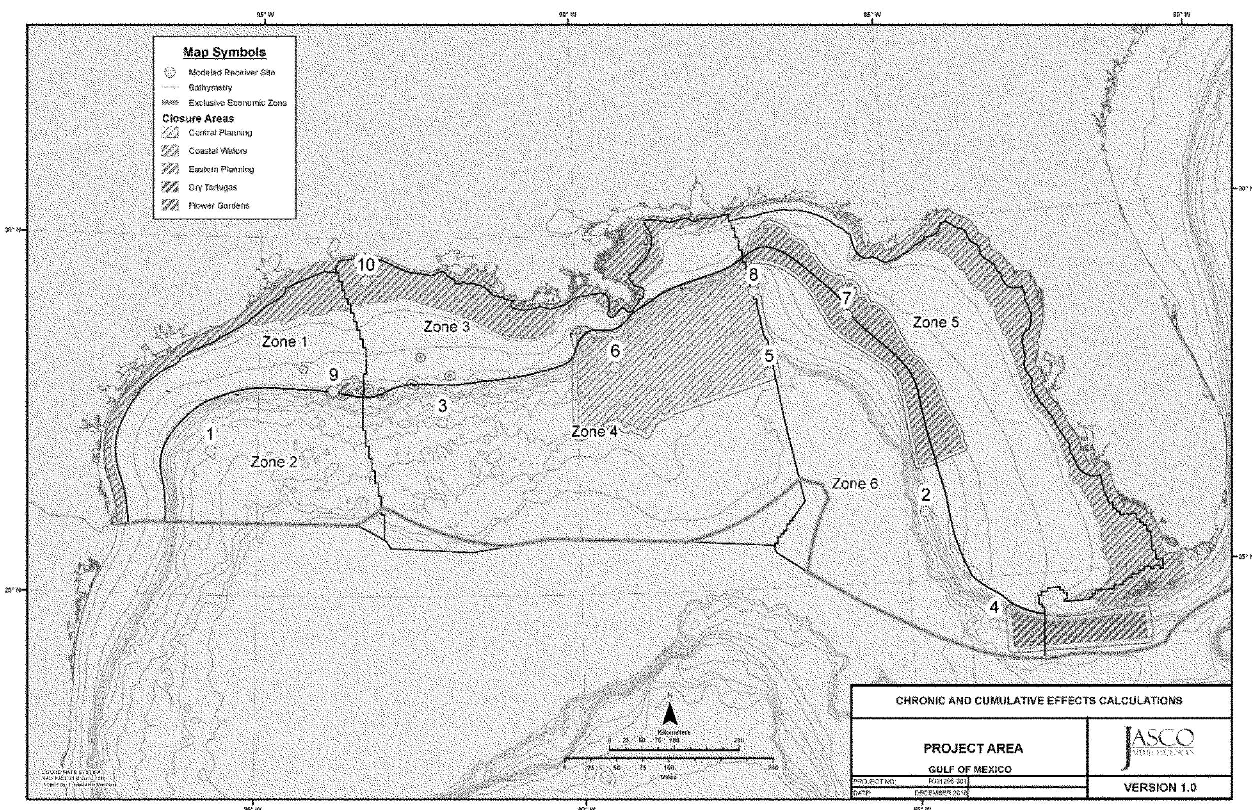


Figure 4. Study Area with Modeled Receiver Sites (Matthews *et al.*, 2016, 2017).

Several simplifying assumptions were necessary. Changes in the distribution of survey activities would result in differences in the relative amount of noise accumulating at different receiver sites, and that variance was not examined. Instead, results associated with zone-varying densities of activity types but homogenous distributions of activities of each type within zones were presented. The approach applied accounts for spatial variance in resulting cumulative noise due to factors affecting sound propagation (*e.g.,* topography, bottom type) among locations of key management interest in the region. However, it does not produce results for additional locations (*e.g.,* a uniform map).

The average of the projected annual amounts of survey activities for ten years in each zone (Table 1) was calculated from the total survey line length within the respective zones. These average activity levels were modified by implementing area restrictions. Two representative acoustic sources were modeled and applied to five total activity types: Various configurations of one or more 8,000 in^3 airgun arrays were used to simulate 2D, 3D NAZ, 3D WAZ, and coil surveys, and a single 90 in^3 airgun was used to simulate boomer and sparker type sources used for geotechnical surveys (see Table 2 in the CCE report for full details of these assumptions). Since the specific location of each type of activity was unknown, the survey source pulses were uniformly distributed throughout the activity zones according to the projected amount of each type of survey activity. In order to account for the seasonal closure of coastal waters, Zones 1, 3, and 5 were separated into waters occurring within coastal vs. deeper waters at the 20-m isobath. The numbers of pulses occurring annually within the coastal versus deeper portions of the zone were titrated to account for only eight months per year of survey activity within the coastal portion.

The acoustic fields at the receiver sites were modeled at frequencies from 10 Hz to 5 kHz, for sources up to 500 km away. Results are provided for three depths as available at each receiver location: 5, 30, and 500 m. Annual cumulative SELs and time-averaged equivalent SPLs (L_{eq}) at the selected receiver sites were calculated for all survey activity. A feature of underwater sound propagation is that nearby sources contribute substantially more SEL than more distant sources, since the exposure levels decay approximately with the square of distance from the source. This causes cumulative SEL received from spatially distributed and moving sources to be dominated by the sources closest to a receiver. However, the duration of exposures from very close sources is typically quite short. While exposures from nearby sources are important for assessing acute effects, their inclusion in a chronic effects assessment can be misleading. To overcome this issue, this approach excluded the highest shot exposures received during a fraction (10 percent) of the total study time period. Thus, the effective accumulation period was 90 percent of a year. The cumulative levels estimated using the approach applied in the study are accurate when the cell dimensions are small, relative to the source-receiver separation. This approach could have led to errors when survey lines approached within a few kilometers from the receiver locations; however, the close range cells where this could have been a problem were automatically excluded by the removal of the top 10 percent of pulse noise contributions. Marine mammal hearing frequency weighting filter coefficients were applied to the received levels, and results are presented both with and without weighting. Results relevant to this proposed rule for cumulative SEL (Tables 8 and 10 in the CCE report) and L_{eq} (Tables 12 and 16 in the CCE report) calculations are presented in the CCE report.

A baseline ambient noise level must be assumed to estimate lost listening area and changes in communication space for various levels of activity. Here, ambient noise levels were defined as some contribution of commercial shipping noise in the 50–800 Hz band and noise from natural sounds (produced mainly by wind and waves). The commercial shipping noise levels were obtained from products available at *cetsound.noaa.gov/sound-index,* which provide commercial shipping noise levels over the GOM region in one third-octave frequency bands between 50–800 Hz (shipping noise was neglected outside this range). Natural ambient noise levels were calculated from the formulas of Wenz (1962) and Cato (2008) for a wind speed of 8.5 kn. The natural noise levels were added to the vessel noise levels to generate composite one third-octave band ambient levels between 10 Hz and 5 kHz. Broadband ambient levels varied between 94.3 and 102.3 dB, depending on the receiver location and depth (Table 7 in the CCE report). Estimates were assigned to each receiver site based on proximity and matched by water depth. Tables 13 and 17 in the CCE report present relevant results for modeled L_{eq} above ambient at each receiver site with and without frequency weighting.

The lost listening area assessment method has been applied to in-air noise (Barber *et al.,* 2009) and in soundscape management contexts (NPS, 2010). Sound sources considered by this method can be from the same species (as discussed for communication space), a different species (*e.g.,* predator or prey), natural sounds, or anthropogenic sounds. The lost listening area method applied by Barber *et al.* (2009) calculates a fractional reduction in listening area due to the addition of anthropogenic noise to ambient noise. It does not provide absolute areas or volumes of space; however, a benefit of the listening area method is that it does not rely on source levels of the sounds of interest. Instead, the method depends on the rate of sound transmission loss. Such results can be considered with frequency weightings, which represent the hearing sensitivity variations of three marine mammal species groups and transmission loss variations with range, or more generally without weighting. Results are presented as a percentage of the original listening area remaining due to the increase in noise levels relative to no activity and between activity scenarios. Relevant results are presented in Tables 20, 22, and 25 of the CCE report.

The communication space assessment was performed for Bryde's whales and sperm whales using methods previously implemented for examining anthropogenic noise effects on whales (Clark *et al.,* 2009; Hatch *et al.,* 2012). Communication space represents the area within which whales can detect calls from other whales. For Bryde's whales, all calculations were performed in the single one third-octave frequency band centered at 100 Hz, representing the highest received sound levels for the calls attributed to Bryde's whales in the GOM (Rice *et al.,* 2014; Sirovic *et al.,* 2014). A one third-octave band sound level of 152 dB at 1 m was specified. An estimate of 12.36 dB signal processing gain (which accounts for the animal's ability to not only detect but recognize a signal from an animal of the same species) was applied. The areas of communication space at each receiver for the Bryde's whale calls under ambient conditions and under each relevant activity scenario are presented in Tables 28, 29, and 31 of the CCE report. Relative losses of communication space (in both areas and percentages) between the activity scenarios are presented in Table 34 of the CCE report.

For sperm whales, calculations were performed in the third-octave frequency band centered at 3,150 Hz, with a specified sound level of 181 dB at 1 m (Madsen *et al.,* 2002b). Sperm whales produce at least four types of clicks: Usual clicks, buzzes (also called creaks), codas (patterns of 3–20 clicks), and slow-clicks (or clangs). Sperm whales on feeding grounds emit slow-clicks in seemingly repetitive temporal patterns (Oliveira *et al.,* 2013), supporting the hypothesis that their function is long range communication between males, possibly relaying information about individual identity or behavioral states. These calls were chosen for the analysis since they have a lower frequency emphasis and longer duration than other sperm whale clicks (the center frequency of usual clicks and buzzes is 15 kHz; Madsen *et al.,* 2002b). Since the frequency band of slow-clicks is closest to that of the airgun activity, these calls are the most affected in the context of the study. In addition, low-frequency sounds generally propagate farther than high-frequency ones. Thus, low-frequency communication is generally more affected by distant noise sources than high-frequency communication. The signal processing gain was estimated at 3.0 dB, based on a median frequency bandwidth of 4 kHz and call length of 500 µs (Madsen *et al.,* 2002b). Results for sperm whales are shown in Table 2 of the CCE report addendum.

In the 3,150 Hz band, noise contribution from airgun survey activities in the GOM was estimated between 82.0 and 82.1 dB for all sites and all alternatives, levels similar to the estimated baseline levels of 82.0 dB at all sites. Therefore, the analysis shows that the survey activities do not significantly contribute to the soundscape in the 3,150 Hz band, and that there will be no significant change in communication space for sperm whales under the modeled alternatives. Because other sperm whale calls are higher-frequency, they would not be expected to be affected. However, we must be clear that this analysis is in reference to potential chronic effects resulting from changes to effective communication space, and that acute expects, as discussed elsewhere in this preamble, remain of concern for sperm whales. The remaining discussion that follows is in reference to the findings for Bryde's whales and to general findings for other hearing groups.

The lost listening area and communication space metrics do not reflect variance in an individual animal's experience of the noise produced by the modeled activities from one moment to the next. With both sources of noise and animals moving, the time-series of an individual's noise exposure will show considerable variation. The methods used by Matthews *et al.* (2016, 2017) were meant to average the conditions generated by low-frequency dominant noise sources throughout a full year, during which animals of key management interest rely on habitats within the study area. Considered as a complement to assessments of the acute effects of the same types of noise sources in the same region (discussed below in the ''Estimated Take'' section), the CCE assessment estimates noise produced by the same sources over much larger spatial scales, and considers how the summation of noise from these sources relates to levels without the proposed activity (ambient). Approaches such as the communication space estimation include approximation for the evolved ability of many acoustically active animals, such as Bryde's whales, to hear the calls of conspecifics in the presence of some overlapping noise.

At most sites, lost listening area was greater for deeper waters than for shallower waters, which is attributed to the downward-refracting sound speed profile near the surface, caused by the thermocline, which steers sound to deeper depths. The winter sound speed profile applied in the CCE modeling (February) was considered to be conservative relative to summer, as it includes a surface sound channel at certain sites that are conducive to sound propagation from shallow sound sources. Shallow water noise levels were reduced due to surface interactions that increase transmission loss, particularly for low frequencies. Listening area reductions were also generally most severe when weighted for low-frequency hearing cetaceans. Filters that more heavily weighted the mid-frequencies modeled in this study (150 Hz–5 kHz) often reduced estimates of lost listening area. Canyon areas in the central and eastern GOM saw significant loss of listening area. Both low- and mid-frequency weighted losses were high in the Mississippi Canyon, while only low-frequency weighted values were high for the De Soto Canyon. Both of these sites are considered important to sperm whales as well as other deep diving odontocetes. Other areas relevant to sperm whales, including site 4 off the Dry Tortugas, also saw heavy reductions in listening area. Additional heavily affected sites were those chosen to represent locations with predicted high densities of cryptic deep divers (*e.g.,* site 1 in the far western GOM). Though most of these species are classified as having mid-frequency hearing sensitivity, many have shown sensitivity to airgun noise, with sperm whales the most well documented in the GOM. These modeling results suggest that accumulations of noise from survey activities below 5 kHz and often heightened at depth could be degrading the availability of animals that forage at great depths in the GOM to use acoustic cues find prey as well as to maintain conspecific contact.

Comparison between results provided for the two metrics applied in the CCE report highlights important interpretive differences for evaluating the biological implications of background noise. The strength of the communication space approach is that it evaluates potential contractions in the availability of a signal of documented importance to a population of animals of key management interest in the region. In this case, losses of communication space for Bryde's whales were estimated to be higher in eastern and central GOM canyons and shelf break areas. The maintenance of listening area and communication space at site 7 is of particular interest because the location is within the area of designated biological importance to the Bryde's whale. The apparent protection of listening area and communication space within the calling frequencies utilized by the Bryde's whale appears to take advantage of both local propagation conditions and the predicted lower levels of survey activity in the shallower portions of the Eastern Planning Area, which more strongly affect noise levels at this site. However, the significant loss of low-frequency listening area and communication space for their calls estimated for in additional locations, including just off the shelf in the eastern GOM, is of concern for this population.

The effectiveness of time-area restrictions for maintaining communication space or listening area were highly variable among locations. This assessment evaluated the implications of displacing a portion (25 percent) of the activity that would have taken place within a restriction area to within the remaining area outside the restriction. Thus, sites that were within large restriction areas (sites 6 and 8) experienced reduced cumulative noise levels and improved listening and communication conditions when those restrictions were in effect. Conditions at sites within restrictions designed around biologically important areas (sites 7 and 10) were not improved solely because they were not degraded under non-restriction conditions. In contrast, some sites outside restrictions, particularly those located in deeper water zones that correspond with denser projected levels of survey activity (sites 1, 3, and 5) experienced higher noise levels with time-area restrictions, due to activity that was displaced to within their propagation vicinity. Finally, the methods used in this assessment to remove 10 percent of shots from survey activity closest to the receiver locations are likely to have reduced the relative difference between accumulated energy resulting from smaller restrictions (which further eliminated shots that would have taken place within the 160 dB buffered restriction areas). This loss of resolution between restriction and non-restriction results does not adequately capture the reduction in acute noise exposure that could be experienced by animals through implementation of a restriction.

The CCE report is described here in order to present information regarding potential longer-term and wider-range noise effects from sources such as airguns. The metrics applied in this study do not, in and of themselves, document the consequences of lost listening area or communication space for the survivorship or reproductive success of individual animals. However, they do translate a growing body of scientific evidence for concern regarding the degradation of the quality of high-value acoustic habitats into quantifiable attributes that can related to baseline conditions, including those to which animals have evolved.

In general, losses of broadband listening area far exceeded losses of communication space when evaluated at the same locations and under the same activity levels. This is appropriate to the interpretive role of the lost listening space calculation, which is to provide a more conservative estimate of the areas over which animals have access to a variety of acoustic cues of importance to their survival and reproductive success. Acoustic cues provide particularly important information in areas where other sensory cues are diminished (*e.g.,* dark) and where navigation is challenging (*e.g.,* complex coastlines and topography). Documentation of such cues (*e.g.,* Barber *et al.,* 2009; Slabbekoorn *et al.,* 2010) indicate that they can be well outside of the frequencies that animals use to communicate with conspecifics, are often of lower source levels than conspecific calls and in many cases cannot benefit from evolved capacity to compensate for noise (*e.g.,* gain applied to communication space calculations), due to the absence of a mechanism for natural selection to act (*e.g.,* most eavesdropping contexts). The results of the CCE study highlight the need for further long-term monitoring in the GOM.

Estimated Take

This section provides an estimate of the number and type of incidental takes that may be expected to occur under the proposed activity, which will inform NMFS's negligible impact determination. Realized incidental takes would be determined by the actual levels of activity at specific times and places that occur under any issued LOAs.

Harassment is the only type of take expected to result from these activities. Except with respect to certain activities not pertinent here, section 3(18) of the MMPA defines ''harassment'' as: Any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment); or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (Level B harassment).

Incidental takes would primarily be expected to be by Level B harassment, as use of the described acoustic sources has the potential to result in disruption of behavioral patterns for individual marine mammals. There is also some potential for auditory injury (Level A harassment) to result for mysticetes and high frequency species due to the size of the predicted auditory injury zones for those species. Auditory injury is less likely to occur for mid-frequency species, due to their relative lack of sensitivity to the frequencies at which the primary energy of an airgun signal is found, as well as such species' general lower sensitivity to auditory injury as compared to high-frequency cetaceans. As discussed in further detail below, we do not expect auditory injury for mid-frequency cetaceans. The proposed mitigation and monitoring measures are expected to minimize the severity of such taking to the extent practicable. No mortality is anticipated as a result of these activities.

Acoustic Thresholds

Using the best available science, NMFS has developed acoustic thresholds that identify the received level of underwater sound above which exposed marine mammals would be reasonably expected to exhibit behavioral disruptions (equated to Level B harassment) or to incur PTS of some degree (equated to Level A harassment).

Level B Harassment—Although available data are consistent with the basic concept that louder sounds evoke more significant behavioral responses than softer sounds, defining sound levels that disrupt behavioral patterns is difficult because responses depend on the context in which the animal receives the sound, including an animal's behavioral mode when it hears sounds (*e.g.,* feeding, resting, or migrating), prior experience, and biological factors (*e.g.,* age and sex). Some species, such as beaked whales, are known to be more highly sensitive to certain anthropogenic sounds than other species. Other contextual factors, such as signal characteristics, distance from the source, and signal to noise ratio, may also help determine response to a given received level of sound. Therefore, levels at which responses occur are not necessarily consistent and can be difficult to predict (Southall *et al.,* 2007; Ellison *et al.,* 2012; Bain and Williams, 2006).

Based on the practical need to use a relatively simple threshold based on available information that is both predictable and measurable for most activities, NMFS has historically used a generalized acoustic threshold based on received level to estimate the onset of Level B harassment. This approach was developed based on the 1997 High-Energy Seismic Survey Workshop (HESS, 1999) and a 1998 NMFS workshop on acoustic criteria, and assumed a step-function threshold. A step-function threshold assumes that animals receiving SPLs that exceed the threshold will always respond in a way that constitutes behavioral harassment, while those receiving SPLs below the threshold will not. This approach assumes that the responses of marine mammals would not be affected by differences in acoustic conditions; differences between species and populations; differences in gender, age, reproductive status, or social behavior; or the prior experience of the individuals (or any other contextual factor). For impulsive sources, such as airguns, a threshold of 160 dB rms SPL was selected on the basis of measured avoidance responses observed in whales. Specifically, the threshold was initially derived from data for mother-calf pairs of migrating gray whales (Malme *et al.,* 1983, 1984) and bowhead whales (Richardson *et al.,* 1985, 1986) responding when exposed to airguns. Subsequent data collection has not suggested that the 160-dB value is generally unrepresentative, inasmuch as a single-value threshold used to predict behavioral responses across multiple taxa and contexts can be adequately representative. This threshold was historically unweighted, meaning that the assessment of potential for behavioral disturbance does not account for differential hearing sensitivity across species.

However, most marine mammals exposed to impulse noise demonstrate responses of varying magnitude in the 140-180 dB rms exposure range (Southall *et al.,* 2007), including the whales studied by Malme *et al.* (1983, 1984), and potential disturbance levels at SPLs above 140 dB rms were also highlighted by HESS (1999). Studies of marine mammals in the wild and in experimental settings do not support the assumptions described above for the single step approach—different species of marine mammals and different individuals of the same species respond differently to noise exposure. Further, studies of animal physiology suggest that gender, age, reproductive status, and social behavior, among other variables, probably affect how marine mammals respond to noise exposures (*e.g.,* Wartzok *et al.,* 2003; Southall *et al.,* 2007; Ellison *et al.,* 2012).

Southall *et al.* (2007) did not suggest any specific new criteria due to lack of convergence in the data, instead proposing a severity scale that increases with sound level as a qualitative scaling paradigm. Lack of controls, precise measurements, appropriate metrics, and context dependency of responses all contribute to variability. Subsequently, Wood *et al.* (2012) proposed a probabilistic response function at which 10 percent, 50 percent, and 90 percent of individuals exposed are assumed to produce a behavioral response at exposures of 140, 160, and 180 dB rms, respectively. It is important to note that the probabilities associated with the steps identify the proportion of an exposed population that is likely to respond to an exposure, rather than an individual's probability of responding. This function is shifted for species (or contexts) assumed to be more behaviorally sensitive, *e.g.,* for beaked whales, 50 percent and 90 percent response probabilities were assumed to occur at 120 and 140 dB rms, respectively.

In assessing the potential for behavioral response as a result of sonar exposure, the U.S. Navy has developed, with NMFS, acoustic risk functions (or ''dose-response'' functions) that relate an exposure to the probability of response. These assume that the probability of a response depends first on the ''dose'' (in this case, the received level of sound) and that the probability of a response increases as the ''dose'' increases (*e.g.,* Dunlop *et al.,* 2017). Based on observations of various animals, including humans, the relationship represented by an acoustic risk function is a more robust predictor of the probable behavioral responses of marine mammals to noise exposure. Similar approaches are commonly used for assessing the effects of other ''pollutants''. However, no such function has yet been developed for exposure to noise from acoustic sources other than military sonar. Defining such a function is difficult due to the complexity resulting from the array of potential social, environmental, and other contextual effects described briefly above, as well as because it requires definition of a ''significant'' response (*i.e.,* one rising to the level of ''harassment''), which is not well-defined.

NMFS acknowledges that the 160-dB rms step-function approach is simplistic, and that an approach reflecting a more complex probabilistic function is better reflective of available scientific information. Such an approach takes the fundamental step of acknowledging the potential for Level B harassment at exposures to received levels below 160 dB rms (as well as the potential that animals exposed to received levels above 160 dB rms will not respond in ways constituting behavioral harassment). Zeddies *et al.* (2015) assessed the potential for behavioral disturbance of marine mammals as a result of the specified activities described herein against both the 160 dB rms step-function and the Wood *et al.* (2012) approach described above. Although Wood *et al.* (2012) also used a modified risk function for migrating baleen whales due to assumed heightened sensitivity when in that behavioral state, this approach was deemed not relevant for the GOM as the only baleen whale present is resident. The modified risk function for sensitive species was used for beaked whales. While there has been no direct evaluation of beaked whale sensitivity to noise from airguns, there is significant evidence of sensitivity by beaked whales to mid-frequency sonar (Tyack *et al.,* 2011; DeRuiter *et al.,* 2013; Stimpert *et al.,* 2014; Miller *et al.,* 2015), as well as to vessel noise (Aguilar Soto *et al.,* 2006; Pirotta *et al.,* 2012).

The approach described by Wood *et al.* (2012), which we are using here, also accounts for differential hearing sensitivity by incorporating frequency-weighting functions. The analysis of Gomez *et al.* (2016) indicates that behavioral responses in cetaceans are best explained by the interaction between sound source type and functional hearing group. Southall *et al.* (2007) proposed auditory weighting functions for species groups based on known and assumed hearing ranges (Type I). Finneran and Jenkins (2012) developed newer weighting functions based on perceptual measure of subjective loudness, which better match the onset of hearing impairment than the original functions (Type II). However, because data for the equal-loudness contours do not cover the full frequency range of the Type I filters, a hybrid approach was proposed. Subsequently, Finneran (2016) recommended new auditory weighting functions (Type III) which were adopted by NMFS (2016). While Type III filters are better designed to predict the onset of auditory injury, as a conservative measure Type I filters were retained for use in evaluating potential behavioral disturbance in conjunction with the Wood *et al.* (2012) probabilistic response function.

NMFS is currently evaluating available information towards development of guidance for assessing the effects of anthropogenic sound on marine mammal behavior. For this specified activity we have determined it appropriate to use the Zeddies *et al.* (2015) exposure estimates produced using the Wood *et al.* (2012) approach as our basis for estimating take and considering the effects of the specified activity on marine mammal behavior.

While we believe that the general approach of Wood *et al.* (2012)—a probabilistic risk function that allows for the likelihood of differential response probability at given received levels on the basis of multiple factors, including behavioral context, distance from the source, and particularly sensitive species—is appropriate, we acknowledge that there is some element of professional judgment involved in defining the particular steps at which specific response probabilities are assumed to occur and that this remains a relatively simplistic approach to a very complex matter. However, we believe that the Wood *et al.* (2012) function is consistent with the best available science, and is therefore an appropriate approach. We are aware of the recommendations of Nowacek *et al.* (2015)—*i.e.,* a similar scheme, but shifted downward with the 50 percent response probability midpoint at 140 dB rms—but disagree that these recommendations are justified by the available scientific evidence. In fact, our preliminary analysis of data presented in available studies describing behavioral response to intermittent sound sources (including airguns and sonar) (*e.g.,* Malme *et al.,* 1984, 1988; Houser *et al.,* 2013; Antunes *et al.,* 2014; Moretti *et al.,* 2014), conducted using a non-parametric regression method, indicates that the 50 percent midpoint is very close to 160 dB rms (*i.e.,* 159 dB rms). While there may be other recommended iterations of this basic approach, we address the differences between Wood *et al.* (2012) and Nowacek *et al.* (2015) below.

Both the Wood *et al.* (2012) and Nowacek *et al.* (2015) functions acknowledge that Level B harassment is not a simple one-step function and responses can occur at received levels below 160 dB rms. The relevant series of step functions provided within Wood *et al.* (2012) for beaked whales (50 percent at 120 dB; 90 percent at 140 dB) and all other species (10 percent at 140 dB; 50 percent at 160 dB; 90 percent at

180 dB) attempt to provide a more realistic behavioral paradigm, which is probabilistic and acknowledges that not all exposures are expected to yield similar responses for every species and/or behavioral context, as described above. The differences between Wood *et al.* (2012) and Nowacek *et al.* (2015) stem from how probabilities at corresponding received level are assigned, with both methodologies seemingly relying upon professional judgment in interpreting available data to make these decisions.

Regarding mysticetes, changes in vocalization associated with exposure to airgun surveys within migratory and non-migratory contexts have been observed (*e.g.,* Castellote *et al.,* 2012; Blackwell *et al.,* 2013; Cerchio *et al.,* 2014). The potential for anthropogenic sound to have impacts over large spatial scales is not surprising for species with large communication spaces, like mysticetes (*e.g.,* Clark *et al.,* 2009), although not every change in a vocalization would necessarily rise to the level of a take. Additionally, because of existing acoustic monitoring techniques, detecting changes in vocalizations at further distances from the source is more likely, as opposed to observing other types of responses (*e.g.,* visible changes in behavior) at these distances. However, the consideration of these observed vocal responses is not contrary to Wood *et al.* (2012). Specifically, Blackwell *et al.* (2013) report the onset of changes in vocal behavior for migratory bowhead whales at received levels that are consistent with those provided in the Wood *et al.* (2012) function for migrating mysticete species (which are not present in the GOM). Cerchio *et al.* (2014) observed the number of singing humpback whales in a breeding habitat decrease in the presence of increasing background received levels during airgun surveys. However, because the study was opportunistic, specific information on distances between singers and source vessels, as well as received levels at the singing whales, could not be obtained. Nevertheless, some probability of these vocal responses would likely be captured by the Wood *et al.* (2012) function for all other species/behaviors. Moreover, a decision about the appropriateness of a particular function should be based on how well it reflects the best available information, rather than on how it affects the resulting number of takes.

We also acknowledge concern regarding the differences between sperm whales and other cetaceans in the mid-frequency group, *i.e.,* sperm whales are believed to be somewhat more sensitive to low-frequency sound, and Miller *et al.* (2009) conclude that exposure to noise from airguns may impact sperm whale foraging behavior. While the available information provides a basis for concern regarding the effects of airguns on sperm whales, the onset of changes in buzz rates (*i.e.,* indicators of foraging behavior) occur at received levels that are consistent with the probabilities predicted by the Wood *et al.* (2012) function for all other species/behaviors. Moreover, the probabilistic function recommended by Nowacek *et al.* (2015) likewise does not make distinctions between any species or species groups, including sperm whales (*i.e.,* Nowacek *et al.* (2015) offers a single function for all species and contexts). Therefore, Nowacek *et al.* (2015) offers no advantage in this regard.

Additionally, the application of the Nowacek *et al.* (2015) approach disregards the important role that distance from a source plays in the likelihood that an animal will respond to a given received level from that source type in a particular manner. By assuming, for example, a 50 percent midpoint at 140 dB rms, the approach implies an unrealistically high probability of marine mammal response to signals received at very far distances from a source (*e.g.,* greater than 50 km). DeRuiter *et al.* (2013) found that beaked whales exposed to similar received levels responded when the sound was coming from a closer source and did not respond to the same level received from a distant source. Although the Wood *et al.* (2012) approach does not specifically include a distance cut-off, the distances at which marine mammals are predicted to respond better comport with the distances at which behavioral responses have been detected and reported in the literature.

Finally, other than providing the 50 percent midpoint, Nowacek *et al.* (2015) offer minimal detail on how their recommended probabilistic function should be derived and/or implemented, and provide no quantitative recommendations for acknowledging that behavioral responses can vary by species group and/or behavioral context. For example, relying upon Nowacek *et al.* (2015), in comparison with Wood *et al.* (2012), does not adequately acknowledge that beaked whales are known to be particularly sensitive and behavioral impacts would be underestimated. The behavioral harassment criteria upon which the analysis presented herein is based are presented in Table 6.

TABLE 6—BEHAVIORAL EXPOSURE CRITERIA

Group	Probability of response to frequency-weighted rms SPL			
	120	140	160	180
Beaked whales	50%	90%	n/a	n/a
All other species	n/a	10%	50%	90%

Level A Harassment—NMFS's *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NMFS, 2016) identifies dual criteria to assess the potential for auditory injury (Level A harassment) to occur for different marine mammal groups (based on hearing sensitivity) as a result of exposure to noise. The technical guidance identifies the received levels, or thresholds, above which individual marine mammals are predicted to experience changes in their hearing sensitivity for all underwater anthropogenic sound sources, and reflects the best available science on the potential for noise to affect auditory sensitivity by:

- Dividing sound sources into two groups (*i.e.,* impulsive and non-impulsive) based on their potential to affect hearing sensitivity;
- Choosing metrics that best address the impacts of noise on hearing sensitivity, *i.e.,* peak sound pressure level (peak SPL) (reflects the physical properties of impulsive sound sources to affect hearing sensitivity) and cumulative sound exposure level (cSEL) (accounts for not only level of exposure but also duration of exposure); and
- Dividing marine mammals into hearing groups and developing auditory weighting functions based on the

science supporting that not all marine mammals hear and use sound in the same manner.

The premise of the dual criteria approach is that, while there is no definitive answer to the question of which acoustic metric is most appropriate for assessing the potential for injury, both the received level and duration of received signals are important to an understanding of the potential for auditory injury. Therefore, peak SPL is used to define a pressure criterion above which auditory injury is predicted to occur, regardless of exposure duration (*i.e.,* any single exposure at or above this level is considered to cause auditory injury), and cSEL is used to account for the total energy received over the duration of sound exposure (*i.e.,* both received level and duration of exposure) (Southall *et al.,* 2007; NMFS, 2016). As a general principle, whichever criterion is exceeded first (*i.e.,* results in the largest isopleth) would be used as the effective injury criterion (*i.e.,* the more precautionary of the criteria). Note that cSEL acoustic threshold levels incorporate marine mammal auditory weighting functions, while peak pressure thresholds do not (*i.e.,* flat or unweighted). Weighting functions for each hearing group (*e.g.,* low-, mid-, and high-frequency cetaceans) are described in NMFS (2016).

NMFS (2016) recommends 24 hours as a maximum accumulation period relative to cSEL thresholds. These thresholds were developed by compiling and synthesizing the best available science, and are provided in Table 7 below. The references, analysis, and methodology used in the development of the thresholds are described in NMFS (2016), which is available online at: *www.nmfs.noaa.gov/pr/acoustics/guidelines.htm.*

TABLE 7—EXPOSURE CRITERIA FOR AUDITORY INJURY FOR IMPULSIVE SOURCES

Hearing group	Peak pressure [1]	Cumulative sound exposure level [2]	
		Impulsive	Non-impulsive
Low-frequency cetaceans.	219 dB	183 dB	199 dB
Mid-frequency cetaceans.	230 dB	185 dB	198 dB
High-frequency cetaceans.	202 dB	155 dB	173 dB

[1] Referenced to 1 μPa; unweighted within generalized hearing range.

[2] Referenced to 1 μPa²-s; weighted according to appropriate auditory weighting function. All airguns and the boomer are treated as impulsive sources; other HRG sources are treated as non-impulsive.

The technical guidance was classified as a Highly Influential Scientific Assessment and, as such, underwent three independent peer reviews, at three different stages in its development, including a follow-up to one of the peer reviews, prior to its dissemination by NMFS. Details of each peer review are included within the technical guidance, and specific peer reviewer comments and NMFS's responses are available online at: *www.nmfs.noaa.gov/pr/acoustics/guidelines.htm.* In addition, there were three separate public comment periods. Responses to public comments were provided in a previous **Federal Register** notice (81 FR 51694; August 4, 2016). At this time, NMFS considers the technical guidance to represent the best available scientific information. Therefore, we are not soliciting and will not respond to comments concerning the contents of the technical guidance, as such comments are outside the scope of this proposed rule. NMFS recently provided a fourth opportunity for review of the technical guidance (82 FR 24950; May 31, 2017) for the specific purpose of soliciting input to assist in review of the technical guidance pursuant to Executive Order 13795.

Modeling Overview

Zeddies *et al.* (2015, 2017a) (*i.e.,* ''the modeling report'') provides estimates of the annual marine mammal acoustic exposure caused by sounds from geophysical survey activity in the GOM for ten years of notional activity levels (Table 1). Here we provide a brief overview of key modeling elements, with more detail provided in the following sections. Significant portions of the following discussion represent incorporation by reference of Zeddies *et al.* (2015) and, for full details of the modeling effort, the interested reader should see the report (available online at: *www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-oil-and-gas*). The original modeling report (Zeddies *et al.,* 2015) evaluated the potential for auditory injury using criteria described by Southall *et al.* (2007) and Finneran and Jenkins (2012), with some appropriate modifications. Following completion of NMFS's technical guidance (NMFS, 2016), the original exposure modeling results for auditory injury were updated using the frequency-weighting functions and associated thresholds described in NMFS (2016) (Zeddies *et al.,* 2017a).

A modeling workshop was held in 2014 as a collaborative effort between the American Petroleum Institute (API) and the International Association of Geophysical Contractors (IAGC), NMFS, and BOEM. The objectives of the workshop were to identify: (1) Gaps in modeling sound fields from airgun arrays and other active acoustic sources, including data requirements and performance in various contexts, (2) gaps in approaches to integration of modeled sound fields with biological data to estimate marine mammal exposures, and (3) assumptions and uncertainties in approaches and resultant effects on exposure estimates. This workshop aided BOEM and NMFS's development of a Request for Proposals, Statement of Work, and, ultimately, the methodologies undertaken in the modeling project.

The project was divided into two phases. Each phase produced exposure estimates computed from modeled sound levels as received by simulated animals (animats) in a specific modeling area. In Phase I (described below under ''Test Scenarios;'' all other discussion here refers to Phase II), a typical 3D WAZ survey was simulated at two locations in order to establish the basic methodological approach and to provide results used to evaluate test scenarios that could influence exposure estimates. Results from the test scenarios were then used to guide the main modeling effort of Phase II. In Phase II, the GOM was divided into seven modeling zones with six survey types simulated within each zone to estimate the potential effects of each survey.

The zones were designed as described previously (''Description of the Specified Activity;'' Figure 2)—shelf and slope waters were divided into eastern, central and, western zones, plus a single deep-water zone—to account for both the geospatial dependence of acoustic fields and the geographic variations of animal distributions. The selected boundaries considered sound propagation conditions and species distribution to create regions of optimized uniformity in both acoustic environment and animal density. Survey types included deep penetration surveys using a large airgun array (2D, 3D NAZ, 3D WAZ, and coil), shallow penetration surveys using a single airgun, and high resolution surveys concurrently using side-scan sonar, subbottom profiler, and multibeam echosounder. The results from each zone were summed to provide GOM-wide estimates of take for each marine mammal species for each survey type for each notional year. To get these annual aggregate exposure estimates, 24-hr average exposure estimates from each survey type were multiplied by the number of expected survey days from BOEM's effort projections. Because these projections are not season-specific, surveys were assumed to be equally likely to occur at any time of the year and at any location within a given zone.

Sound Field Modeling

Acoustic source emission levels and directivity of a single airgun and an airgun array were modeled using JASCO Applied Sciences' Airgun Array Source Model (AASM). Source levels for high-resolution sources were obtained from manufacturer's specifications for representative sources. The AASM accounts for the physics of oscillation and radiation of airgun bubbles (Ziolkowski, 1970) and nonlinear pressure interactions between airguns, port throttling, bubble damping, and generator-injector gun behavior (Dragoset, 1984; Laws *et al.,* 1990; Landro, 1992). The model was originally fit to a large library of empirical airgun data, consisting of measured signatures of Bolt 600/B airguns ranging in volume from 5 to 185 in^3. Airgun signatures have a random component at higher frequencies that cannot be predicted using a deterministic model; therefore, AASM uses a stochastic simulation to predict the high-frequency components based on a statistical analysis of a large collection of airgun source signature data (maintained by the International Association of Oil and Gas Producers' Joint Industry Programme). AASM is capable of predicting airgun source levels at frequencies up to 25 kHz, and produces a set of notional signatures for each array element based on array layout; volume, tow depth, and firing pressure for each element; and interactions between different elements in the array. The signatures are summed to obtain the far-field source signature of the entire array in the horizontal plane, which is then filtered into one third-octave frequency bands to compute the source levels of the array as a function of frequency band and azimuthal angle in the horizontal plane (at the source depth), after which it is considered to be an azimuth-dependent directional point source in the far field. Electromechanical sources were modeled on the basis of transducer beam theory, which is often used to estimate beam pattern of the source in the absence of field measurements, and which is described in detail in the modeling report.

It should be noted that source modeling for the boomer source was compared to that for the single airgun. Results of the comparison indicate that the acoustic field modeling results for the airgun adequately approximate the ones for the boomer. Considering the negligible fraction of total surveys conducted using boomers and that the estimated impact from the single airgun is always greater than for the boomer, the single airgun results were used as a conservative substitute for the boomer.

Underwater sound propagation (*i.e.,* transmission loss) as a function of range from each source was modeled using JASCO Applied Sciences' Marine Operations Noise Model (MONM) for multiple propagation radials centered at the source to yield 3D transmission loss fields in the surrounding area. The MONM computes received per-pulse SEL for directional sources at specified depths. MONM uses two separate models to estimate transmission loss.

At frequencies less than 2 kHz, MONM computes acoustic propagation via a wide-angle parabolic equation (PE) solution to the acoustic wave equation (Collins, 1993) based on a version of the U.S. Naval Research Laboratory's Range-dependent Acoustic Model (RAM) modified to account for an elastic seabed (Zhang and Tindle, 1995). MONM–RAM incorporates bathymetry, underwater sound speed as a function of depth, and a geoacoustic profile based on seafloor composition, and accounts for source horizontal directivity. The PE method has been extensively benchmarked and is widely employed in the underwater acoustics community (Collins *et al.,* 1996), and MONM–RAM's predictions have been validated against experimental data in several underwater acoustic measurement programs conducted by JASCO (*e.g.,* Aerts *et al.,* 2008; Funk *et al.,* 2008; Ireland *et al.,* 2009; Blees *et al.,* 2010; Warner *et al.,* 2010). At frequencies greater than 2 kHz, MONM accounts for increased sound attenuation due to volume absorption at higher frequencies (Fisher and Simmons, 1977) with the widely-used BELLHOP Gaussian beam ray-trace propagation model (Porter and Lui, 1994). This component incorporates bathymetry and underwater sound speed as a function of depth with a simplified representation of the sea bottom, as subbottom layers have a negligible influence on the propagation of acoustic waves with frequencies above 1 kHz. MONM–BELLHOP accounts for horizontal directivity of the source and vertical variation of the source beam pattern. Both propagation models account for full exposure from a direct acoustic wave, as well as exposure from acoustic wave reflections and refractions (*i.e.,* multi-path arrivals at the receiver).

These propagation models effectively assume a continuous wave source, which is an acceptable assumption for a pulse in the case of the SEL metric because the energy in the various multi-path arrivals is summed. When significant multi-path arrivals cause broadening of the pulse, the continuous wave assumption breaks down for pressure metrics such as rms SPL. Multipath arrivals can have very different temporal and spectral properties when received by marine mammals (Madsen *et al.,* 2006b).

Models are more efficient at estimating SEL than rms SPL. Therefore, conversions may be necessary to derive the corresponding rms SPL. Propagation was modeled for a subset of sites using a full-wave RAM PE model (FWRAM), from which broadband SEL to SPL conversion factors were calculated using a sliding 100 ms integration window. This window was selected to represent the shortest expected temporal integration time for the mammalian ear (Plomp and Bouman, 1959; MacGillivray *et al.,* 2014). The FWRAM required intensive calculation for each site, thus a representative subset of modeling sites were used to develop azimuth-, range-, and depth-dependent conversion factors. These conversion factors were used to calculate the broadband rms SPL from the broadband SEL prediction at all the modeling sites. Conversion factors were calculated for each modeling location.

For electromechanical source and single airgun propagation modeling, a fixed conversion difference of +10 dB from SEL to rms SPL was applied at all receiver positions, because there was little variability over the range of propagation for these sources. This approach is accurate at distances where the pulse duration is less than 100 ms, and conservative for longer distances. Most of the effects of these sources occur at relatively short distances where the pulse durations are short so this approach is not expected to be overly conservative even for lower-level effects. This is a conservative but reasonable approximation to simplify the variability across all HRG sources, effectively assuming that an HRG transmission is on for only 1/10 of a second for any given second.

As described below, in order to accurately estimate exposure a simulation must adequately cover the various location- and season-specific environments. The surveys may be conducted at any location within the planning area and occur at any time of the year, so simulations must adequately cover each area and time period. We previously introduced the seven zones within which potential exposures were modeled, corresponding with shelf and slope environments subdivided into western, central, and eastern areas, as well as a single and deep zone (Figure 2). The subdivision depth definitions are: Shelf, 0–200 m; slope, 200–2,000 m; and deep, greater than 2,000 m. Within each of the seven zones, a set of representative survey-simulation rectangles for each of the survey types was defined, with larger areas for the ''large-area'' surveys (*i.e.,* deep penetration airgun) and smaller areas for the ''small-area'' surveys (*i.e.,* shallow penetration airgun and HRG). In Figure 2, the smaller numbered boxes represent the survey area extents for the different survey types. The stars represent acoustic modeling sites along western, central, and eastern transects (Figure 2).

A set of 30 sites was selected to calculate acoustic propagation loss grids as functions of source, range from the source, azimuth from the source, and receiver depth. These were then used as inputs to the acoustic exposure model. Geographic coordinates and water column depth of each acoustic modeling site are listed in Table 48 of the modeling report. The environmental parameters and acoustic propagation conditions represented by these 30 modeling sites were chosen to be representative of the prevalent acoustic propagation conditions within the survey extents. Inputs are as follows:

• Water depths throughout the modeled area were obtained from the National Geophysical Data Center's U.S. Coastal Relief Model l. Bathymetry data have a horizontal resolution of approximately 80 x 90 m.

• The top sections of the sediment cover in the GOM are represented by layers of unconsolidated sediments at least several hundred meters thick, with grain size of the surficial sediments following the general trend for sedimentary basins (decreasing with the distance from the shore). For the shelf zone, the general surficial bottom type was assumed to be sand, for the slope zone silt, and for the deep zone clay. In constructing a geoacoustic model for input to MONM, a median grain size value was generally selected. Assumed geoacoustic properties for each zone as a function of depth are presented in Tables 52–55 of the modeling report.

• The sound speed profiles for the modeled sites were derived from temperature and salinity profiles from the U.S. Naval Oceanographic Office's *Generalized Digital Environmental Model V 3.0* (GDEM). GDEM provides an ocean climatology of temperature and salinity for the world's oceans on a latitude-longitude grid with 0.25° resolution, with a temporal resolution of one month, based on global historical observations from the U.S. Navy's Master Oceanographic Observational Data Set. The GDEM temperature-salinity profiles were converted to sound speed profiles.

Variation in the sound speed profile throughout the year was investigated and a set of 12 sound speed profiles produced, each representing one month in the shelf, slope, and deep zones. The set was divided into four seasons and, for each zone, one month was selected to represent the propagation conditions in the water column in each season. Acoustic fields were modeled using sound speed profiles for winter (January–March) and summer (July–September). Profiles for Season 1 (February) provided the most conservative propagation environment because a surface duct, caused by upward refraction in the top 50–75 m (of sound above 500 and 250 Hz, respectively), was present. Ducting of the sound above the relevant frequency cutoffs is important as most marine mammals are sensitive to these sounds and the horizontal far-field acoustic projection from the airgun array sources do have significant energy in this part of the spectrum. Profiles for Season 3 (August or September) provided the least conservative results because they have weak to no sound channels at the surface and are strongly downward refracting in the top 200 m. Only the top 100 m of the water column are affected by the seasonal variation in the sound speed.

Many assumptions are necessary in modeling complex scenarios. When possible, the most representative data or methods were used. When necessary, the choices were made to be conservative so as not to ultimately underestimate potential marine mammal exposures to noise. Assumptions related to acoustic modeling include:

• The environmental input parameters used for transmission loss modeling were from databases that provide averaged values with limited spatial and temporal resolution. Sound speed profiles are averaged seasonal values taken from many sample locations. Geoacoustic parameters (including sediment type, thickness, and reflectivity coefficients) and bathymetric grids are smoothed and averaged to characterize large regions of the seafloor. Local variability, which can be affected by weather, daily temperature cycles, and small-scale surface and sediment details, generally increases signal transmission loss, but was removed by these averaging processes. As a result, the transmission loss could in some cases be underestimated and, therefore, the received levels would be overestimated.

• The acoustic propagation model, MONM, used the horizontal-direction source level for all vertical angles. This may slightly underestimate the true sound levels in the vertical directional beam of the array that ensonifies a zone directly under the array. This is expected to be a minor effect given the small volume over which the reduction occurs. Additionally, there is a steep angle limitation in the PE model used in MONM that also leads to slightly reduced levels directly under the array. The wide-angle PE that is used in MONM is accurate to at least 70 degrees. The reduced-level zone is a cone within a few degrees of vertical, which represents a relatively small water volume that should not significantly affect results.

• Seasons modeled: To account for seasonal variation in propagation, winter (most conservative) and summer (least conservative) were both used to calculate exposure estimates. Propagation during spring and fall was found to be almost identical to the results for summer, so those seasons were represented with the summer results. The primary seasonal influence on transmission loss is the presence of a sound channel, or duct, near the surface in winter.

Marine Mammal Density Information

The best available scientific information was considered in conducting marine mammal exposure estimates (the basis for estimating take). Historically, distance sampling methodology (Buckland *et al.,* 2001) has been applied to visual line-transect survey data to estimate abundance within large geographic strata (*e.g.,* Fulling *et al.,* 2003; Mullin and Fulling, 2004). Design-based surveys that apply such sampling techniques produce stratified abundance estimates and do not provide information at appropriate spatiotemporal scales for assessing environmental risk of a planned survey. To address this issue of scale, efforts were developed to relate animal observations and environmental correlates such as sea surface temperature in order to develop predictive models used to produce fine-scale maps of habitat suitability (*e.g.,* Waring *et al.,* 2001; Hamazaki, 2002; Best *et al.,* 2012). However, these studies generally produce relative estimates that cannot be directly used to quantify potential exposures of marine mammals to sound, for example. A more recent approach known as density surface modeling couples traditional distance sampling with multivariate regression modeling to produce density maps predicted from fine-scale environmental covariates (*e.g.,* DoN, 2007b; Becker *et al.,* 2014; Roberts *et al.,* 2016).

Roberts *et al.* (2016) provided several key improvements over information previously available for the GOM, by incorporating NMFS aerial and shipboard survey data collected over the period 1992–2009; controlling for the influence of sea state, group size, availability bias, and perception bias on the probability of making a sighting; and modeling density from an expanded set of eight physiographic and 16 dynamic oceanographic and biological covariates. There are multiple reasons why marine mammals may be undetected by observers. Animals are missed because they are underwater (availability bias) or because they are available to be seen, but are missed by observers (perception and detection biases) (*e.g.,* Marsh and Sinclair, 1989). Negative bias on perception or detection of an available animal may result from environmental conditions, limitations inherent to the observation platform, or observer ability. Therefore, failure to correct for these biases may lead to underestimates of cetacean abundance (as is the case for NMFS's SARs abundance estimates for the GOM). Additional data was used to improve detection functions for taxa that were rarely sighted in specific survey platform configurations. The degree of underestimation would likely be particularly high for species that exhibit long dive times or are cryptic, such as sperm whales, beaked whales, or *Kogia* spp. In summary, consideration of additional survey data and an improved modeling strategy allowed for an increased number of taxa modeled and better spatiotemporal resolutions of the resulting predictions. More information concerning the Roberts *et al.* (2016) models, including the model results and supplementary information for each model, is available online at *seamap.env.duke.edu/models/Duke-EC-GOM-2015/.*

In the GOM, there are clear differences in marine mammal distribution by water depth, *i.e.,* from shelf to slope and from slope to deep. Division of the modeling area into zones was chosen so that nominal marine mammal densities remain relatively constant over the resulting depth intervals. Density of several species varies within the shelf and slope areas, seemingly correlated with the orientation and differences in the widths of these areas over the east-west extent of the project area. Therefore, shelf and slope zones were divided in western, central, and eastern areas according to BOEM's planning area boundaries (Figure 2). The minimum, maximum, and mean (and standard deviation of the mean) zone-specific marine mammal density estimates, derived from Roberts *et al.* (2016), are shown in Tables 62–68 of the modeling report (with density seeding adjustments). Although sperm whales are sometimes encountered in shallower water, they were depth restricted in the model to waters greater than 1,000 m. Females are rarely seen in waters less than 1,000 m (Taylor *et al.,* 2008), and Wursig (2017) reports a mean encounter depth of 1,732 m, so this is a reasonable restriction. It is important to note that the Zone 6 densities for Bryde's whales (Table 67 in the modeling report) reflect the output of an earlier iteration of the Bryde's whale density model. This earlier iteration predicted the presence of Bryde's whales in Zone 6 (western GOM slope), an area where they are not currently believed to occur, on the basis of two ambiguous *Balaenoptera* spp. sightings from 1992. Subsequently, Roberts *et al.* (2016) revised the model by changing the modeling period from 1992–2009 to 1994–2009 so that those sightings were not included, and also added a bivariate smooth of XY to the model, to concentrate density where sightings were reported (Roberts *et al.,* 2015c). Based on the results of this revised model, Bryde's whales would not be expected to occur in Zone 6 and, on this basis, we have discounted the predicted exposures of Bryde's whales in that zone.

Animal Movement Modeling and Exposure Estimates

The sound received by an animal when near a sound source is a function of the animal's position relative to the source, and both source and animals may be moving. To a reasonable approximation, we know, predict, or specify the location of the sound source, a 3D sound field around the source, and the expected occurrence of animals within 100 km² grid cells (Roberts *et al.,* 2016). However, because the specific location of animals within the modeled sound field is unknown, agent-based animal movement modeling is necessary to complete the assessment of potential acoustic exposure. Realistic animal movement within the sound field can be simulated, and repeated random sampling (Monte Carlo)—achieved by simulating many animals within the operations area—used to estimate the sound exposure history of animals during the operation. Animats are randomly placed, or seeded, within the simulation boundary at a specified density, and the probability of an event's occurrence is determined by the frequency with which it occurs in the simulation. Higher densities provide a finer resolution for an estimate of the probability distribution function (PDF), but require greater computational resources. To ensure good representation of the PDF, the animat density is set as high as is practical, with the resulting PDF then scaled using the real-world animal density (Roberts *et al.,* 2016) to obtain the real-world number of individuals affected.

Several models for marine mammal movement have been developed (*e.g.,* Frankel *et al.,* 2002, Gisiner *et al.,* 2006; Donovan *et al.,* 2013). Animats transition from one state to another, with user-specified parameters representing simple states, such as the speed or heading of the animal, or complex states, such as likelihood of an animal foraging, playing, resting, or traveling. This analysis uses the Marine Mammal Movement and Behavior (3MB) model (Houser, 2006). 3MB controls animat movement in horizontal and vertical directions using sub-models. Travel sub-models determine horizontal movement, including sub-models for the animats' travel direction and the travel rate (speed of horizontal movement). Dive sub-models determine vertical movement. Diving behavior sub-models include ascent and descent rates, maximum dive depth, bottom following, reversals, and surface interval. Bottom following describes the animat's behavior when it reaches the seafloor, for example during a foraging dive. Reversals simulate foraging behavior by defining the number of vertical excursions the animat makes after it reaches its maximum dive depth. The surface interval is the amount of time an animat spends at the surface before diving again. 3MB allows a user to define multiple behavioral states, which distinguish between specific subsets of behaviors like shallow and deep dives, or more general behavioral states such as foraging, resting, and socializing. The transition probability between these states can be defined as a probability value and related to the time of day. The level of detail included depends on the amount of data available for the species, and on the temporal and spatial framework of the simulation.

Parameter values to control animat movement are typically determined using available species-specific behavioral studies, but the amount and quality of available data varies by species. While available data often provides a detailed description of the proximate behavior expected for real individual animals, species with more available information must be used as surrogates for those without sufficient available information. In this study, pantropical spotted dolphins are used as a surrogate for Clymene, spinner, and striped dolphins; short-finned pilot whales are surrogates for Fraser's dolphins, *Kogia* spp., and melon-headed whales; and rough-toothed dolphins are surrogates for false killer whales and pygmy killer whales. Observational data for all remaining species in the study were sufficient to determine animat movement. The use of surrogate species is a reasonable assumption for the simulation of proximate or observable behavior, and it is unlikely that this choice adds more uncertainty about location preference. Species-specific parameter values are given in Tables D–1 to D–18 of the modeling report.

Species-specific animats were created with programmed behavioral parameters describing dive depth, surfacing and dive durations, swimming speed, course change, and behavioral aversions (*e.g.,* water too shallow). The programmed animats were then randomly distributed over a given bounded simulation area; boundaries extend at least one degree of latitude or longitude beyond the extent of the vessel track to ensure an adequate number of animats in all directions, and to ensure that the simulation areas extend beyond the area where substantial behavioral reactions might be anticipated. Because the exact positions of sound sources and animals are not known in advance for proposed activities, multiple runs of realistic predictions are used to provide statistical validity to the simulated scenarios. Each species-specific simulation was seeded with approximately 0.1 animats/km^2 which, in most cases, represents a higher density of animats in the simulation than occurs in the real environment. A separate simulation was created and run for each combination of location, survey movement pattern, and marine mammal species. Representative survey patterns were described under ''Detailed Description of Activities.''

During all simulations in this modeling effort, any animat that left the simulation area as it crossed the simulation boundary was replaced by a new animat traveling in the same direction and entering at the opposite boundary. For example, an animat heading north and crossing the northern boundary of the simulation was replaced by a new animat heading north and entering at the southern boundary. By replacing animats in this manner, the animat modeling density remained constant. Animats were only allowed to be 'taken' once during a 24-hr evaluation period. That is, an animat whose received level exceeds the peak SPL threshold more than once during an evaluation period was only counted once. Energy accumulation for SEL occurred throughout the 24-hr integration period and was reset at the beginning of each period. Similarly, the maximum received rms SPL was determined for the entirety of the evaluation period and reset at the beginning of each period.

In Figure 2, the large transparent boxes represent the seven defined modeling areas (animal simulation extents) within the seven zones. During the survey simulations, the source was moved within the smaller survey area extents, but the sound output would ensonify a larger area (represented by the animal simulation extents). These animat simulation boxes set the geographic limits of the 3MB simulation.

For the large-area surveys, injury simulation boxes extend outward (north, south, east, and west) by 10 km from the survey limits, a distance over which the unweighted received levels drop below 160 dB SEL for a single shot. The behavior simulation boxes, on the other hand, extend outward by 50 km from the survey limits, a distance necessary to ensure that the animat movement modeling extends out to where the weighted received levels drop to 120 dB rms SPL or lower, and below 160 dB SEL for unweighted received levels. Geographic extent of the boxes is shown in Tables 59–60 of the modeling report.

The received levels for the single airgun and electromechanical sources drop off much more quickly with range than for the airgun array sources discussed above. Consequently, the 3MB simulation boxes for the small-area surveys were extended to 10 km from the center of the survey in each cardinal direction, a much larger distance than that required for the received level conditions, but one that supports more realistic animal movements. Geographic extent of the boxes is shown in Table 61 of the modeling report.

The JASCO Exposure Modeling System (JEMS) combines animal movement data (*i.e.,* the output from 3MB), with pre-computed acoustic fields. The JEMS output was the time-history of received levels and slant ranges (the three dimensional distance between the animat and the source) for all animats of the 3MB simulation. Animat received levels and slant ranges are used to determine the risk of acoustic exposure. JEMS can use any acoustic field data provided as a 3D radial grid. Source movement and shooting patterns can be defined, and multiple sources and sound fields used. For impulsive sources, a shooting pattern based on movement can be defined for each source, with shots distributed along the vessel track by location (or time). Because the acoustic environment varies with location, acoustic fields are pre-computed at selected sites in the simulation area and JEMS chooses the closest modeled site to the source at each time step. There were many animats in the simulations and together their received levels represent the probability, or risk, of exposure for each survey.

All survey simulations were for 7 days and a sliding 4-hr window approach was used to get the average 24-hr exposure. In this sliding-windows approach, 42 exposure estimate samples are obtained for each seven-day simulation, with the mean value then used as the 24-hr exposure estimate for that survey. The 24-hr exposure levels were then scaled by the projected level of effort for each survey type (*i.e.,* multiplied by the number of days) to calculate associated annual exposure levels. The number of individual animals expected to exceed threshold during the 24-hr window is the number of animats exposed to levels exceeding threshold multiplied by the ratio of real-world animal density to model animat density.

As described above for acoustic modeling, assumptions and choices must be made when modeling complex scenarios:

• *Social grouping:* Marine mammals often form social groups, or pods, that may number in the hundreds of animals. Although it was found that group size affects the distribution of the exposure estimates (see Test Scenario 2, below), the mean value of the exposure estimate was, generally, unchanged. Because the annual exposure estimates are meant to represent the aggregate of many surveys conducted in many locations at various times throughout the year, it is the mean exposure estimates that are most relevant. For this reason, social group size was not included in the exposure estimates.

• Mitigation procedures, such as shutting down an airgun array when animals are detected within an established exclusion zone, can reduce the injury exposure estimates. Mitigation effectiveness was found to be influenced by several factors, most importantly the ability to detect the animals within the exclusion zone. Some species are more easily detected than others, and detection probability varies with weather and observational set-up. Weather during any seismic survey is unknown beforehand and detection probabilities are difficult to predict, so the effects of mitigation were not included in the exposure estimates (see Test Scenario 3, below).

• Aversion is a context-dependent behavioral response affected by biological factors, including energetic and reproductive state, sociality, and health status of individual animals. Animals may avoid loud or annoying sounds, which could reduce exposure levels. The effect of aversion itself can be considered as a take (Level B harassment) that results in avoidance of potential for more serious take (Level A harassment). Currently, too little is known about the factors that lead to avoidance (or attraction) of sounds to quantify aversive behavior for these activities when modeling marine mammal exposure to sound (see Test Scenario 4, below). However, we include an aversion factor in defining the level of take that may occur, as compared with the modeled exposure estimates.

Injury—To evaluate the likelihood an animal might be injured as a result of accumulated sound energy, the cSEL for each animat in the simulation was calculated. To obtain that animat's cSEL, the SEL an animat received from each source over the 24-hr integration window was summed, and the number of animats whose cSEL exceeded the specified thresholds (Table 7) during the integration window was counted. To evaluate the likelihood an animal might be injured via exposure to peak SPL, the range at which the specific peak SPL threshold occurs (Table 7) for each source based on the broadband peak SPL source level was estimated. For each 24-hr integration window, the number of animats that came within this range of the source was counted.

Behavior—To evaluate the likelihood an animal might experience disruption of behavioral patterns (*i.e.,* a ''take''), the number of animats that received a maximum rms SPL exposure within the specified step ranges (Table 6) was calculated. The number of animats with a maximum rms SPL received level categorized into each bin of the step function was multiplied by the probability of the behavioral response specific to that range (Table 6). Specifically, 10 percent of animals exposed to received levels from 140–159 dB rms would be assumed as ''takes,'' while 50 percent exposed to levels between 160–179 dB rms and 90 percent exposed to levels of 180 dB rms and above would be. The totals within each bin were then summed as the total estimated number of exposures above behavioral harassment thresholds. This process was repeated for each 24-hr integration window.

Potential for disruption of behavioral patterns was also evaluated using NMFS's standard 160 dB rms criterion. To evaluate this likelihood, the exposure simulation was set to use unweighted rms SPL acoustic fields. The number of animats that received an exposure greater than 160 dB was counted as the number of behavioral responses. However, note that the modeling report also separately evaluated exposures at received levels exceeding 180 dB rms; therefore, the true number of exposures greater than 160 dB rms would be the sum of separately calculated exposures between 160 and 180 dB and greater than 180 dB. As with the other criteria, the animat received level was reset at the beginning of each 24-hr integration window. Please see Zeddies *et al.* (2015) for exposure results relating to the 160-dB rms criterion. The methods did not account for potential habituation, whereby severity of behavioral reactions to a stimulus may be reduced due to reduced sensitivity in individual animals from repeated exposure over time. However, we are not aware of any literature suggesting that marine mammals in the wild and away from areas with consistent industrial activity (*e.g.,* ports) become habituated to noise or of any method by which such theoretical habituation could be modeled.

Test Scenarios

As described above, Phase I of the modeling effort involved preliminary modeling of a typical 3D WAZ survey (all survey parameters were described under ''Detailed Description of Activities''), which was simulated at two locations in order to establish the basic methodological approach and to provide results used to evaluate test scenarios that could influence exposure estimates. We provide a summary of each of the six evaluated test scenarios below. For all test scenarios, please see the modeling report for full details.

Locations considered were both near the Mississippi Canyon, including a site centered on the slope of the continental shelf break and a site centered on the deep ocean plain (please see Figure 10 in Zeddies *et al.* (2015)). A reduced suite of six representative species were included in the Phase I effort: Bryde's whale, sperm whale, Cuvier's beaked whale, bottlenose dolphin, dwarf sperm whale, and short-finned pilot whale. Bryde's whales and dwarf sperm whales were chosen as the only low-frequency species in the GOM and as the representative high-frequency species, respectively. The four mid-frequency species were chosen to represent various other aspects of diving and hearing sensitivity. Cuvier's beaked whales are deep-diving and behaviorally sensitive to sound, while sperm whales are also deep-diving and are a unique species in the GOM behaviorally. Short-finned pilot whales and bottlenose dolphins both represent the swimming behavior of smaller cetaceans with different preferred water depths. Note that, for this preliminary modeled scenario, density estimates were obtained from DoN (2007b), as Roberts *et al.* (2016) was not yet available. Full details of the preliminary modeling are available in the modeling report.

To evaluate potential behavioral response, 30-day simulations of the hypothetical 3D WAZ survey were run at both sites for each of the species evaluated. The boundaries of the simulation were determined from transmission loss calculations, and were set at 50 km from the source.

Test Scenario 1 (Long-duration Surveys and Scaling Methods)—Some surveys operate (nearly) continuously for months. Evaluating the potential impacts due to underwater sound exposures from these extended operations is challenging because assumptions about parameters that are valid for short-duration simulations may become less valid, or more varied, as the time period increases. Treating parameters such as sound velocity profile or large-scale animal movement as constant over longer durations, as is typically done in shorter duration simulations, could lead to errors. However, there is no information indicating that species migrate regularly on a large-scale in the GOM; thus, large-scale movement was not integrated into the animal movement model. Therefore, a test scenario was used to evaluate possible systematic bias in the modeling process, and methods for scaling results from shorter-duration simulations to longer duration operations were suggested.

Exposure estimates from 30-day and 5-day simulations, using different animat seeding values (0.1 and 2.0 animats/km^2, respectively), were determined in subsets using a 'sliding window' to find the number of exposures as a function of time. The 30-day simulation was used to evaluate exposures against the rms SPL criteria, and the 5-day simulation was used to evaluate exposures against the peak SPL and cSEL criteria. The length of the sliding window was 24 hr, advanced by 4 hr, resulting in 174 samples from the 30-day simulation and 25 samples from the 5-day simulation. A sliding window of 7 days advancing by 1 day for the 30-day simulation was also evaluated. Bias in the model was expected to manifest itself as a trend in the exposure levels as a function of time.

To investigate potential systematic, and possibly unknown, biases in the modeling procedure, behavioral exposure estimates were determined for subsets of the simulations. Behavioral exposure estimates were determined as a function of time by finding the number of exposures occurring in 24-hr subsets using a sliding window that advanced in 4-hr increments. Trends were evident, particularly at the slope site, but the trends appeared to be the consequence of survey design, such as changing sound fields as the vessels move into different acoustic zones. For sperm whales, there was an additional bias due to their general avoidance of water depths less than 1000 m. The area of the slope site began at a location with water depth approximately 1,500 m, but proceeds to depths less than 200 m. Therefore, fewer sperm whale animats were within exposure range of the source later in the simulation. To determine if undesired, and unknown, systematic biases exist in the modeling procedure, simulations were run with the source stationary and with no limiting bathymetric constraints. No clear trends were found, indicating that undesired systematic biases in the modeling procedure, if present, were small relative to the survey design and would not affect scaling up the results in time, if applied.

The number of animats exposed to levels exceeding threshold for 24-hr time periods multiplied by the number of days in the simulations was compared to the number of animats exposed to levels exceeding threshold for the entire duration of the simulations. Given that an animat represents an individual marine mammal, scaling up the 24-hr average SPL exposure estimates to 30 days greatly overestimates the number of individual marine mammals exposed to levels exceeding threshold when determined over the entire simulation (although the estimated instances of exposure are reasonably accurate). This occurs because animats were commonly exposed to levels exceeding these thresholds and the relatively short reset period of 24-hr means that individual animats were, in effect, counted several times during the scale-up (*i.e.,* on multiple days) that would only have been counted once when evaluating over the entire simulation. Comparison between the full-duration estimate (obtained through modeling the full survey duration) and the estimate developed through ''scaling'' the 24-hr exposure estimate allows for better interpretation of the exposure estimates, *e.g.,* through a refined estimate of the number of individuals exposed above behavioral harassment criteria (versus instances of exposure) and the average number of days on which those exposures occur (described below in ''Description of Exposure Estimates''). Because SEL is an accumulation of energy, evaluating over a longer period (*e.g.,* summing accumulation over 30 days) could result in more animats exposed to levels exceeding SEL thresholds than when evaluated over a shorter period (unlike as described above for SPL metrics).

The systematic trends evident in the modeling procedure indicated that survey design can affect exposure estimates when scaling is used. Therefore, the minimum duration of a simulation should include all of the acoustic environments likely to be encountered during the operation. The test scenario produced the following recommendations, which were employed during the Phase II modeling effort: (1) Identify the shortest large-scale animal movement time-period (*e.g.,* seasonal migration); (2) Identify acoustic environments over which the survey will occur (*e.g.,* shallow, slope, deep, and associated geoacoustic parameters); (3) Identify the minimum period of validity for the acoustic model (*e.g.,* month due to changing sound velocity profile); (4) Break the survey into parts that are shorter in duration than both large-scale animal movement times and the period of acoustic model validity; (5) Create animal movement simulations for acoustic exposure with adequate duration to meaningfully sample the exposure-estimating parameter (*e.g.,* for a 24-hr reset period, enough samples should be obtained to get a reliable mean value given the various acoustic environments); (6) If the simulation time is less than the duration of the survey parts determined in Step 4, then scale the results by the ratio of survey duration to simulation time (*e.g.,* if the simulation time is one week, but the survey division is 28 days, then multiply the simulation exposure results by four); and (7) Sum, or aggregate, the results from the survey parts to calculate exposures for the entire survey.

This test scenario also illustrated that knowing the amount of time that animals are exposed to levels exceeding the threshold criteria can provide additional information about the potential impacts of the activity. For example, the amounts of time that animats were exposed to levels exceeding 160 dB rms SPL over the 30-day duration were approximately twice as long as the average times in a 24-hr window, as it was common for the threshold to be exceeded on multiple separate occasions. Two factors contributed to the total time thresholds were exceeded—the amount of time per occasion (*i.e.,* how long an animat was near the source) and the number of occasions that occur (*i.e.,* how many times an animat was near a source). The number of occasions was, essentially, the same item determined when finding the number of animats with exposures exceeding threshold criteria (the typical use of the threshold criteria). The number of occasions scales with the duration of the evaluation period, but the time per occasion does not, and is specific to how an individual animat interacted with a source. Information provided through this investigation was used to derive scaler values (described below in ''Description of Exposure Estimates'') for use in determining the expected number of individuals represented by a sum total of exposures generated through the scaling of 24-hr exposures up to match the total duration of a modeled survey.

Test Scenario 2 (Sources and Effects of Uncertainty)—The modeling process requires the use of simplifying assumptions about oceanographic parameters, seabed parameters, and animal behaviors. These assumptions carry some uncertainty, which may lead to uncertainty in the form of variance or error in individual model outputs and in the final estimates of marine mammal acoustic exposures. For example, acoustic propagation models assume a specific shape of the sound speed profile in the ocean (speed of sound versus depth) for each season. We know, however, that the real sound speed profile regularly changes and that substantial variation within a season is possible. The assumption that a single profile represents the environment through a full season approximates real-world cases but can, to some degree, cause errors. The uncertainty in model outputs caused by approximations like this can be investigated by examining how much the outputs change when the inputs are purposely offset. ''Parametric uncertainty analysis'' provides a means to characterize the accuracy, or uncertainty, of the model results in light of errors in model inputs and can also be used to characterize the expected variability in model results due to natural variations in some of the input parameters. Use of resampling techniques can quantify the effects of uncertainty in exposure estimates due to uncertainty in acoustic and animal movement models. Uncertainty related to acoustic modeling can be introduced through source characterization modeling; acoustic propagation modeling; and selection of inputs for sound speed profiles, geoacoustic parameters, bathymetry, and sea state. Uncertainty in animal modeling can be introduced through incomplete knowledge regarding animal locations and behavioral/motivational states. Both the uncertainty in acoustic modeling and uncertainty in the animal modeling contribute to overall uncertainty in the exposure estimates. Please see the modeling report for full details of these investigations.

Zeddies *et al.* (2015) describe uncertainties in the acoustic field as representing a multi-dimensional envelope that can be wrapped around the main modeling results. This envelope is meant to enclose the modeled acoustic field and the real world acoustic field. The uncertainties in the different dimensions of this envelope (sound speed profile, geoacoustics, bathymetry, and sea state) cannot be summed to yield a ''total'' uncertainty as this would be a meaningless quantity. The overall uncertainty is measured for the volume of the multi-dimensional uncertainty envelope, but this is a difficult concept to use in operational planning. The best way to visualize the overall uncertainty is in terms of the different dimensions of the uncertainty envelope, which range from inconsequential (*e.g.,* effects of sea state) to greater than 10 dB between median and maximum propagation scenarios in the shelf zone due to uncertainty in the sound speed profile.

With regard to uncertainty relating to animal movement parameters, comparisons between animals generally resulted in similar exposure estimates when the same filtering and thresholds were applied. The exposure estimates for bottlenose dolphins, short-finned pilot whales and, to some extent, sperm whales were similar. For sperm whales, however, the behavioral depth restriction for this species (animats do not enter water depths less than 1,000 m) resulted in differences. Sperm whales also showed greater potential of behavioral response to noise exposure than other species with the same auditory thresholds. Sperm whales are deep divers; in this downward refracting environment they appear to receive consistently greater exposures relative to shallow diving species.

In order to address overall uncertainty in the exposure estimates resulting from combined uncertainty due to both acoustic and animal modeling, a ''bootstrap'' resampling process was used in which relevant uncertainty could be added to animats' received levels. For example, for potential auditory injury, the primary acoustic uncertainty was the source level variance. Airguns are designed to have low inter-shot variability and predicted source levels within 3 dB. A conservative estimate of ±3 dB standard deviation was used to investigate the effects of source level variance on SEL injury exposure estimates. While the mean number of animats above SEL threshold increased relative to the expected value, the exposure estimate distributions did not change much. For potential behavioral disturbance, propagation uncertainty (due to the greater ranges involved) also contributes to the uncertainty in the acoustic modeling predictions; therefore, 6 dB was chosen as a test to include both the source variance plus uncertainty due to propagation. The mean behavioral disruption estimates and the distribution ranges stayed approximately the same when ± 6dB of acoustic variability was included. During resampling, acoustic uncertainty can be combined with real-world density (mean ± standard deviation) and social group size (mean ± standard deviation). In general, the uncertainty associated with the animals (density and group size) does not change the mean exposure estimate, but can affect the exposure estimate distribution.

Test Scenario 3 (Mitigation Effectiveness)—With reference to detection-based mitigation, effectiveness at reducing marine mammal exposure to potentially injurious sound levels is unknown. Mitigation effectiveness corresponds with the ability to detect an animal in the relevant zone. Detectability, and consequently mitigation efficacy, depends on the species, potentially individual animal characteristics, survey configuration, and environmental conditions. Mitigation effectiveness was evaluated using a modeling approach to quantify the potential reduction in the numbers of exposures at or above Level A harassment thresholds for selected species by comparing acoustic exposure estimates with and without mitigation (array shutdown). For each of the six species considered in the preliminary modeling, a range of detection probabilities (*i.e., g*(0)) was considered. The positions of animats in the simulation are known and reported in short time steps. The detection probability, however, is the probability of detecting an animal along the trackline as the survey passes through an area, rather than for an individual time step. For this evaluation, *g*(0) is used as estimate of the detection probability for animats near the surface and close to the vessel.

Level A harassment exposure estimates associated with the 5-day survey simulation were calculated with and without a mitigation procedure. Exposure estimates were computed relative to SEL and peak SPL exposure criteria. Airgun shutdown was modeled by zeroing all animat received levels when an animat was detected within an exclusion zone, with detection registered when the horizontal range of an animat from the source was less than 500 m, its depth was less than 50 m, and a random draw from a uniform distribution between 0 and 1 indicated detection. If the random value was less than the assumed *g*(0), the detection was registered, the time of the closest point of approach (CPA) was found, and the received levels for all animats were zeroed for 30 minutes before and after the CPA. For the purposes of the simulation, it was assumed that portions of the survey line missed during shutdown were re-surveyed (*i.e.,* shutdowns result in an increase in the overall survey duration in order to keep the distance surveyed the same as the unmitigated case). Shutdown was assumed to occur only for the source array around which the animat was detected. Other sources present in the simulation continued operating. Model simulations were run for detection probabilities of 0.05 to 0.45 (increments of 0.05) and 0.5 to 0.9 (increments of 0.1) to simulate a reasonable range of probabilities for cryptic species and other species, respectively.

The inclusion of mitigation procedures in the simulations reduced the numbers of exposures based on peak SPL criteria for five out of six species and detection probabilities considered, even though an extension in the survey period due to line re-shoot was taken into account. The exception was Bryde's whales, due to low real-world density values. Mitigation effectiveness, expressed as the reduction in the number of individual animals exposed, was generally related to animal densities; species with higher densities were more often exposed and the reduction in the number of exposures from mitigation was greater. As expected, the percentage reduction in exposures for species with relatively high detection probability was higher than the percentage reduction for species with relatively low detection probability.

The usefulness of mitigation depends on species characteristics and environmental conditions, meaning that there is a high degree of inherent variability (and potential error) involved in attempting to predict some reduction in potential exposures resulting from mitigation effectiveness. Reductions due to mitigation for easily-detected species with large populations may be large in terms of percentage decrease (assuming shutdown is a required measure) while, for low-density species that are difficult to detect in rough seas, there may be little realistic mitigation effect. Further, for deep-diving species with unreliable vocal rates, a very conservative estimate of mitigation effectiveness should be used. Ultimately, on the basis of these findings, quantification of mitigation effectiveness was not incorporated into the Phase II modeling effort (*i.e.,* is not reflected in the modeled exposure estimates).

Test Scenario 4 (Effects of Aversion)—Animal behavior in response to sound exposure may vary widely, but if sounds are perceived as a threat or an annoyance, animals might temporarily or permanently avoid the area near the source (*e.g.,* Southall *et al.,* 2007; Ellison *et al.,* 2012)—a phenomenon referred to as aversion. Aversive responses to sounds are of particular interest here because such behavior could decrease the number of injuries that result from acoustic exposure in the real world. If aversion occurs at a received level lower than that considered an injurious exposure, a decrease in the corresponding number of estimated exposures above Level A harassment criteria can be assumed. The degree of aversion and level of onset for aversion, however, are poorly understood.

As for mitigation effectiveness, a test scenario was investigated using a modeling approach to quantify the potential reduction in injury exposure estimates due to aversion. Aversion is simulated as a reduction in received levels and, because little is known about the received levels at which animals begin to avert, the sound levels and probabilities used to evaluate potential behavioral disturbance are used to approximate aversion. However, it is possible that aversion could occur at greater or lesser received sound levels, depending on the context and/or motivation of the animal. It is important to note that, as considered here, aversion itself can represent a behavioral disruption; therefore, aversion is only meaningful in reducing the potential for injury, *i.e.,* those animals that avert may have avoided Level A harassment, but would have nevertheless experienced Level B harassment.

Injury exposure estimates associated with the 5-day 3D WAZ simulation were determined with and without aversion. The difference in the mean value of the exposure estimate distributions with and without aversion indicates the effect of aversion on the injury exposure estimates. Each animat sampled during the bootstrap resampling process has an associated exposure history, *i.e.,* a time series of received sound levels arising from relative motion of the source and animat. These exposure histories were computed assuming the animats' behaviors were otherwise unaffected by their received sound levels. Each exposure history was then modified based on received-level dependent probabilities of averting:

- *Step 1:* For each bootstrap sample, the occurrence of aversion was determined probabilistically based on the exposure level and the probability of aversion defined according to the function described previously (Table 6) for both SEL and peak SPL. An iteration-specific aversion efficacy was also chosen randomly from a uniform distribution in the range of 2–10 dB.
- *Step 2:* Animats for which aversion occurred in Step 1 had their received levels adjusted as described in the following steps. The received levels were unchanged for animats that did not avert.
- *Step 3:* For an animat entering an averted state, the aversion level excesses (the levels above the threshold that prompted aversion) until the end of the aversion episode were calculated from the difference between the received level at the start of aversion and the threshold level at which aversion began up to a maximum of 5 dB.
- *Step 4:* The adjusted received level during aversion was set to the greater of two quantities: (1) The received level minus the aversion efficacy (from Step 1), or (2) the threshold level plus the aversion level excess at the start of aversion (from Step 3).

Adjusted exposure histories were computed separately for each source, animat, and episode of aversion; each occurrence of aversive behavior was thus independent. Although the probability of aversion was defined in terms of the rms SPL, exposure histories were recorded in terms of the per-pulse SEL. A nominal conversion offset of +10 dB from SEL to rms SPL was used so the two metrics could be compared. Cumulative SELs over the 5-day simulation, were weighted using Type I filters for Bryde's whales and Type II filters for mid- and high-frequency cetaceans, but behavioral effects were estimated using Type I filters for all species, with appropriate adjustments made to the 5-day SEL exposure histories. The mean time spent in an averted state for four of six species were approximately 18 and 4 min for the slope and deep sites, respectively. For beaked whales, the means were 41 and 19 min. Too few Bryde's whale animats exceeded threshold to obtain a reliable statistical measure.

Aversion in the simulations reduced the numbers of exposures based on peak SPL criteria for most species. Aversion effectiveness, as measured by the percentage reduction in the exposure estimates, could be high: Approximately 85 percent for bottlenose dolphins, Cuvier's beaked whales, short-finned pilot whales, and sperm whales, and 40 percent for dwarf sperm whales. Bryde's whales, whose real-world densities were so low that no exposures were modeled even in the absence of aversion, were the exception. The numbers of exposures based on SEL criteria were near zero for most species even without aversion. The reduction in exposures was influenced by the criteria used to estimate exposures and by the assumptions made with respect to aversion probability. For example, although the real-world densities of dwarf sperm whales (a high-frequency cetacean) are similar to those for Cuvier's beaked whales (a mid-frequency cetacean), exposure estimates and the decrease in number of exposure estimates arising from aversion were different. The differences in aversion effectiveness reflect differences in injury threshold criteria and aversion probability. Ultimately, the effects of aversion were not quantified in the Phase II modeling due to lack of information regarding species-specific degree of aversion and level of onset.

Test Scenarios 5–6 (Separation Distance and Simultaneous Source Firing)—Geophysical surveys using airgun arrays may use survey designs that involve multiple source vessels separated by tens of meters to several kilometers, while newer technology has allowed for different surveys to be performed closer together than previously. Due to the possibility that the combined sound pressure levels of multiple airgun arrays operated close to one another could lead to increased noise effects than would occur with a single source, these scenarios were designed to address the issue of the aggregate noise produced by multiple airgun arrays and the potential for those signals to combine and lead to larger effects.

The investigations found that while SEL increases for overlapping surveys, injury due to accumulated energy is a rare event, and threshold exceedance resulted from a few high-level exposures near a source rather than an accumulation of many lower-level exposures. The range to injury assessed by peak SPL is up to a few hundred meters and does not accumulate. Injury in typical airgun surveys, therefore, occurs mainly because of a close encounter with a single airgun array. There are practical limits to how close two acquisition lines can be without one survey source interfering with the other survey's recordings. Depending on the survey type and the propagation environment of the area, the stand-off distance between fully concurrent surveys operating independently may be several tens of kilometers. If two surveys are conducted in closer proximity, then the operators will generally agree to ''time-sharing'' strategies whereby, for example, one survey acquires a line while the other completes a line turn with the source inactive, or similar ways of minimizing the amount of missed effort. Effects of overlapping surveys on injury exposure estimates are unlikely.

For potential behavioral disturbance, overlapping surveys may affect exposure estimates, but the effect is either small or potentially negative (reducing the overall number of estimated exposures). Because coincident reception in which the sound level increases appreciably occurs only in small portions of the ensonified volume, overlapping survey sound fields do not generally result in higher maximum received sound pressure levels. And, because animals may only be ''taken'' once within a 24-hr window, animals exposed in more than one survey are only counted once in the aggregate of the surveys. This does not preclude possible behavioral effects of animals spending more time above threshold, but such effects are not addressed by existing criteria.

From an energetic perspective, the relative firing pattern of different arrays does not matter. The same SEL will be registered when two arrays are alternated or fired simultaneously. For the pressure-based metrics, peak SPL and rms SPL, simultaneous firing can increase the received levels, but in only a small portion of the ensonified volume. Because the maximum received levels are rarely increased, the exposure estimates based on SPL are rarely increased. The most likely place for meaningful summation to occur is very near the source, and in that case the firing pattern would be included in the simulation and therefore in the exposure estimates.

In summary, neither separation distance nor simultaneous firing is of significant concern when estimating exposures using the current criteria.

Modeling Issues

NMFS is aware of criticism that the modeling results are unrealistic or overly conservative (*e.g.,* ''biased modeling based on flawed assumptions''). For example, we received public comment in response to our **Federal Register** notice of receipt of the petition from the IAGC, API, National Ocean Industries Association, and Offshore Operators Committee (hereafter referred to as ''the Associations''). The Associations quote certain statements made by BOEM in its draft Programmatic EIS (*e.g.,* ''an overly conservative upper limit,'' exposure estimates are ''higher than BOEM expects would actually occur in a real world environment,'' modeling results represent a ''worst-case scenario''). NMFS strongly disagrees with these characterizations. While the modeling required that a number of assumptions and choices be made by subject matter experts, some of these are purposely conservative to minimize the likelihood of underestimating the potential impacts on marine mammals represented by the level of effort specified by the applicant. The modeling effort incorporated representative sound sources and projected survey scenarios (both based on the best available information obtained through BOEM's consultation with members of industry as well as historical permit application data), physical and geological oceanographic parameters at multiple locations within the GOM and during different seasons, the best available information regarding marine mammal distribution and density, and available information regarding known behavioral patterns of the affected species. Current scientific information and state-of-the-art acoustic propagation and animal movement modeling were used to reasonably estimate potential exposures to noise. NMFS's position is that the results of the modeling effort represent a conservative but reasonable best estimate, not a ''worst-case scenario.''

We call attention to our own public comments submitted to BOEM following review of the draft PEIS: ''[NMFS] disagrees that the PEIS analysis is based on the 'upper limit' of potential marine mammal exposures to sound produced by [survey] activities. The PEIS provides no reasonable justification as to why the exposure estimates [. . .] should be considered as 'conservative upper limits', represent an 'overestimate,' or are 'unrealistically high.' [NMFS] believes that the exposure estimates represent a conservative but reasonable best estimate [. . . .] [NMFS] disagrees that 'each of the inputs into the models is purposely developed to be conservative.' Although it may be correct that conservativeness accumulates throughout the analysis, BOEM has not adequately described the nature of conservativeness associated with model inputs or to what degree (either quantitatively or qualitatively) such conservativeness 'accumulates.' While exposure modeling is inherently complex, complexity does not inherently result in overestimation of exposures [. . . .] [NMFS] strongly disagrees that the exposure estimates are 'overly conservative,' are 'upper limits,' or that these estimates are in some way differentiated from what might actually be expected to occur.'' Finally, we note that BOEM's final PEIS removed erroneous statements and provided additional clarification regarding descriptions of the modeling results to more accurately describe the nature of the results as a conservative but reasonable best estimate, consistent with NMFS's comments on the draft PEIS.

IAGC and API contracted with JASCO Applied Sciences, who performed the modeling effort, to conduct additional analysis regarding the effect that various acoustic model parameters or inputs have on the outputs used to estimate numbers of animals exposed to threshold levels of sound from geophysical sources used in the GOM (''*Gulf of Mexico Acoustic Exposure Model Variable Analysis;*'' Zeddies *et al.,* 2017b). The results of this analysis were not made available to NMFS in time to fully consider them in preparing these proposed regulations. However, the report is available online for public review (*www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-oil-and-gas*) and we expect to consider these results as appropriate in developing a final rule. The primary finding of Zeddies *et al.* (2017b) is that use of appropriate acoustic injury criteria (*i.e.,* NMFS, 2016) and quantitative consideration of animal aversion and mitigation effectiveness decrease predictions of injurious exposure. As described herein, we have used acoustic criteria for both Level A and Level B harassment that reflect the best available science, and have incorporated reasonable correction for animal aversion.

Here, we address some specific issues regarding the modeling assumptions and briefly address the results provided by Zeddies *et al.* (2017b):

• Representative large array. The Associations state that the selected array (8,000 in^3) is unrealistically large, resulting in an overestimation of likely source levels and, therefore, size of the sound field with which marine mammals would interact. Zeddies *et al.* (2017b) evaluated the use of a substitute 4,130 in^3 array, finding that reduction in array volume reduces the number of predicted exposures. Use of a smaller airgun array volume with lower source level creates a smaller ensonified area resulting in fewer numbers of animals expected to exceed exposure thresholds.

The particular array was selected as a realistic representative proxy after BOEM's discussions with individual geophysical companies. An 8,000-in^3 array was considered reasonable, as it falls within the range of typical airgun arrays currently used in the GOM, which are roughly 4,000–8,400 in^3 (BOEM, 2017). According to BOEM's permitting records, approximately one-third of arrays used in a recent year were 8,000 in^3 or greater. More importantly, the horizontal modeling of the 8,000-in^3 array should give sound pressure results similar to other configurations. The output of an airgun array is directly proportional to the firing pressure and to the number of elements. However, the sound pressure (peak amplitude) generated by the array is not linear but instead is proportional to the cube root of the volume of that array. For example, doubling the size of the airgun array from 4,000 to 8,000 in^3 would be expected to add approximately 3 dB to the source pressure level. Thus, an 8,000 in^3 array produces only about twice the loudness of a 1,000 in^3 array, assuming similar parameters such as the number of elements and the spatial dimensions of the array. This volume to loudness ratio holds for the sizes of single elements as well, *e.g.,* a 240-in^3 element only generates twice the peak pressure level of a 30-in^3 element (not eight times the level). It is primarily the frequency components of the source signals that differ with size, *i.e.,* larger elements produce more low-frequency sound. It should also be noted that airgun arrays are configured geometrically so as to direct energy downward into the seafloor (known as tuning the array); the model fully recognizes this directionality and accounts for the lower sound energy radiated at shallower angles and at specific bearings in computing the exposure levels.

The exact configuration of the 4,130 in^3 array evaluated by Zeddies *et al.* (2017b) is not provided. Assuming that it is roughly symmetrical to the 8,000 in^3 array modeled by Zeddies *et al.* (2015, 2017a), and using the scaling laws where only total volume applies, the larger array would be expected to be about 2 dB louder. Contrary to this estimate, Zeddies *et al.* (2017b) report a 7.3 dB difference in source levels, a result that cannot be completely understood given the information provided by Zeddies *et al.* (2017b). One identified issue is that the source level for the smaller array (247.9 dB) is for a broadside prediction, while the source level for the larger array (255.2 dB) is for the endfire prediction. The broadside source level for the larger array is predicted to be 248.1 dB, which is reasonably close to that of the smaller array (*i.e.,* within 2 dB difference). The broadside value may be a better representation of source level for the main beams which are directed downward, while the endfire is applicable for a smaller range of horizontal bearing from the array. Ultimately, differences in the array geometry may be significant, and the lack of transparency in disclosing this information for the smaller array problematic to a meaningful comparison of results. Overall, the 8,000-in^3 array used by Zeddies *et al.* (2015, 2017a) remains a reasonable representation of the arrays that may be used in the future, without being overly conservative.

• Sound propagation modeling. Acoustic propagation in the GOM is complex and routinely changing due to variations in the Loop Current (and its eddies) and weather (including hurricanes). Additionally, propagation modeling needs to address a wide range of water depths (*i.e.,* shelf, slope, and deep waters) as well as strong freshwater runoff from the Mississippi River and other rivers. In order to capture this variability, the acoustic propagation modeling examined the historic sound velocity profiles (SVP) for the entire U.S. GOM throughout the entire year. As summarized earlier, these SVPs were analyzed for similarities and ultimately grouped into seven zones or areas with SVPs of similar structure or characteristics. These seven zones also included consideration of bathymetric, oceanographic, and biological factors in their definition. The SVP analysis also identified the need to capture seasonal variations by modeling the summer and winter seasons, which represent the bounds of reasonable environmental variability, rather than ''extremes.'' The profiles selected to model each of these seven zones are reasonable representatives of the family of SVPs for that zone and reflect an average of feasible conditions. Within each of the geographic boundaries for each modeled zone, multiple sites were selected to serve as the actual acoustic location for a modeled source, in order to capture the propagation for that zone. The sites selected for these locations included consideration of the overall characteristic of the zone (*i.e.,* it should be representative of the zone and not an extreme case), the proximity of the adjacent zones, the location of important bathymetric or oceanographic features, and, if possible, any important information on biologically important factors (*e.g.,* migratory routes, animal concentrations). Finally, the 3D propagation fields for each of the zones were examined by modeling multiple azimuthal planes radiating out from the source location. For additional detail, see the modeling report.

• Mitigation and aversion. As discussed in further detail above, the effects of mitigation and aversion on exposure estimates were investigated via Test Scenarios. We acknowledge that both of these factors would lead to a reduction in likely injurious exposure to some degree. However, these factors were ultimately not quantified in the modeling because, in summary, there is too much inherent uncertainty regarding the effectiveness of detection-based mitigation to support any reasonable quantification of its effect in reducing injurious exposure and there is too little information regarding the likely level of onset and degree of aversion to justify its use in the modeling. Zeddies *et al.* (2017b) found that incorporation of aversion into the modeling process appears to reduce the number of predicted injurious exposures, though the magnitude of the effect was variable. The authors state that this variability is likely because there are few samples of injurious exposure exceedance, meaning that the statistical variability of re-running simulations is evident. While aversion and mitigation implementation would be expected to reduce somewhat the modeled levels of injurious exposure, they would not be expected to result in any meaningful reduction in assumed exposures resulting in behavioral disturbance. However, we incorporated a reasonable adjustment to modeled Level A exposure estimates to account for aversion for low- and high-frequency species and, as described below, we do not believe that Level A harassment is likely to occur for mid-frequency cetaceans.

In conclusion, and as stated by BOEM (2017), the results of the modeling are expected to incorporate a reasonable margin of conservatism, and they represent use of the most credible, science-based methodologies and information available at this time. We believe it appropriate to incorporate conservatism to a reasonable extent in order to produce take estimates that would be sufficient to address the likely impacts of the activity and to allow for issuance of authorizations that would cover the expected requests by operators over the course of 5 years.

Take Estimates

In order to provide an estimate of takes of marine mammals that could occur as a result of a reasonably expected level of geophysical survey activity in the GOM over the course of 5 years, we evaluated BOEM's 10-year level of effort predictions and the associated modeled exposures provided by Zeddies *et al.* (2015, 2017a). The acoustic exposure history of many simulated animals (animats) allows for the estimation of takes due to operations. These modeled takes are summed and represent the aggregate takes expected to result from future surveys given the specified levels of effort for each survey type in each year, and may vary according to the statistical distribution associated with these mean annual exposures. We use the scaling factors derived from the results of Test Scenario 1 to differentiate between the total number of predicted instances of take and the likely number of individual marine mammals to which the takes occur. This information—total number of takes (with Level A harassment takes based on assumptions relating to mid-frequency cetaceans in general as well as aversion, as described below) and individuals, on an annual basis for five hypothetical years representing three different potential levels of survey effort—provide a partial basis for our negligible impact analysis, as well as the bounds within which incidental take authorizations would be issued in association with this proposed regulatory framework.

In summary, BOEM provided estimated levels of effort for geophysical survey activity in the GOM for a notional ten-year period. Exposure estimates were then computed from modeled sound levels received by animats for several representative types of geophysical surveying. Because animals and acoustic sources move relative to the environment and each other, and the sound fields generated by the sources are shaped by various physical parameters, the sound levels received by an animal are a complex function of location and time. The basic modeling approach was to use acoustic models to compute the 3D sound fields and their variations in time. Animats were modeled moving through these fields to sample the sound levels in a manner similar to how real animals would experience these sounds. From the time histories of the received sound levels of all animats, the numbers of animals exposed to levels exceeding effects threshold criteria were determined and then adjusted by the number of animals expected in the area, based on density information, to estimate the potential number of real-world marine mammal exposures to levels above the defined criteria.

With the overall modeling goal to estimate exposure levels from future survey activity whose individual details such as exact location and duration are unknown, a primary concern was how to account for different survey types, locations and spatial extents, and durations. In Test Scenario 1, issues arising when estimating impacts during long-duration surveys were investigated and a method was suggested. The defined 24-hr integration window, or reset period, creates a scaling time-basis for impact analysis, and 24 hours is short relative to most surveys. Test Scenario 1 demonstrated that while scaling (multiplying) the average 24-hr exposure estimate by the number of days of a survey is appropriate for estimating the number of instances of exposure above threshold, this same number is likely an overestimate of the number of individual marine mammals exposed above threshold during that time period. The associated 30-day model runs resulted in lower numbers of animats exposed to levels exceeding the threshold because individual animats were only counted once in the 30-day period even when exposed above the threshold across multiple days, which allows for a more refined consideration of individual animal takes, *i.e.,* comparison between the results of these two methods (24-hr exposure estimate scaled to 30 days versus 30-day exposure estimate) allows for a more realistic understanding of the likely numbers of individuals exposed within a 30-day period (as well as a better understanding of which species are likely taken across more days). However, while this correction helps account for the difference in estimates of individuals taken between the primary modeling method (24-hr modeled exposures multiplied by total number of survey days) and a 30-day modeled event, these remain somewhat of an overestimate, as evidenced by the total predicted takes versus the population abundance. Reasons include that many of the surveys will likely be significantly longer than 30 days, and that this correction does not address the fact that individuals could be taken by multiple surveys within a given year. In conclusion, while the exposure estimates presented in the modeling report identify instances of anticipated take, the ''corrected'' take numbers identify a closer approximation, and relative comparison, of the numbers of individuals affected. However, this method of correction still overestimates the numbers of individuals affected across the year, as it does not consider the additional repeated takes of individuals during surveys that are longer than 30 days or by multiple surveys.

The parameters governing animal movement were obtained from short-duration events, such as several dives, and for this modeling effort did not include long-duration behavior like migration or periodically revisiting an area as part of a circulation pattern. These behaviors could be modeled, but there are no data available currently to support detailed modeling of this type of behavior in the GOM. Seven-day simulations were chosen to ensure differing environments would be sampled.

With any modeling exercise, uncertainty in the input parameters results in uncertainty in the output. Sources of uncertainty and their effects on exposure estimates were investigated in Test Scenario 2. The primary source of uncertainty in this project was the location of the animals at the times of the surveys, which drives the choice of using an agent-based modeling approach and Monte Carlo sampling. Density estimates assume a uniform, static distribution of animals over a survey area, although real world animal densities can fluctuate significantly. However, assuming many surveys will be conducted in many locations, the variations in density are expected to average toward the mean. Sources of uncertainty in the other modeling parameters were found to affect the variance of the modeling results, as opposed to their mean, and the use of mean input parameters is therefore justified by the same argument as using mean animal densities: With many surveys occurring over many locations, variations are expected to average toward the mean. The effects of the variability in many of the modeling parameters on exposure estimates were quantified using a resampling technique. It was found that uncertainty in parameters such as animal density and social group size had a profound effect on the distribution of the exposure estimates, but not on the mean exposure. That is, the distribution shape and range of the number of animals above threshold changed, but the mean number of animals above threshold remained the same.

We previously presented BOEM's 10-year activity projections under ''Detailed Description of Activities'' (Table 1), and identified representative ''high,'' ''moderate,'' and ''low'' effort years. Level of effort is currently significantly reduced in the GOM. A decrease in permit applications was seen over the 2016 calendar year and the trend in reduced exploration activity continued in 2017. However, BOEM states that they assume that future levels will return to previous levels. Therefore, the existing scenario levels, which contain projections based on BOEM's analysis by subject matter experts of past activity levels and trends as well as industry-projected activity levels, remain valid (BOEM, 2017). BOEM's projected activity levels must be viewed as notional years. While they are based on expert professional judgment as informed by historical data and the best available information, it would be inappropriate to view them as literal representations of what would definitively happen in a given year. Therefore, in order to provide the best reasonable basis for conducting a negligible impact analysis, and in recognition of the current economic downturn as it relates to oil and gas industry exploratory activity, we select one ''high-activity'' year, two separate ''moderate-activity'' years, and two separate ''low-activity'' years as the basis for our assessment (corresponding with the detailed per-survey type effort projections given in Table 1 for Years 1, 4, 5, 8, and 9, respectively). Exposure estimates above Level A and Level B harassment criteria, developed by Zeddies *et al.* (2015, 2017a) in association with the activity projections for these year scenarios, are presented here (Table 8). Exposure estimates were generated based on the specific modeling scenarios (including source and survey geometry), *i.e.,* 2D survey (1 × 8,000 in^3 array), 3D NAZ survey (2 × 8,000 in^3 array), 3D WAZ survey (4 × 8,000 in^3 array), coil survey (4 × 8,000 in^3 array), shallow penetration survey (either single 90 in^3 airgun or boomer), and HRG surveys (side-scan sonar, multibeam echosounder, and subbottom profiler). Here, we present scenario-based pooled exposure estimates by species.

TABLE 8—ESTIMATED EXPOSURES BY SURVEY SCENARIO

[Zeddies *et al.,* 2015, 2017a][1]

Species	Survey effort scenario[2]									
	High		Moderate #1		Moderate #2		Low #1		Low #2	
	A	B	A	B	A	B	A	B	A	B
Bryde's whale	15	560	11	413	14	498	11	386	11	402
Sperm whale	45	43,504	29	27,271	38	33,340	30	26,651	32	27,657
Kogia spp	3,640	16,189	2,375	11,428	3,180	13,644	2,358	10,743	2,811	11,165
Beaked whale	52	235,615	38	162,134	47	190,777	37	151,708	38	156,584
Rough-toothed dolphin	150	37,666	114	30,192	128	31,103	112	28,663	105	26,315
Bottlenose dolphin	1,940	653,405	2,797	977,108	1,783	596,824	2,679	938,322	1,718	579,403
Clymene dolphin	469	110,742	312	72,913	380	87,615	304	69,609	310	72,741
Atlantic spotted dolphin	331	133,427	423	174,705	290	116,698	397	164,824	269	109,857
Pantropical spotted dolphin	2,924	606,729	2,048	419,738	2,535	511,037	1,987	399,581	2,032	419,824
Spinner dolphin	262	82,779	195	59,623	246	73,013	189	56,546	195	59,253
Striped dolphin	194	44,038	133	29,936	164	36,267	130	28,522	133	29,890
Fraser's dolphin	52	13,858	36	9,654	44	11,394	35	9,127	35	9,391
Risso's dolphin	103	27,062	73	18,124	91	21,914	71	17,309	74	18,092
Melon-headed whale	252	68,900	171	47,548	213	56,791	169	44,842	170	46,631
Pygmy killer whale	83	18,029	57	12,278	71	14,788	56	11,677	57	12,141
False killer whale	111	25,511	77	17,631	94	20,828	75	16,774	76	17,163
Killer whale	5	1,493	3	1,031	4	1,258	3	984	3	1,036
Short-finned pilot whale	68	19,258	43	12,155	51	14,163	42	11,523	42	11,900

[1] A and B refer to estimated exposures above Level A and Level B harassment criteria, respectively. For all species other than the Bryde's whale, exposures above Level A harassment criteria were predicted by the peak SPL metric. For the Bryde's whale, exposures above Level A harassment criteria were predicted by the cSEL metric.

[2] High survey effort scenario corresponds with level of effort projections given previously for Year 1 (Table 1). Moderate #1 and #2 and Low #1 and #2 correspond with Years 4, 5, 8, and 9, respectively.

For all mid-frequency cetaceans, *i.e.,* all species other than the Bryde's whale and *Kogia* spp., we do not expect Level A harassment to actually occur. For all species other than low-frequency cetaceans (*i.e.,* Bryde's whale), the estimates of exposure above Level A harassment criteria are based on the peak pressure metric and, for mid-frequency cetaceans, no exposures above Level A harassment criteria were predicted for airgun surveys on the basis of the cSEL metric. However, the estimated zone size for the 230 dB peak threshold for mid-frequency cetaceans is only 18 m and, while in a theoretical modeling scenario it is possible for animats to engage with a zone of 18 m radius around a notional point source and, subsequently, for these interactions to scale to predictions of real world exposures given a sufficient number of predicted 24-hr survey days in confluence with sufficiently high predicted real world animal densities, this is not a realistic outcome. The source level of the array is a theoretical definition assuming a point source and measurement in the far field of the source. The 230 dB isopleth was within the near field of the array where the definition of source level breaks down, so actual locations within the 18 m of the array center where the sound level exceeds 230 dB peak SPL would not necessarily exist. Further, our proposed mitigation (see discussion in ''Proposed Mitigation'' would require a power-down for small dolphins within a 500-m exclusion zone (and a shutdown for other mid-frequency cetaceans). During the power-down procedure, a single airgun would remain firing. The output of a single airgun would not be expected to exceed the peak pressure injury threshold for mid-frequency cetaceans. Therefore, we expect the potential for Level A harassment of mid-frequency cetaceans to be de minimis, even before the likely moderating effects of aversion are considered. When considering potential for aversion, we do not believe that Level A harassment is a likely outcome for any mid-frequency cetacean.

For other species (*i.e.,* Bryde's whales and *Kogia* spp.), we believe that while some amount of Level A harassment is likely, the lack of aversion within the animal movement modeling process results in overestimates of potential injurious exposure. Although there was not sufficient information to inform a precise quantification of aversion within the modeling (Test Scenario 4), we believe that sufficient information exists to inform a reasonable, conservative approximation of aversion and apply an offset method accordingly (Southall *et al.,* 2017). Ellison *et al.* (2016) demonstrated that animal movement models where no aversion probability was used overestimated the potential for high levels of exposure required for PTS by about five times. Accordingly, total estimated exposures above Level A harassment criteria (without accounting for behavioral aversion) were multiplied by 0.2 to reasonably obtain a more realistic estimate of potential injurious exposure. Adjusted total scenario-specific and mean annual take estimates are given in Table 9.

TABLE 9—SCENARIO-SPECIFIC EXPECTED TAKE NUMBERS AND MEAN ANNUAL TAKE LEVEL [1]

Species	Survey effort scenario [2]											
	High		Moderate #1		Moderate #2		Low #1		Low #2		Mean annual take	
	A	B	A	B	A	B	A	B	A	B	A	B
Bryde's whale	3	560	2	413	2	498	2	386	2	402	2	452
Sperm whale	0	43,504	0	27,271	0	33,340	0	26,651	0	27,657	0	31,685
Kogia spp	728	16,189	475	11,428	636	13,644	472	10,743	562	11,165	575	12,634
Beaked whale	0	235,615	0	162,134	0	190,777	0	151,708	0	156,584	0	179,364
Rough-toothed dolphin	0	37,666	0	30,192	0	31,103	0	28,663	0	26,315	0	30,788
Bottlenose dolphin	0	653,405	0	977,108	0	596,824	0	938,322	0	579,403	0	749,012
Clymene dolphin	0	110,742	0	72,913	0	87,615	0	69,609	0	72,741	0	82,724
Atlantic spotted dolphin	0	133,427	0	174,705	0	116,698	0	164,824	0	109,857	0	139,902
Pantropical spotted dolphin	0	606,729	0	419,738	0	511,037	0	399,581	0	419,824	0	471,382
Spinner dolphin	0	82,779	0	59,623	0	73,013	0	56,546	0	59,253	0	66,243
Striped dolphin	0	44,038	0	29,936	0	36,267	0	28,522	0	29,890	0	33,731
Fraser's dolphin	0	13,858	0	9,654	0	11,394	0	9,127	0	9,391	0	10,685
Risso's dolphin	0	27,062	0	18,124	0	21,914	0	17,309	0	18,092	0	20,500
Melon-headed whale	0	68,900	0	47,548	0	56,791	0	44,842	0	46,631	0	52,942
Pygmy killer whale	0	18,029	0	12,278	0	14,788	0	11,677	0	12,141	0	13,783
False killer whale	0	25,511	0	17,631	0	20,828	0	16,774	0	17,163	0	19,581
Killer whale	0	1,493	0	1,031	0	1,258	0	984	0	1,036	0	1,160
Short-finned pilot whale	0	19,258	0	12,155	0	14,163	0	11,523	0	11,900	0	13,800

[1] A and B refer to expected scenario-based instances of take by Level A and Level B harassment, respectively. For the Bryde's whale and *Kogia* spp., expected Level A takes represent modeled exposures adjusted to account for aversion.

[2] High survey effort scenario correspond level of effort projections given previously for Year 1 (Table 1). Moderate #1 and #2 and Low #1 and #2 correspond with Years 4, 5, 8, and 9, respectively.

Economic Baseline

This proposed rule has been designated as significant under Executive Order 12866. Accordingly, a draft regulatory impact analysis (RIA) has been prepared and is available for review online at: *www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-oil-and-gas.* The RIA evaluates the potential costs and benefits of these proposed incidental take regulations, as well as a more stringent alternative, against two baselines. The two baselines correspond with: (1) Regulatory requirements associated with management of geophysical survey activity in the GOM prior to 2013 pursuant to permits that were issued by BOEM under its authorities in the Outer Continental Shelf Lands Act but that did not address statutory requirements of the MMPA administered by NOAA; and (2) conditions in place since 2013 pursuant to a settlement agreement, as amended through stipulated agreement, involving a stay of litigation (*NRDC et al.* v. *Zinke et al.,* Civil Action No. 2:10 cv-01882 (E.D. La.)). Under the settlement agreement (which expires in November 2018), industry trade groups representing operators agreed to include certain mitigation requirements for geophysical surveys in the GOM. Appendix B of the RIA provides an initial regulatory flexibility analysis (IRFA), while Appendix C addresses other compliance requirements.

Office of Management and Budget (OMB) Circular A–4 directs that the baseline for regulatory analysis should be the agency's best assessment of the state of the world in the absence of the proposed action. A–4 also provides that agencies may present multiple baselines where this would provide additional useful information to the public on the projected effects of the regulation. We are presenting two baselines for public information and comment, consistent with the A–4 provision allowing agencies to present multiple baselines. Thus, in addition to a baseline that reflects current assumed industry practices as agreed upon in the 2013 settlement agreement, NMFS is also presenting a baseline corresponding with geophysical activities in the GOM as carried out prior to the 2013 settlement agreement but without authorization from NMFS under the MMPA.

Estimated direct costs of the measures in the proposed regulations, relative to both baselines, are presented in Table 10. Details regarding cost estimation are available in the RIA. A qualitative evaluation of indirect costs related to the proposed regulations is also provided in the RIA. Note that these costs would be diffused across all operators receiving LOAs.

TABLE 10—QUANTIFIED DIRECT COMPLIANCE COSTS BY BASELINE

Mitigation measure	Annualized costs, millions [1]	
	Pre-stay agreement baseline (prior to 2013)	Stay agreement baseline (2013–present)
Mitigation requirements for dolphins: Shutdowns for large dolphins in the exclusion zone and power downs for small dolphins in the exclusion zone	$3.9–$49.7	$3.9–$49.7
Expanded observer requirements and mitigation in shallow waters: Shutdowns for all "whale" species in the exclusion zone for airgun surveys in water depths less than 200 m in the Central and Western Planning Areas	$0.02–$2.1	$0
Additional mitigation requirements: Shutdowns for Bryde's/beaked/Kogia whales outside of exclusion zone for deep penetration airgun surveys	$1.1–$3.0	$1.1–$3.0

TABLE 10—QUANTIFIED DIRECT COMPLIANCE COSTS BY BASELINE—Continued

Mitigation measure	Annualized costs, millions [1]	
	Pre-stay agreement baseline (prior to 2013)	Stay agreement baseline (2013–present)
Acoustic monitoring and associated mitigation: Shutdowns for all non-delphinid detections for deep penetration airgun surveys	$43.9–$127	$21.9–$65.8
Observer requirements for non-airgun HRG surveys and associated mitigation: Shutdowns for whale and large dolphin observations in the exclusion zone	$0.12–$0.39	$0.12–$0.39
Remove minimum separation distance requirements for deep penetration airgun surveys: The stay agreement baseline includes minimum separation distances. Costs reflect the downtime associated with maintaining the minimum separation distance from other surveys. This mitigation measure is not included in the proposed rule, thus creating a benefit (negative cost) of the proposed rule relative to the stay agreement baseline	n/a	($37.9)–($266)
Proposed Rule Total Direct Compliance Costs	$49–$182	[2] ($10.8)–($147)

[1] Costs are presented in terms of 2016 U.S. dollars and are annualized over the five-year timeframe applying a 7% discount rate. Annualized costs applying a 3% discount rate are provided in Appendix D of the RIA.

[2] Estimates within parentheses indicate negative costs, or cost savings. The proposed rule total direct compliance costs relative to the stay agreement baseline reflect new costs of $27–$119 less cost savings of $38–$266.

Proposed Mitigation

Under Section 101(a)(5)(A) of the MMPA, NMFS must set forth the permissible methods of taking pursuant to such activity, and other means of effecting the least practicable adverse impact on such species or stock and its habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of such species or stock for taking for certain subsistence uses (''least practicable adverse impact''). Consideration of the availability of marine mammal species or stocks for taking for subsistence uses pertains only to Alaska, and is therefore not relevant here. NMFS does not have a regulatory definition for ''least practicable adverse impact.'' However, NMFS's implementing regulations require applicants for incidental take authorizations to include information about the availability and feasibility (economic and technological) of equipment, methods, and manner of conducting such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks and their habitat (50 CFR 216.104(a)(11)). It is important to note that in some cases, certain mitigation may be necessary in order to ensure a ''negligible impact'' on an affected species or stock, which is a fundamental requirement of issuing an authorization—in these cases, consideration of practicability may be a lower priority for decision-making if impacts to marine mammal species or stocks would be greater than negligible in the measure's absence.

In evaluating how mitigation may or may not be appropriate to ensure the least practicable adverse impact on species or stocks and their habitat, we carefully consider two primary factors:

(1) The manner in which, and the degree to which, implementation of the measure(s) is expected to reduce impacts to marine mammal species or stocks, their habitat, and their availability for subsistence uses (when relevant). This analysis will consider such things as the nature of the potential adverse impact (such as likelihood, scope, and range), the likelihood that the measure will be effective if implemented, and the likelihood of successful implementation.

(2) The practicability of the measure for applicant implementation. Practicability of implementation may consider such things as cost, impact on operations, personnel safety, and practicality of implementation.

While the language of the least practicable adverse impact standard calls for minimizing impacts to affected species or stocks, we recognize that the reduction of impacts to those species or stocks accrues through the application of mitigation measures that limit impacts to individual animals. Accordingly, our analysis focuses on measures designed to avoid or minimize impacts on marine mammals from activities that are likely to increase the probability or severity of population-level effects, including auditory injury or disruption of important behaviors, such as foraging, breeding, or mother/calf interactions. See also 82 FR 19460 (April 27, 2017) and 83 FR 10954 (March 13, 2018) (discussion of least practicable adverse impact standard in proposed incidental take rule for Navy's Surveillance Towed Array Sensor System Low Frequency Sonar activities and Atlantic Fleet Testing and Training activities, respectively).

NMFS is aware of public statements that there is no scientific evidence that geophysical survey activities have caused adverse consequences to marine mammal stocks or populations, and that there are no known instances of injury to individual marine mammals as a result of such surveys. For example, BOEM stated publicly that ''there has been no documented scientific evidence of noise from airguns . . . adversely affecting marine animal populations'' (BOEM, 2014; *www.boem.gov/BOEM-Science-Note-August-2014/*). On their face, these carefully worded statements are not incorrect; however, they are easily misconstrued and, as used in arguments against certain proposed mitigation measures, represent a common logical fallacy (*i.e.,* that a proposition is false because it has not yet been proven true). In reality, conclusive statements regarding population-level consequences of acoustic stressors cannot be made due to insufficient investigation, as such studies are exceedingly difficult to carry out and no appropriate study and reference populations have yet been established. For example, a recent report from the National Academy of Sciences noted that, while a commonly-cited statement from the National Research Council (''[n]o scientific studies have conclusively demonstrated a link between exposure to sound and adverse effects on a marine mammal population'') remains true, it is largely because such impacts are very difficult to demonstrate (NRC, 2005; NAS, 2017). Population-level effects are inherently difficult to assess because of high variability, migrations, and multiple factors affecting the populations.

The MMPA defines ''take'' to include Level B (behavioral) harassment, which has been documented numerous times for marine mammals in the presence of airguns (in the form of avoidance of areas, notable changes in vocalization or movement patterns, or other shifts in important behaviors), as well as auditory injury (Level A harassment), for which there is also evidence from loud sound sources (*e.g.,* Southall *et al.,* 2007). Further, there is growing scientific evidence demonstrating the connections between sub-lethal effects, such as behavioral disturbance, and population-level effects on marine mammals (*e.g.,* Lusseau and Bedjer, 2007; New *et al.,* 2014). Disruptions of important behaviors, in certain contexts and scales, have been shown to have energetic effects that can translate to reduced survivorship or reproductive rates of individuals (*e.g.,* feeding is interrupted, so growth, survivorship, or ability to bring young to term is compromised), which in turn can adversely affect populations depending on their health, abundance, and growth trends. As BOEM stated in a follow-up to the above-referenced Science Note, ''[we] should not assume that lack of evidence for adverse population-level effects of airgun surveys means that those effects may not occur.'' (BOEM, 2015; *www.boem.gov/BOEM-Science-Note-March-2015/*).

While direct evidence of impacts to species or stocks from a specified activity is rarely available, and additional study is still needed to describe how specific disturbance events affect the fitness of individuals of certain species, there have been improvements in understanding the process by which disturbance effects are translated to the population. With recent scientific advancements (both marine mammal energetic research and the development of energetic frameworks), the relative likelihood or degree of impacts on species or stocks may often be inferred given a detailed understanding of the activity, the environment, and the affected species or stocks. This same information is used in the development of mitigation measures and helps us understand how mitigation measures contribute to lessening effects (or the risk thereof) to species or stocks. We also acknowledge that there is always the potential that new information, or a new recommendation that we had not previously considered, becomes available and necessitates reevaluation of mitigation measures (which may be addressed through adaptive management) to see if further reduction of population impacts are possible and practicable.

In the evaluation of specific measures, the details of the specified activity will necessarily inform each of the two primary factors discussed above (expected reduction of impacts and practicability), and will be carefully considered to determine the types of mitigation that are appropriate under the least practicable adverse impact standard. Analysis of how a potential mitigation measure may reduce adverse impacts on a marine mammal stock or species and practicability of implementation are not issues that can be meaningfully evaluated through a yes/no lens. The manner in which, and the degree to which, implementation of a measure is expected to reduce impacts, as well as its practicability in terms of these considerations, can vary widely. For example, a time/area restriction could be of very high value for decreasing population-level impacts (*e.g.,* avoiding disturbance of feeding females in an area of established biological importance) or it could be of lower value (*e.g.,* decreased disturbance in an area of high productivity but of less firmly established biological importance). Regarding practicability, a measure might involve operational restrictions that completely impede the operator's ability to acquire necessary data (higher impact), or it could mean additional incremental delays that increase operational costs but still allow the activity to be conducted (lower impact). A responsible evaluation of ''least practicable adverse impact'' will consider the factors along these realistic scales. Expected effects of the activity and of the mitigation as well as status of the stock all weigh into these considerations. Accordingly, the greater the likelihood that a measure will contribute to reducing the probability or severity of adverse impacts to the species or stock, the greater the weight that measure is given when considered in combination with practicability to determine the appropriateness of the mitigation measure, and vice versa. We discuss consideration of these factors in greater detail below.

1. Reduction of Adverse Impacts to Marine Mammal Species and Stocks and Their Habitat

The emphasis given to a measure's ability to reduce the impacts on a species or stock considers the degree, likelihood, and context of the anticipated reduction of impacts to individuals as well as the status of the species or stock. The ultimate impact on any individual from a disturbance event (which informs the likelihood of adverse species- or stock-level effects) is dependent on the circumstances and associated contextual factors, such as duration of exposure to stressors. Though any proposed mitigation needs to be evaluated in the context of the specific activity and the species or stocks affected, measures with the following types of goals are often applied to reduce the likelihood or severity of adverse species- or stock-level impacts: Avoiding or minimizing injury or mortality; limiting interruption of known feeding, breeding, mother/calf, or resting behaviors; minimizing the abandonment of important habitat (temporally and spatially); minimizing the number of individuals subjected to these types of disruptions; and limiting degradation of habitat. Mitigating these types of effects is intended to reduce the likelihood that the activity will result in energetic or other types of impacts that are more likely to result in reduced reproductive success or survivorship. It is also important to consider the degree of impacts that were expected in the absence of mitigation in order to assess the added value of any potential measures. Finally, because the least practicable adverse impact standard authorizes NMFS to weigh a variety of factors when evaluating appropriate mitigation measures, it does not compel mitigation for every kind of individual take, even when practicable for implementation by the applicant.

The status of the species or stock is also relevant in evaluating the appropriateness of certain mitigation measures in the context of least practicable adverse impact. The following are examples of factors that may (either alone, or in combination) result in greater emphasis on the importance of a mitigation measure in reducing impacts on a species or stock: The stock is known to be decreasing or status is unknown, but believed to be declining; the known annual mortality (from any source) is approaching or exceeding the PBR level; the affected species or stock is a small, resident population; or the stock is involved in a UME or has other known vulnerabilities, such as recovering from an oil spill.

Habitat mitigation, particularly as it relates to rookeries, mating grounds, and areas of similar significance, is also relevant to achieving the standard and can include measures such as reducing impacts of the activity on known prey utilized in the activity area or reducing impacts on physical habitat. As with species- or stock-related mitigation, the emphasis given to a measure's ability to reduce impacts on a species or stock's habitat considers the degree, likelihood, and context of the anticipated reduction of impacts to habitat. Because habitat value is informed by marine mammal presence and use, in some cases there may be overlap in measures for the species or stock and for use of habitat.

We consider available information indicating the likelihood of any measure to accomplish its objective. If evidence shows that a measure has not typically been effective or successful, then either that measure should be modified or the potential value of the measure to reduce effects is lowered.

2. Practicability

Factors considered may include those such as cost, impact on operations, personnel safety, and practicality of implementation. In carrying out the MMPA's mandate, we apply the previously described context-specific balance between the manner in which and the degree to which measures are expected to reduce impacts to the affected species or stocks and their habitat and practicability for the applicant. The effects of concern, addressed previously in the ''Potential Effects of the Specified Activity on Marine Mammals and Their Habitat'' section, include auditory injury, severe behavioral reactions, disruptions of critical behaviors, and potentially detrimental chronic and/or cumulative effects to acoustic habitat (see discussion of this concept in the ''Anticipated Effects on Marine Mammal Habitat'' section). Here, we focus on measures with proven or reasonably presumed ability to avoid or reduce the intensity of acute exposures that may potentially result in these effects with an understanding of the drawbacks of these requirements, while also evaluating time-area restrictions that would avoid or reduce both acute and chronic impacts. To the extent of the information available to us, we consider practicability concerns, as well as potential undesired consequences of the measures, *e.g.,* extended periods using the acoustic source due to the need to reshoot lines. We also recognize that instantaneous protocols, such as shutdown requirements, are not capable of avoiding all acute effects, and are not suitable for avoiding many cumulative or chronic effects and do not provide targeted protection in areas of greatest importance for marine mammals. Therefore, in addition to a basic suite of seismic mitigation protocols, we also consider measures that may not be appropriate for other activities (*e.g.,* time-area restrictions specific to the proposed surveys discussed here) but that are warranted here given the scope of these specified activities and associated higher potential for population-level effects and/or a large magnitude of take of individuals of certain species, in the absence of such mitigation.

In order to satisfy the MMPA's least practicable adverse impact standard, we propose a suite of basic mitigation protocols that are required regardless of the status of a stock. Additional or enhanced protections are proposed for species whose stocks are in poor health and/or are subject to some significant additional stressor that lessens that stock's ability to weather the effects of the specified activity without worsening its status. We reviewed the mitigation measures proposed in the petition, the requirements specified in BOEM's PEIS, seismic mitigation protocols required or recommended elsewhere (*e.g.,* HESS, 1999; DOC, 2013; IBAMA, 2005; Kyhn *et al.,* 2011; JNCC, 2017; DEWHA, 2008; BOEM, 2016; DFO, 2008; GHFS, 2015; MMOA, 2015; Nowacek *et al.,* 2013; Nowacek and Southall, 2016), and the available scientific literature. We also considered recommendations given in a number of review articles (*e.g.,* Weir and Dolman, 2007; Compton *et al.,* 2008; Parsons *et al.,* 2009; Wright and Cosentino, 2015; Stone, 2015b). The suite of mitigation measures proposed here differs in some cases from the measures proposed in the petition and/ or those specified by BOEM in the preferred alternative identified in their PEIS in order to reflect what we believe to be the most appropriate suite of measures to satisfy the requirements of the MMPA.

For purposes of defining mitigation requirements, we differentiate here between requirements for two classes of airgun survey activity: Deep penetration and shallow penetration, with surveys using arrays greater than 400 in^3 total airgun volume considered deep penetration. We consider this a reasonable cutoff as most arrays or single airguns of this size or smaller will typically be purposed for shallow penetration surveys—BOEM states in the petition that airgun sources used for shallow penetration surveys typically range from 40–400 in^3, while the Associations state in their comments on the petition that deep penetration array volumes used in the GOM range from approximately 2,000 to 8,400 in^3. We also consider a third general class of surveys, referred to here as HRG surveys and including those surveys using the non-airgun sources described previously. HRG surveys are treated differentially on the basis of water depth, with 200 m as the divider between shallow and deep HRG. We use this as an indicator for surveys (shallow) that should be expected to have less potential for impacts to marine mammals, because HRG sources used in shallow waters are typically higher-frequency, lower power, and/or having some significant directionality to the beam pattern. Finally, HRG surveys using only sources operating at frequencies greater than or equal to 200 kHz would be exempt from the mitigation requirements described herein, with the exception of adherence to vessel strike avoidance protocols. We do not make any distinction in standard required mitigations on the basis of BOEM's planning areas (*i.e.,* Western Planning Area (WPA), CPA, EPA).

As described previously in the ''Marine Mammal Hearing'' section, the upper limit of hearing for marine mammals is approximately 160 kHz; therefore, they would not be expected to detect signals from systems operating at frequencies of 200 kHz and greater. Sounds that are above the functional hearing range of marine animals may be audible if sufficiently loud (*e.g.,* Møhl, 1968). However, the typical relative output levels of these sources mean that they would potentially be detectable to marine mammals at maximum distances of only a few meters, and are highly unlikely to be of sufficient intensity to result in Level B harassment. Sources operating at high frequencies also generally have short duration signals and highly directional beam patterns, meaning that any individual marine mammal would be unlikely to even receive a signal that would almost certainly be inaudible.

We are aware of two studies (Deng *et al.,* 2014; Hastie *et al.,* 2014) demonstrating some behavioral reaction by marine mammals to acoustic systems operating at user-selected frequencies above 200 kHz. These studies generally indicate only that sub-harmonics could be detectable by certain species at distances up to several hundred meters. However, this detectability is in reference to ambient noise, not to thresholds for assessing the potential for incidental take for these sources. Source levels of the secondary peaks considered in these studies—those within the hearing range of some marine mammals—range from 135–166 dB, meaning that these sub-harmonics would either be below levels likely to result in Level B harassment or would attenuate to such a level within a few meters. Therefore, acoustic sources operating at frequencies greater than or equal to 200 kHz are not expected to have any effect on marine mammals. Further, recent sound source verification testing of these and other similar systems did not observe any sub-harmonics in any of the systems tested under controlled conditions (Crocker and Fratantonio, 2016). While this can occur during actual operations, the phenomenon may be the result of issues with the system or its installation on a vessel rather than an issue that is inherent to the output of the system. We do not discuss these surveys further and none of the requirements described below (other than vessel strike avoidance procedures) would apply to these surveys.

Our consideration of the two major points described above (*i.e.,* ability of the measure to reduce the probability or severity of adverse impacts on marine mammal species or stocks and their habitat and practicability for the applicant) points to the need for a basic system of mitigation protocols that reasonably may be expected to achieve the following outcomes: (1) Avoid or minimize effects of concern that otherwise could accrue in a way that could cause or appreciably increase the risk of population-level impacts; (2) be easily implemented in the field; (3) reduce subjective decision-making for observers to the extent possible; and, (4) appropriately weigh a range of potential outcomes from sound exposure in determining what should be avoided or minimized where possible. Subsequently, we describe measures specific to the GOM in relation to specific contextual concerns.

Mitigation-Related Monitoring

Avoidance or minimization of acute exposure is first and foremost dependent upon detection of animals present in the vicinity of the survey activity. Requirements necessary to adequately detect marine mammals incur costs, which we consider in scaling mitigation-related monitoring requirements relative to the expected effects of the specific activity (as described above, we bin activity types and detail below the proposed monitoring requirements associated with each). Visual monitoring is a critical component of any detection system, as evidenced by the inclusion of visual monitoring requirements in every set of protocols and recommendations we reviewed, and has long been accepted as such. However, visual monitoring is only effective during periods of good visibility and when animals are available for detection (*i.e.,* at the surface).

Acoustic monitoring is an equally critical component of an effective detection system, supplanting visual monitoring during periods of poor visibility and supplementing during periods of good visibility. There are multiple explanations of how marine mammals could be in a shutdown zone and yet go undetected by observers. Animals are missed because they are underwater (availability bias) or because they are available to be seen, but are missed by observers (perception and detection biases) (*e.g.,* Marsh and Sinclair, 1989). Negative bias on perception or detection of an available animal may result from environmental conditions, limitations inherent to the observation platform, or observer ability. Species vary widely in the inherent characteristics that inform expected bias on their availability for detection or the extent to which availability bias is convolved with detection bias (*e.g.,* Barlow and Forney (2007) estimate probabilities of detecting an animal directly on a transect line (*g*(0)), ranging from 0.23 for small groups of Cuvier's beaked whales to 0.97 for large groups of dolphins). Typical dive times range widely, from just a few minutes for Bryde's whales (Alves *et al.,* 2010) to more than 45 minutes for sperm whales (Jochens *et al.,* 2008; Watwood *et al.,* 2006), while *g*(0) for cryptic species such as *Kogia* spp. declines more rapidly with increasing Beaufort sea state than it does for other species (Barlow, 2015). Barlow and Gisiner (2006) estimated that when weather and daylight considerations were taken into account, visual monitoring would detect fewer than two percent of beaked whales that were directly in the path of the ship. PAM can be expected to improve on that performance, and has been used effectively as a mitigation tool by operators in the GOM since at least 2012. BOEM highlighted the importance of PAM to detection-based mitigation protocols in the petition for rulemaking, submitted to NMFS in support of industry, and we agree. However, we do not agree that use of 24-hr PAM should be limited to the Mississippi Canyon and De Soto Canyon lease blocks (as proposed by BOEM). Species that are difficult to detect but vocally active are present in significant numbers outside those areas, and PAM should be a standard component of detection-based mitigation anywhere such species are expected to be present.

PAM does have limitations, *e.g.,* animals may only be detected when vocalizing, species making directional vocalizations must vocalize towards the array to be detected, and species identification and localization may be difficult. However, for certain species and in appropriate environmental conditions it is an indispensable complement to visual monitoring during good sighting conditions and it is the only meaningful monitoring technique during periods of poor visibility; without PAM, there can be no expectation that any animal would be detected at night, and even during good conditions many deep-diving and/or cryptic species would go undetected much of the time. In the GOM, beaked whales and sperm whales (both vocally active) are two taxa of greatest concern; beaked whales would rarely be detected by visual means alone (an analysis of six years of GOM survey data found only 11 records for beaked whales; Barkaszi *et al.,* 2012), and, while commonly observed when they are at the surface, sperm whales spend significant amounts of time in locations where they are unavailable for visual detection. However, acoustic monitoring imposes additional costs on operators and, as discussed by Nowacek *et al.* (2013), we consider this in relation to the anticipated effects of the survey type. Thus, while PAM should be required during the deep penetration airgun surveys of greatest concern, we do not propose to require it for other survey types.

Note that, although we propose requirements related only to observation of marine mammals, we hereafter use the generic term ''protected species observer'' (PSO). Monitoring by dedicated, trained marine mammal observers is required in all water depths and, for certain surveys, observers must be independent. Additionally, for some surveys, we propose to require that some PSOs have prior experience in the role. Independent observers are employed by a third-party observer provider; vessel crew may not serve as PSOs when independent observers are required. Dedicated observers are those who have no tasks other than to conduct observational effort, record observational data, and communicate with and instruct the geophysical survey operator (*i.e.,* vessel captain and crew) with regard to the presence of marine mammals and mitigation requirements. Communication with the operator may include brief alerts regarding maritime hazards. We are proposing to define trained PSOs as having successfully completed an approved PSO training course (see the ''Proposed Monitoring and Reporting'' section), and experienced PSOs as having additionally gained a minimum of 90 days at-sea experience working as a PSO, with no more than 18 months having elapsed since the conclusion of the relevant at-sea experience. Training and experience is specific to either visual or acoustic PSO duties (where required). Furthermore, we propose that an experienced visual PSO must have completed approved, relevant training and must have gained the requisite experience working as a visual PSO. An experienced acoustic PSO must have completed a passive acoustic monitoring (PAM) operator training course and must have gained the requisite experience working as an acoustic PSO. Hereafter, we also refer to acoustic PSOs as PAM operators, whereas when we use ''PSO'' without a qualifier, the term refers to either visual PSOs or PAM operators (acoustic PSOs).

NMFS expects to provide informal approval for specific training courses in consultation with BOEM and the Bureau of Safety and Environmental Enforcement (BSEE) as needed to approve PSO staffing plans. NMFS does not propose to formally administer any training program or to sanction any specific provider, but will approve courses that meet the curriculum and trainer requirements specified herein (see the ''Proposed Monitoring and Reporting'' section). We propose this in context of the need to ensure that PSOs have the necessary training to carry out their duties competently while also approving applicant staffing plans quickly. In order for PSOs to be approved, we propose that NMFS must review and approve PSO resumes accompanied by a relevant training course information packet that includes the name and qualifications (*i.e.,* experience, training completed, or educational background) of the instructor(s), the course outline or syllabus, and course reference material as well as a document stating the PSO's successful completion of the course. Although we are proposing that NMFS must affirm PSO approvals, third-party observer providers and/or companies seeking PSO staffing should expect that observers having satisfactorily completed approved training and with the requisite experience (if required) will be quickly approved and, if NMFS does not respond within one week of having received the required information, we propose that such PSOs shall be considered to be approved. A PSO may be trained and/or experienced as both a visual PSO and PAM operator and may perform either duty, pursuant to scheduling requirements. Where multiple PSOs are required and/or PAM operators are required, we propose that PSO watch schedules shall be devised in consideration of the following restrictions: (1) A maximum of two consecutive hours on watch followed by a break of at least one hour between watches for visual PSOs (periods typical of observation for research purposes and as used for airgun surveys in certain circumstances (Broker *et al.,* 2015)); (2) a maximum of four consecutive hours on watch followed by a break of at least two consecutive hours between watches for PAM operators; and (3) a maximum of 12 hours observation per 24-hour period. Further information regarding PSO requirements may be found in the ''Proposed Monitoring and Reporting'' section, later in this document. NMFS has discussed the PSO requirements specified herein with BSEE and with third-party observer providers; these parties have indicated that the requirements should not be expected to result in any labor shortage. For example, a significantly greater amount of survey activity was occurring in the GOM during 2013–2015 than at present (*i.e.,* as many as 30 source vessels) with requirements similar to those described here. No labor shortage was experienced. We request comment on this assumption. We also invite comment on the proposed definitions of trained and experienced PSOs, requirements for PSO approval by NMFS, and watch schedule for visual PSO and PAM operators.

Deep Penetration Airgun—During deep penetration airgun survey operations (*e.g.,* any day on which use of the acoustic source is planned to occur; whenever the acoustic source is in the water, whether activated or not), we propose the additional requirement that a minimum of two independent PSOs must be on duty and conducting visual observations at all times during daylight hours (*i.e.,* from 30 minutes prior to sunrise through 30 minutes following sunset) and 30 minutes prior to and during nighttime ramp-ups of the airgun array (see ''Ramp-ups'' below). PSOs should use NOAA's solar calculator (*www.esrl.noaa.gov/gmd/grad/solcalc/*) to determine sunrise and sunset times at their specific location. We recognize that certain daytime conditions (*e.g.,* fog, heavy rain) may reduce or eliminate effectiveness of visual observations; however, on-duty PSOs shall remain alert for marine mammal observational cues and/or a change in conditions.

We propose that all source vessels must carry a minimum of one experienced visual PSO, who shall be designated as the lead PSO, coordinate duty schedules and roles, and serve as primary point of contact for the operator. Experience is critical to best performance of the PSO team (*e.g.,* Stone, 2015b), *e.g.,* Mori *et al.* (2003) found that observers classed as having limited experience were significantly less successful in detecting animals than were experienced observers. A survey of professional PSOs and other experts (GHFS, 2015) highlighted the importance of experience as a best practice in selecting PSOs, both for improved performance in detecting animals but also due to the unique challenges a PSO faces while charged with implementing required mitigations onboard a working survey vessel. Experience breeds the confidence and professionalism necessary to maintain positive relations with the vessel operator while making sometimes difficult decisions regarding implementation of mitigation. However, while it is desirable for all PSOs to be qualified through experience, we are also mindful of the need to expand the workforce by allowing opportunity for newly trained PSOs to gain experience. Therefore, the lead PSO shall devise the duty schedule such that experienced PSOs are on duty with trained PSOs (*i.e.,* those PSOs with appropriate training but who have not yet gained relevant experience) to the maximum extent practicable in order to provide necessary mentorship.

With regard to specific observational protocols, we are proposing to largely follow those described in Appendix B of BOEM's PEIS (BOEM, 2017). The lead PSO shall determine the most appropriate observation posts that will not interfere with navigation or operation of the vessel while affording an optimal, elevated view of the sea surface; these should be the highest elevation available on each vessel, with the maximum viewable range from the bow to 90 degrees to port or starboard of the vessel. PSOs shall coordinate to ensure 360° visual coverage around the vessel, and shall conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner. All source vessels must be equipped with pedestal-mounted ''bigeye'' binoculars that will be available for PSO use. Within these broad outlines, the lead PSO and PSO team will have discretion to determine the most appropriate vessel- and survey-specific system for implementing effective marine mammal observational effort. Any observations of marine mammals by crew members aboard any vessel associated with the survey, including receiver or chase vessels, should be relayed to the source vessel and to the PSO team.

We are proposing that all source vessels must use a towed PAM system for potential detection of marine mammals at all times when operating the sound source in waters deeper than 100 m. In shallower waters, only two species are typically present (bottlenose and Atlantic spotted dolphin; rough-toothed dolphins are the only other species potentially encountered in shelf waters but are typically found in deep water (Davis *et al.,* 1998; Fulling *et al.,* 2003; Maze-Foley and Mullin, 2006)). While dolphins may be detected using PAM, we are not proposing to require shutdowns of the source for dolphin presence (described below); therefore, the mitigation would be of low value relative to the estimated cost of equipment and additional personnel.

We are proposing that the system must be monitored at all times during use of the acoustic source, and acoustic monitoring must begin at least 30 minutes prior to ramp-up. PAM operators must be independent. Because the role of PAM operator is more technically complex than is the role of visual PSO, experience is more important (D. Epperson, BSEE, pers. comm.) and we are proposing that all source vessels shall carry a minimum of two experienced PAM operators, which is a stricter requirement than for visual PSOs. PAM operators shall communicate all detections to visual PSOs, when visual PSOs are on duty, including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination. Further detail regarding PAM system requirements may be found in the ''Proposed Monitoring and Reporting'' section, later in this document. The effectiveness of PAM depends to a certain extent on the equipment and methods used and competency of the PAM operator, but no established standards are currently in place. We do offer some specifications later in this document and would require that applicants follow any standards that are established in the future.

Visual monitoring must begin at least 30 minutes prior to ramp-up (described below) and must continue until one hour after use of the acoustic source ceases or until 30 minutes past sunset. If any marine mammal is observed at any distance from the vessel, a PSO would record the observation and monitor the animal's position (including latitude/longitude of the vessel and relative bearing and estimated distance to the animal) until the animal dives or moves out of visual range of the observer. A PSO would continue to observe the area to watch for the animal to resurface or for additional animals that may surface in the area. Visual PSOs shall communicate all observations to PAM operators, including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination.

As noted previously, all source vessels must carry a minimum of one experienced visual PSO and two experienced PAM operators. The observer designated as lead PSO (including the full team of visual PSOs and PAM operators) must have experience as a visual PSO. The applicant may determine how many additional PSOs are required to adequately fulfill the requirements specified here. To summarize, these requirements are: (1) 24-Hour acoustic monitoring during use of the acoustic source in waters deeper than 100 m; (2) visual monitoring during use of the acoustic source by two PSOs during all daylight hours, with one visual PSO on-duty during nighttime ramp-ups; (3) maximum of two consecutive hours on watch followed by a minimum of one hour off watch for visual PSOs and a maximum of four consecutive hours on watch followed by a minimum of two consecutive hours off watch for PAM operators; and (4) maximum of 12 hours of observational effort per 24-hour period for any PSO, regardless of duties. We invite comment on the mitigation-related monitoring requirements proposed for deep penetration airgun survey operations.

Shallow Penetration Airgun—We are proposing that shallow penetration airgun surveys (those using a total volume of airguns less than or equal to 400 in^3) follow the same requirements described above for deep penetration surveys, with one notable exception. The use of PAM is not required, except to begin use of the airgun(s) at night in waters deeper than 100 m. A nighttime start-up must follow the same protocol described above for deep-penetration surveys: Monitoring of the PAM system during a 30-minute pre-clearance period and during the ramp-up period (if applicable). If a PAM system is used during a shallow penetration survey, the PAM operator must have prior experience and training but may be a crew member, and the PAM system does not need to be monitored during full-power firing.

Non-Airgun HRG Surveys—HRG surveys would differ from the previously described protocols for airgun surveys and, as described previously, we differentiate between deep-water (greater than 200 m) and shallow-water HRG. Water depth in the GOM provides a reliable indicator of the marine mammal fauna that may be encountered and, therefore, the complexity of likely observations and concern related to potential effects on deep-diving and/or sensitive species. We are proposing to generally follow the HRG protocol described in Appendix B of BOEM's PEIS (BOEM, 2017), with some differences.

Deep-water HRG surveys would be required to employ a minimum of one independent visual PSO during all daylight operations, in the same manner as was described for airgun surveys. Shallow-water HRG surveys would be required to employ a minimum of one visual PSO, which may be a crew member. PSOs employed during shallow-water HRG surveys would only be required during a pre-clearance period. PAM would not be required for any HRG survey.

PAM Malfunction—Emulating sensible protocols described by the New Zealand Department of Conservation for airgun surveys conducted in New Zealand waters (DOC, 2013), we are proposing that survey activity may continue for brief periods of time when the PAM system malfunctions or is damaged. Activity may continue for 30 minutes without PAM while the PAM operator diagnoses the issue. If the diagnosis indicates that the PAM system must be repaired to solve the problem, operations may continue for an additional two hours without acoustic monitoring under the following conditions:

- Daylight hours and sea state is less than or equal to Beaufort sea state (BSS) 4;
- No marine mammals (excluding delphinids) detected solely by PAM in the exclusion zone (see below) in the previous two hours;
- NMFS is notified via email as soon as practicable with the time and location in which operations began without an active PAM system; and
- Operations with an active acoustic source, but without an operating PAM system, do not exceed a cumulative total of four hours in any 24-hour period.

Practicability—As discussed above, both visual and acoustic monitoring capabilities are critical components of any detection-based mitigation plan, and are routine requirements around the world. Without the use of acoustic monitoring, even during periods of good visibility, species projected to bear the greatest consequences of effects from the specified activity (*e.g.,* beaked whales and sperm whales; see ''Negligible Impact Analysis and Preliminary Determination'') would go undetected much of the time. In addition, the data collected through both visual and acoustic monitoring comprises a majority of the separate monitoring requirements proposed here to satisfy the requirements of the MMPA (see ''Proposed Monitoring and Reporting'').

The use of visual observers has historically been required by BOEM; therefore, the RIA does not assess the costs associated with our proposal to continue this requirement. The use of PAM came into use in the GOM via an incentive scheme introduced in MMS's 2007 Notice to Lessees concerning ''Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program'' (NTL No. 2007–G02), which allowed nighttime start-ups conditional upon use of PAM. More recently, use of PAM in the GOM was expanded pursuant to the terms of the 2013 settlement agreement (as amended and extended through stipulated agreements) referenced above, in which industry parties agreed to use PAM in water depths greater than 100 m during times of reduced visibility. The RIA considers the likely incremental costs of our proposal to require the use of PAM at all times in waters greater than 100 meters in depth and associated shutdowns for detections of ''whales'' (*i.e.,* sperm whales, baleen whales, beaked whales, and *Kogia* spp.), reflecting the increased costs associated with hardware, software, personnel, and additional shutdowns due to acoustic detections relative to both pre-2013 settlement agreement and post-2013 settlement agreement. The range of costs shown in Table 10 reflects the range of projected activity levels provided by BOEM. Please see the RIA for full details. Operationally, use of PAM should not present meaningful difficulty to operators because PAM has been used in some form in the GOM for many years.

In consideration of the expected benefits of the expanded PAM requirements in reducing the probability or severity of impacts to marine mammals species or stocks and the practicability for applicant implementation (*e.g.,* in light of the costs and historical use), we preliminarily determine these measures are warranted. We invite comment on the costs for the additional observer and monitoring requirements and our interpretation of the analysis for determining what measures are warranted.

Exclusion Zone and Buffer Zone

For deep penetration airgun surveys, we are proposing that the PSOs shall establish and monitor a 500-m exclusion zone and additional 500-m buffer zone (total 1 km) during the pre-clearance period and a 500-m exclusion zone during the ramp-up and operational periods. PSOs should focus their observational effort within this 1-km zone, although animals observed at greater distances should be recorded and mitigation action taken as necessary (see below). For shallow penetration airgun surveys, we are proposing that the PSO shall establish and monitor a 200-m exclusion zone with additional 200-m buffer (total 400 m zone) during the pre-clearance period and a 200-m exclusion zone during the ramp-up (for small arrays only, versus single airguns) and operational periods. These zones would be based upon radial distance from any element of the airgun array or from a single airgun (rather than being based on the center of the array or around the vessel itself). During use of the acoustic source, occurrence of marine mammals within the buffer zone (but outside the exclusion zone) would be communicated to the operator to prepare for the potential shutdown of the acoustic source. Use of the buffer zone in relation to ramp-up is discussed under ''Ramp-up.'' Further detail regarding the exclusion zone and shutdown requirements is given under ''Exclusion Zone and Shutdown Requirements.''

For deep-water non-airgun HRG surveys, the PSO would establish and monitor a 400-m zone during the pre-clearance period and a 200-m exclusion zone during the operational periods (the latter as required under BOEM's HRG protocol). For shallow-water non-airgun HRG surveys, the PSO would establish and monitor and 200-m pre-clearance zone (no shutdowns required during operational periods).

Ramp-Up

Ramp-up of an acoustic source is intended to provide a gradual increase in sound levels, enabling animals to move away from the source if the signal is sufficiently aversive prior to its reaching full intensity. We are proposing that ramp-up is required for all airgun surveys (unless using only one airgun), but is not required for non-airgun HRG surveys, as the types of acoustic sources used in such surveys are not typically amenable to ''ramping up'' the acoustic output in the way that multi-element airgun surveys are. We infer on the basis of behavioral avoidance studies and observations that this measure results in some reduced potential for auditory injury and/or more severe behavioral reactions. Stone (2015a) reported on behavioral observations during airgun surveys from 1994–2010, stating that detection rates of cetaceans during ramp-up were significantly lower than when the airguns were not firing and on surveys with large arrays (defined in that study as greater than 500 in^3), more cetaceans were observed avoiding or traveling away from the survey vessel during the ramp-up than at any other time. Dunlop *et al.* (2016) studied the effect of ramp-up during an airgun survey on migrating humpback whales, comparing ramp-up versus use of a constant source level operating at a higher level than the initial ramp-up stage but lower than at full power. Although behavioral response indicating potential avoidance was observed, there was no evidence that audibly increasing levels during ramp-up was more effective in this experimental context at causing aversion than was a constant source. Regardless, the majority of whale groups did avoid the source vessel at distances greater than the radius of most mitigation zones (Dunlop *et al.,* 2016). Von Benda-Beckmann *et al.* (2013), in a study of the effectiveness of ramp-up for sonar, found that ramp-up procedures reduced the risk of auditory injury for killer whales, and that extending the duration of ramp-up did not have a corresponding effect on mitigation benefit. Although this measure is not proven and some arguments have been made that use of ramp-up may not have the desired effect of aversion (which is itself a potentially negative impact assumed to be better than the alternative), ramp-up remains a relatively low-cost, common-sense component of standard mitigation for airgun surveys. Ramp-up is most likely to be effective for more sensitive species (*e.g.,* beaked whales) (*e.g.,* Tyack *et al.,* 2011; DeRuiter *et al.,* 2013; Miller *et al.,* 2015).

The ramp-up procedure involves a step-wise increase in the number of airguns firing and total array volume until all operational airguns are activated and the full volume is achieved. Ramp-up would be required at all times as part of the activation of the acoustic source (including source tests; see ''Miscellaneous Protocols'' for more detail) and may occur at times of poor visibility, assuming appropriate acoustic monitoring with no detections in the 30 minutes prior to beginning ramp-up. Acoustic source activation should only occur at night where operational planning cannot reasonably avoid such circumstances. For example, a nighttime initial ramp-up following port departure is reasonably avoidable and may not occur. Ramp-up may occur at night following acoustic source deactivation due to line turn or mechanical difficulty. The operator must notify a designated PSO of the planned start of ramp-up as agreed-upon with the lead PSO; the notification time should not be less than 60 minutes prior to the planned ramp-up. A designated

PSO must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the PSO to proceed.

We are proposing that ramp-up procedures follow the recommendations of IAGC (2015). Ramp-up would begin by activating a single airgun (*i.e.,* array element) of the smallest volume in the array. Ramp-up continues in stages by doubling the number of active elements at the commencement of each stage, with each stage of approximately the same duration. Total duration should be not less than approximately 20 minutes but is not prescribed and will vary depending on the total number of stages. There will generally be one stage in which doubling the number of elements is not possible because the total number is not even. This should be the last stage of the ramp-up sequence. We are proposing that the operator would be required to provide information to the PSO documenting that appropriate procedures were followed, and request comment on how this information would best be documented. Ramp-ups should be scheduled so as to minimize the time spent with source activated prior to reaching the designated run-in. We are proposing to adopt this approach to ramp-up (increments of array elements) because we believe it is relatively simple to implement for the operator as compared with more complex schemes involving activation by increments of array volume, or activation on the basis of element location or size. Such approaches may also be more likely to result in irregular leaps in sound output due to variations in size between individual elements within an array and their geometric interaction as more elements are recruited. It may be argued whether smooth incremental increase is necessary, but stronger aversion than is necessary should be avoided. The approach proposed here is intended to ensure a perceptible increase in sound output per increment while employing increments that produce similar degrees of increase at each step. We request comment on the proposed ramp-up procedures and requirements.

During deep penetration airgun surveys, we are proposing that PSOs must monitor a 1,000-m zone (or to the distance visible if less than 1,000 m) for a minimum of 30 minutes prior to ramp-up (*i.e.,* pre-clearance) or start-up (for single airgun or non-airgun surveys). While the delineation of zones is typically associated with shutdown, the period during which use of the acoustic source is being initiated is critical, and in order to avoid more severe behavioral reactions it is important to be cautionary regarding marine mammal presence in the vicinity when the source is turned on. This requirement has broad acceptance in other required protocols: The Brazilian Institute of the Environment and Natural Resources requires a 1,000-m pre-clearance zone (IBAMA, 2005), the New Zealand Department of Conservation requires that a 1,000-m zone be monitored as both a pre-clearance and a shutdown zone for most species (DOC, 2013), and the Australian Department of the Environment, Water, Heritage and the Arts requires an even more protective scheme, in which a 2,000-m ''power down'' zone is maintained for higher-power surveys (DEWHA, 2008). Broker *et al.* (2015) describe the use of a precautionary 2-km exclusion zone in the absence of sound source verification (SSV), with a minimum zone radius of 1 km (regardless of SSV results). We believe that the simple doubling of the proposed exclusion zone described here is appropriate for use as a pre-clearance zone. Thus, the pre-clearance zone would be 1,000 m for deep penetration airgun surveys, 400 m for shallow penetration airgun surveys or deep-water HRG surveys, and 200 m for shallow-water HRG surveys. We request comment on this interpretation of a pre-clearance zone which would provide the appropriate protections for the different survey types.

The pre-clearance period may occur during any vessel activity (*i.e.,* transit, line turn). Ramp-up must be planned to occur during periods of good visibility when possible; operators may not target the period just after visual PSOs have gone off duty. Following deactivation of the source for reasons other than mitigation, the operator must communicate the near-term operational plan to the lead PSO with justification for any planned nighttime ramp-up. Any suspected patterns of abuse must be reported by the lead PSO to be investigated by NMFS. Ramp-up may not be initiated if any marine mammal is within the designated 1,000-m zone. If a marine mammal is observed within the zone during the pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting the zone or until an additional time period has elapsed with no further sightings. We suggest an appropriate elapsed time period should be 15 minutes for small odontocetes and 30 minutes for all other species, and request comment on this proposal. PSOs will monitor the 500-m exclusion zone during ramp-up, and ramp-up must cease and the source shut down upon observation of marine mammals within or approaching the zone.

Exclusion Zone and Shutdown Requirements

Deep Penetration Airgun—An exclusion zone is a defined area within which occurrence of a marine mammal triggers mitigation action intended to reduce potential for certain outcomes, *e.g.,* auditory injury, more severe disruption of behavioral patterns. For deep penetration airgun surveys, we propose that PSOs must establish a minimum exclusion zone with a 500-m radius as a perimeter around the outer extent of the airgun array (rather than being delineated around the center of the array or the vessel itself). If a marine mammal appears within or enters this zone, the acoustic source would be shut down (*i.e.,* power to the acoustic source must be immediately turned off). If a non-delphinid marine mammal is detected acoustically, the acoustic source would be shut down, unless the PAM operator is confident that the animal detected is outside the exclusion zone or that the detected species is not subject to the shutdown requirement.

The 500-m radial distance of the standard exclusion zone is expected to contain sound levels exceeding peak pressure injury criteria for all hearing groups other than, potentially, high-frequency cetaceans, while also providing a consistent, reasonably observable zone within which PSOs would typically be able to conduct effective observational effort. Although significantly greater distances may be observed from an elevated platform under good conditions, we believe that 500 m is likely regularly attainable for PSOs using the naked eye during typical conditions. In addition, an exclusion zone is expected to be helpful in avoiding more severe behavioral responses. Behavioral response to an acoustic stimulus is determined not only by received level but by context (*e.g.,* activity state) including, importantly, proximity to the source (*e.g.,* Southall *et al.,* 2007; Ellison *et al.,* 2012; DeRuiter *et al.,* 2013). Ellison *et al.* (2012) describe a qualitative, 10-step index for the severity of behavioral response on the basis of the observed physical magnitude of the response (*e.g.,* minor change in orientation, change in respiration rate, fleeing the area) and its potential biological significance (*e.g.,* cessation of vocalizations, abandonment of feeding, separation of mother and offspring). In prescribing an exclusion zone, we seek not only to avoid most potential auditory injury but also to reduce the likely severity of the behavioral response at a given received level of sound.

Use of monitoring and shutdown or power-down measures within defined exclusion zone distances is inherently an essentially instantaneous proposition—a rule or set of rules that requires mitigation action upon detection of an animal. This indicates that definition of an exclusion zone on the basis of cumulative sound exposure level (cSEL) thresholds, which require that an animal accumulate some level of sound energy exposure over some period of time (*e.g.,* 24 hours), has questionable relevance as a standard protocol. A PSO aboard a mobile source will typically have no ability to monitor an animal's position relative to the acoustic source over relevant time periods for purposes of understanding whether auditory injury is likely to occur on the basis of cumulative sound exposure and, therefore, whether action should be taken to avoid such potential.

Cumulative SEL thresholds are more relevant for purposes of modeling the potential for auditory injury than they are for dictating real-time mitigation, though they can be informative (especially in a relative sense). We recognize the importance of the accumulation of sound energy to an understanding of the potential for auditory injury and that it is likely that, at least for low-frequency cetaceans, some potential auditory injury is likely impossible to mitigate and should be considered for authorization.

Considering both the dual-metric thresholds described previously (and shown in Table 7) and hearing group-specific marine mammal auditory weighting functions in the context of the airgun sources considered here, auditory injury zones indicated by the peak pressure metric are expected to be predominant for both mid- and high-frequency cetaceans, while zones indicated by cSEL criteria are expected to be predominant for low-frequency cetaceans. Assuming a source level of 255.2 dB 0-pk SPL for the notional 8,000 in^3 array and spherical spreading propagation, distances for exceedance of group-specific peak injury thresholds are as follows: 65 m (LF), 18 m (MF), and 457 m (HF) (for high-frequency cetaceans, although the notional source parameters indicate a zone less than 500 m, we recognize that actual isopleth distances will vary based on specific array characteristics and site-specific propagation characteristics, and that it is therefore possible that a real-world distance to the injury threshold could exceed 500 m). Assuming a source level of 227.7 dB 0-pk SPL for the notional 90 in^3 single airgun and spherical spreading propagation, these distances would be 3 m (LF) and 19 m (HF) (the source level is lower than the threshold criterion value for mid-frequency cetaceans).

Consideration of auditory injury zones based on cSEL criteria are dependent on the animal's applied hearing range and how that overlaps with the frequencies produced by the sound source of interest in relation to marine mammal auditory weighting functions (NMFS, 2016). As noted above, these are expected to be predominant for low-frequency cetaceans because their most susceptible hearing range overlaps the low frequencies produced by airguns, while the modeling indicates that zones based on peak pressure criteria dominate for mid- and high-frequency cetaceans. In order to evaluate notional zone sizes and to incorporate the technical guidance's weighting functions over a seismic array's full acoustic band, we obtained unweighted spectrum data (modeled in 1 Hz bands) for a reasonably equivalent acoustic source (*i.e.,* a 36-airgun array with total volume of 6,600 in^3). Using these data, we made adjustments (dB) to the unweighted spectrum levels, by frequency, according to the weighting functions for each relevant marine mammal hearing group. We then converted these adjusted/weighted spectrum levels to pressures (micropascals) in order to integrate them over the entire broadband spectrum, resulting in broadband weighted source levels by hearing group that could be directly incorporated within NMFS's User Spreadsheet (*i.e.,* override the spreadsheet's more simple weighting factor adjustment). Using the User Spreadsheet's ''safe distance'' methodology for mobile sources (described by Sivle *et al.,* 2014) with appropriate dB adjustments derived from the methodology described above, and inputs assuming a 231.8 dB SEL source level for the notional 8,000 in^3 array, spherical spreading propagation, a source velocity of 4.5 kn, pulse duration of 100 ms, and a 25-m shot interval (shot intervals may vary, with longer shot intervals resulting in smaller calculated zones), distances for group-specific threshold criteria are as follows: 574 m (LF), 0 m (MF), and 1 m (HF).

We also assessed the potential for injury based on the accumulation of energy resulting from use of the single airgun and, assuming a source level of 207.8 dB SEL, there would be no realistic zone within which injury would occur. On the basis of this finding as well as the potential zone sizes based on the peak pressure criteria described above, we do not expect any reasonable potential for auditory injury resulting from use of the single airgun. No potential injurious exposures were predicted for single airgun surveys (Zeddies *et al.,* 2015, 2017a).

We expect that the proposed 500-m exclusion zone would typically contain the entirety of any potential injury zone for mid-frequency cetaceans (realistically, there is no such zone), while the zones within which injury could occur may be larger for high-frequency cetaceans (on the basis of peak pressure and depending on the specific array) and for low-frequency cetaceans (on the basis of cumulative sound exposure). These findings indicate that auditory injury is unlikely for mid-frequency cetaceans.

In summary, our intent in prescribing a standard exclusion zone distance is to (1) encompass zones for most species within which auditory injury could occur on the basis of instantaneous exposure; (2) provide additional protection from the potential for more severe behavioral reactions (*e.g.,* panic, antipredator response) for marine mammals at relatively close range to the acoustic source; (3) provide consistency and ease of implementation for PSOs, who need to monitor and implement the exclusion zone; and (4) to define a distance within which detection probabilities are reasonably high for most species under typical conditions. Our use of 500 m as the zone is not based directly on any quantitative understanding of the range at which auditory injury would be entirely precluded or any range specifically related to disruption of behavioral patterns. Rather, we believe it is a reasonable combination of factors. This zone has been proven as a feasible measure through past implementation by operators in the GOM. In summary, a practicable criterion such as this has the advantage of familiarity and simplicity while still providing in most cases a zone larger than relevant auditory injury zones, given realistic movement of source and receiver. Increased shutdowns, without a firm idea of the outcome the measure seeks to avoid, simply displace survey activity in time and increase the total duration of acoustic influence as well as total sound energy in the water (due to additional ramp-up and overlap where data acquisition was interrupted). The shutdown requirement described here would be required for most marine mammals, with the exception of small delphinoids, described in the following section; and Bryde's whales, any large whale observed with calf, sperm whales, beaked whales, and *Kogia* spp., described in the subsequent section entitled ''Other Shutdown Requirements.'' We request comment on our interpretation of the data, proposed standard exclusion zone, and shutdown requirements for most species (see subsequent proposed exceptions) during deep penetration airgun surveys.

Dolphin Exception—As defined here, the small delphinoid group is intended to encompass those members of the Family Delphinidae most likely to voluntarily approach the source vessel for purposes of interacting with the vessel and/or airgun array (*e.g.,* bow riding). This exception to the shutdown requirement applies solely to specific genera of small dolphins—*Steno, Tursiops, Stenella,* and *Lagenodelphis* (see Table 3)—and applies under all circumstances, regardless of what the perception of the animal(s) behavior or intent may be. Variations of this measure that include exceptions based on animal behavior—*e.g.,* ''bow-riding'' dolphins, or only ''traveling'' dolphins, meaning that the intersection of the animal and exclusion zone may be due to the animal rather than the vessel—have been proposed by both NMFS and BOEM and have been criticized, in part due to the subjective on-the-spot decision-making this scheme would require of PSOs. If the mitigation requirements are not sufficiently clear and objective, the outcome may be differential implementation across surveys as informed by individual PSOs' experience, background, and/or training. The proposal here is based on several factors: The lack of evidence of or presumed potential for the types of effects to these species of small delphinoid that our shutdown proposal for other species seeks to avoid, the uncertainty and subjectivity introduced by such a decision framework, and the practicability concern presented by the operational impacts. While there may be some potential for adverse impacts to dolphins—Gray and Van Waerebeek (2011) report an observation of a pantropical spotted dolphin exhibiting severe distress in close proximity to an airgun survey, examine other potential causes for the display, and ultimately suggest a cause-effect relationship—we are not aware of other such incidents despite a large volume of observational effort during airgun surveys in the GOM, where dolphin shutdowns have not previously been required. Dolphins have a relatively high threshold for the onset of auditory injury (*i.e.,* permanent threshold shift) and more severe adverse behavioral responses seem less likely given the evidence of purposeful approach and/or maintenance of proximity to vessels with operating airguns.

The best available scientific evidence indicates that auditory injury as a result of airgun sources is extremely unlikely for mid-frequency cetaceans, primarily due to a relative lack of sensitivity and susceptibility to noise-induced hearing loss at the frequency range output by airguns (*i.e.,* most sound below 500 Hz) as shown by the mid-frequency cetacean auditory weighting function (NMFS, 2016). Criteria for temporary threshold shift (TTS) in mid-frequency cetaceans for impulsive sounds were derived by experimental measurement of TTS in beluga whales exposed to pulses from a seismic watergun; dolphins exposed to the same stimuli in this study did not display TTS (Finneran *et al.,* 2002). Moreover, when the experimental watergun signal was weighted appropriately for mid-frequency cetaceans, less energy was filtered than would be the case for an airgun signal. More recently, Finneran *et al.* (2015) exposed bottlenose dolphins to repeated pulses from an airgun and measured no TTS.

While dolphins are observed voluntarily approaching source vessels (*e.g.,* bow-riding or interacting with towed gear), the reasons for the behavior are unknown. In context of an active airgun array, the behavior cannot be assumed to be harmless. Although bow-riding comprises approximately 30 percent of behavioral observations in the GOM, there is a much lower incidence of the behavior when the acoustic source is active (Barkaszi *et al.,* 2012), and this finding was replicated by Stone (2015a) for surveys occurring in United Kingdom waters. There appears to be strong evidence of aversive behavior by dolphins during firing of airguns. Barkaszi *et al.* (2012) found that the median closest distance of approach to the acoustic source was at significantly greater distances during times of full-power source operation when compared to silence, while Stone (2015a) and Stone and Tasker (2006) reported that significant behavioral responses, including avoidance and changes in swimming or surfacing behavior, were evident for dolphins during firing of large arrays. Goold and Fish (1998) described a ''general pattern of localized disturbance'' for dolphins in the vicinity of an airgun survey. However, while these general findings—typically, dolphins will display increased distance from the acoustic source, decreased prevalence of ''bow-riding'' activities, and increases in surface-active behaviors—are indicative of adverse or aversive responses that may be construed as ''take'' (as defined by the MMPA), they are not indicative of any response of a severity such that the need to avoid it outweighs the impact on practicability for the industry and operators.

Additionally, increased shutdowns resulting from such a measure would require source vessels to revisit the missed track line to reacquire data, resulting in an overall increase in the total sound energy input to the marine environment and an increase in the total duration over which the survey is active in a given area.

Instead of shutdown, if a dolphin of the indicated genera (*Steno, Tursiops, Stenella,* and *Lagenodelphis*) appears within or enters the 500-m exclusion zone, or is acoustically detected and localized within the zone, we present two alternatives.

- *Proposal 1:* The acoustic source would be powered down to the smallest single element of the array. The power-down is intended to minimize potential disturbance to dolphins in a practicable way, by reducing the acoustic output while maintaining what should be an aversive stimulus. Power-down conditions would be maintained until the animal(s) is observed exiting the exclusion zone or for 15 minutes beyond the last observation of the animal, following which full-power operations may be resumed without ramp-up. A source vessel traveling at a typical speed of approximately 4.5 kn would transit approximately 2 km during this period. We expect that the resulting gap in data acquisition would be sufficiently small as to not require reshooting for infill; therefore, increased time over which acoustic energy is output, as well as significant operational impacts, would be avoided while maintaining reasonable protections for dolphins.
- *Proposal 2:* No shutdown or power-down would be required. We described above the information that supports our preliminary decision that an exception to the general shutdown requirement is warranted for small dolphins, as well as the information that we believe indicates that a power-down requirement is warranted in lieu of shutdown. However, members of the public may interpret this information as supporting an exception to the shutdown requirement with no power-down requirement.

We request comment on both proposals and other variations of these proposals, including our interpretation of the data and any other data that support the necessary findings regarding small dolphins for no shutdown and no power-down or no shutdown but a power-down.

Although other mid-frequency hearing specialists (*e.g.,* large delphinoids) are considered no more likely to incur auditory injury than are small delphinoids, they are much less likely to approach vessels. Therefore, we have evaluated that retaining a shutdown requirement for large delphinoids would not have similar impacts in terms of either practicability for the applicant or corollary increase in sound energy output and time on the water. We do anticipate some benefit for a shutdown requirement for large delphinoids in that it simplifies somewhat the total array of decision-making for PSOs and may preclude any potential for physiological effects other than to the auditory system as well as some more severe behavioral reactions for any such animals in close proximity to the source vessel. The variations in regulatory text for these proposals can be found in ''Alternative Regulatory Text,'' later in this preamble, and in the regulatory text at the end of the document.

Practicability—The requirement to use a generalized 500-m exclusion zone and to require shutdown upon observation of whales within that zone has historically been required by BOEM. Here, we assess practicability for possible dolphin shutdowns (described in full in the RIA). The IAGC provided information in response to a 2014 survey regarding the costs of survey activities including, by survey type, average survey duration, mobilization and pre-mobilization costs, and vessel operating costs per day, allowing for estimates of total average survey costs. IAGC also provided information relating to estimated average shutdown time following marine mammal observations in the exclusion zone and typical additional hours required to reshoot the areas missed during the shutdown period. For the latter, estimates ranged from 1–2 additional hours up to 12 hours (for 3D WAZ surveys). Barkaszi *et al.* (2012) found that small dolphins were observed within the exclusion zone on 5.7 percent of days, and that large dolphins were observed in the exclusion zone on 1.2 percent of days (unidentified delphinid species were observed on an additional 1.2 percent of days). The cost of shutdowns for dolphins in the exclusion zone is a function of the total number of days added to a survey, which accrue via (1) total time from shutdown until resuming data acquisition (1.6–2 hours) and (2) time required to reshoot an interrupted survey line (1–12 hours, depending on the survey type). To quantify this cost, the total number of added days is multiplied by the daily vessel operating cost for each survey type that uses airguns, with resulting annualized costs for shutdowns due to dolphins in the exclusion zone depending on actual level of activity (see RIA for cost estimates). In consideration of the preceding discussion of expected benefit from shutdowns for dolphins in context with these impacts on operations, we do not consider full shutdown for small dolphins in the exclusion zone to be warranted. The alternative presented requiring power-down for small dolphins in the exclusion zone is expected to cost less because of the ability to start back up without a ramp-up and the potentially reduced need to reshoot lines. The same would hold true for the alternative presented requiring no power-down based on there being no need to modify the survey at all. Operationally, we have attempted to minimize the potential for subjective and potentially inconsistent decision-making by PSOs. NMFS expects that large delphinoids (*e.g.,* false killer whales, melon-headed whales) in general are easily distinguished from small delphinoids (*e.g.,* spotted dolphins, Clymene dolphins) in general by trained, experienced observers on the basis of differences in size, color, and cranial/dorsal morphology, and requests any information relating to this assumption. Based on the protective value of the described measure and the understanding of practicability, we preliminarily determine the power-down measures are warranted.

Other Shutdown Requirements—We are proposing that shutdown of the acoustic source should also be required in the event of certain other observations regardless of the defined exclusion zone. It must be noted up front that any such observations would still be within range of where behavioral disturbance of some form and degree would be likely to occur, *e.g.,* Zeddies *et al.* (2015) estimated unweighted mean 95 percent range to 160 dB rms threshold (*i.e.,* the 50 percent midpoint for behavioral disturbance) levels across water depths and seasons at approximately 13 km (range 7.7–21.8 km) for the 8,000 in^3 array (Zeddies *et al.,* 2015). Thus, for the species or situations listed below, we present two alternatives:

• *Proposal 1:* Shutdown of the acoustic source would occur in the circumstances listed below, with no distance limit (*i.e.,* at any distance from the source). While visual PSOs would focus observational effort within the vicinity of the acoustic source and vessel (*i.e.,* approximately 1 km radius), this does not preclude them from periodic scanning of the remainder of the visible area, and we do not have a reason to believe that such periodic scans by professional PSOs would hamper the ability to maintain observation of areas closer to the source and vessel.

• *Proposal 2:* Shutdown of the acoustic source would occur in the circumstances listed below, only within 1 km of the source (measured as the radial distance from any element of the airgun array).

We request comment on both proposals and other variations of these proposals, including our interpretation of the data and any other data that support the necessary findings regarding initiating shutdown for certain circumstances at any distance or within 1 km. The variations in regulatory text for these proposals can be found in ''Alternative Regulatory Text,'' later in this preamble, and in the regulatory text at the end of the document.

Circumstances triggering Proposal 1 or Proposal 2 include:

• Upon detection (visual or acoustic) of a Bryde's whale. On the basis of the findings of NMFS's status review (described in a NOAA technical memorandum; Rosel *et al.,* 2016), NMFS has proposed to list the GOM Bryde's whale as an endangered species pursuant to the ESA (81 FR 88639; December 8, 2016). These whales form a small and resident population in the northeastern GOM, with a highly restricted geographic range and a very small population abundance (fewer than 100)—recently determined by a status review team to be ''at or below the near-extinction population level'' (Rosel *et al.,* 2016). The review team stated that, aside from the restricted distribution and small population, the whales face a significant suite of anthropogenic threats, one of which is noise produced by geophysical surveys. We believe it appropriate to eliminate potential effects to individual Bryde's whales to the extent practicable. As described previously, there may be rare sightings of vagrant baleen whales of other species in the GOM; if identification of the observed whale is inconclusive the shutdown must be implemented.

• Upon observation of a large whale (*i.e.,* sperm whale or any baleen whale) with calf, with ''calf'' defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult. Groups of whales are likely to be more susceptible to disturbance when calves are present (*e.g.,* Bauer *et al.,* 1993), and disturbance of cow-calf pairs could potentially result in separation of vulnerable calves from adults. McCauley *et al.* (2000a) found that groups of humpback whale females with calves consistently avoided a single operating airgun, while male humpbacks were attracted to it, concluding that cow-calf pairs are more likely to exhibit avoidance responses to unfamiliar sounds and that such responses should be a focus of management. Behavioral disturbance has been implicated in mother-calf separations for odontocete species as well (Noren and Edwards, 2007; Wade *et al.,* 2012). Separation, if it occurred, could be exacerbated by airgun signals masking communication between adults and the separated calf (Videsen *et al.,* 2017). Absent separation, airgun signals can disrupt or mask vocalizations essential to mother-calf interactions. Given the status of large whales in the GOM, the consequences of potential loss of calves, as well as the functional sensitivity of the mysticete whales to frequencies associated with the subject geophysical survey activity, we believe this measure is warranted by the MMPA's least practicable adverse impact standard.

- Upon acoustic detection of a sperm whale. Sperm whales are not necessarily expected to display physical avoidance of sound sources (*e.g.,* Madsen *et al.,* 2002a; Jochens *et al.,* 2008; Winsor *et al.,* 2017). Although Winsor *et al.* (2017) report that distances and orientations between tagged whales and active airgun arrays appeared to be randomly distributed with no evidence of horizontal avoidance, it must be noted that their study was to some degree precipitated by an earlier observation of significantly decreased sperm whale density in the presence of airgun surveys (Mate *et al.,* 1994). However, effects on vocal behavior are common (*e.g.,* Watkins and Schevill, 1975; Watkins *et al.,* 1985). In response to a low-frequency tone, sperm whales were observed to cease vocalizing (vocalizations detected during 24 percent of a baseline period and not detected during transmission; vocalizations resumed at most 36 hours post-transmission). Although the signal characteristics in this study were dissimilar to airgun signals, the authors also note that an airgun survey was being conducted simultaneously with signals exceeding background noise by 10–15 dB (Bowles *et al.,* 1994). The sperm whale's primary means of locating prey is echolocation (Miller *et al.,* 2004), and multiple studies have shown that noise can disrupt feeding behavior and/or significantly reduce foraging success for sperm whales at relatively low levels of exposure (*e.g.,* Miller *et al.,* 2009, 2012; Isojunno *et al.,* 2016; Sivle *et al.,* 2012; Cure *et al.,* 2016). Effects on energy intake with no immediate compensation, as is suggested by disruption of foraging behavior without corollary movements to new locations, would be expected to result in bioenergetics consequences to individual whales. Farmer *et al.* (2018) developed a stochastic life-stage structured bioenergetic model to evaluate the consequences of reduced foraging efficiency in sperm whales, finding that individual resilience to foraging disruptions is primarily a function of size (*i.e.,* reserve capacity) and daily energetic demands, and that the ultimate effects on reproductive success and individual fitness are largely dependent on the duration and frequency of disturbance.

Sperm whales in the GOM spend the majority of their time foraging, engaging in dive cycles consisting of deep dives of approximately 45 minutes followed by shorter surface intervals (resting bouts) of approximately 10 minutes (Watwood *et al.,* 2006). Sperm whales alternate between shallow and deep dives over periods of several hours, targeting predominantly epipelagic prey during shallow dives and benthopelagic prey during deep dives (Fais *et al.,* 2015). During the search phase of their dive, whales emit regular clicks with high directionality, high source levels, and frequencies around 15 kHz, suitable for long-range sonar (Møhl *et al.,* 2003). During the capture phase, interclick interval, amplitude, and signal duration decrease dramatically, providing rapid updates on the location of prey during capture, creating a sound termed as either a creak or a buzz (Madsen *et al.,* 2002b; Miller *et al.,* 2004). On the basis of observed echolocation during the ascent phase, Fais *et al.* (2015) concluded that sperm whale decisions about where to forage during subsequent dives may be based on both prior foraging success and information gathered during ascent, suggesting that sperm whales can perform auditory stream segregation of multiple targets when echolocating, simultaneously tracking several targets for sequential capture and perceptually organizing a multi-target auditory scene. As stated by Farmer *et al.* (2018), this complex information-gathering allows sperm whales to efficiently locate and access prey resources in a dark, patchy, and vast environment while leaving whales vulnerable to reduction in sensory volume and/or interference with complex auditory stream signal processing (Fais *et al.,* 2015). Such effects, which may result from increased noise in the environment, can increase search effort required to locate resources and ultimately reduce foraging efficiency (*e.g.,* Zollner and Lima, 1999). As deep-diving animals, sperm whales may be expected to be more consistently exposed to elevated sound levels in the downward-refracting acoustic environment.

Miller *et al.* (2009) showed that GOM sperm whales are susceptible to disruption of foraging behavior upon exposure to relatively moderate sound levels at distances greater than contemplated for our proposed general exclusion zone. Although tagged whales did not change behavioral state during exposure or show horizontal avoidance, they increased energy put into swimming and their buzz rates (a proxy for attempts to capture prey) were approximately 20 percent lower (though not a statistically significant result). One whale, despite not showing avoidance behavior, engaged in an unusually long resting bout of 265 minutes (compared with typical duration of approximately 10 min), representing a significant delay in foraging effort (Miller *et al.,* 2008, 2009). This finding is of particular importance, as it indicates that sperm whales may not be as likely to show avoidance of active sound sources which would then leave them more vulnerable to subsequent foraging disruption—an effect of greater significance. Analysis conducted by Jochens *et al.* (2008) suggested that, for these whales, a 20 percent decrease in foraging activity was more likely than no change in foraging activity, with one whale showing a statistically significant decrease of 60 percent.

The income breeding strategy used by sperm whales requires stable or predictable environments that enable continuous energy acquisition throughout the year, at rates of up to thousands of kilograms of prey per day (Irvine *et al.,* 2017; Clarke *et al.,* 1993; Farmer *et al.,* 2018). On days when sperm whale foraging is impaired, whales would likely compensate for the caloric deficit by depleting carbohydrate reserves and, secondarily, lipid and protein reserves (Lockyer, 1991; Castellini and Rea, 1992; Farmer *et al.,* 2018). Energy reserves are available from carbohydrates in the blubber and muscle; lipids in the blubber, muscle, and viscera; and proteins in the muscle and viscera. However, physiological evidence suggests that sperm whales are poorly adapted to handle periods of food shortage, as the energy density of sperm whale blubber is much lower than that of baleen whales; sperm whales do not exhibit appreciable changes in blubber thickness relative to body length, even during lactation; and the vast majority of blubber lipids are stored in a form that helps to conserve oxygen during metabolism but is less accessible as a source of energy (Lockyer, 1981; Koopman, 2007; Farmer *et al.,* 2018). If total energy reserves are depleted below critical levels, an individual's body condition would be expected to decline over time and, for pregnant or lactating females, fetus abortion or calf abandonment could occur (*e.g.,* New *et al.,* 2013). In this way, responses to airgun survey noise can accrue towards population-level impacts (*e.g.,* New *et al.,* 2014; King *et al.,* 2015; Fleishman *et al.,* 2016).

Sperm whales in the northern GOM have a relatively small population abundance, and with a relatively narrow distribution that overlaps almost completely with areas of current and future geophysical survey activity and other oil and gas industry activity. Further, most resident female sperm whale movements in the GOM range within smaller areas—approximately 200 km around a core home range—although larger individual and group movements were also observed (Jochens *et al.,* 2008). The bioenergetic simulations of Farmer et al. (2018) show that frequent disruptions in foraging, as might be expected when large amounts of survey activity overlap with areas of importance for sperm whales, can have potentially severe fitness consequences. Even partial disturbances of foraging, if sufficiently frequent, may lead to lower body condition, with potential indirect effects of delayed sexual maturation or reduced reproductive fitness (Farmer *et al.,* 2018). It is also unlikely that any ''hunger response'' following disruption of foraging would result in increases in daily growth rate that could be expected to offset the effects of sustained foraging disruption (Farmer *et al.,* 2018). While the modeling exercise conducted by Farmer *et al.* (2018) shows that terminal starvation is an unlikely outcome—though possible in mature whales repeatedly exposed to sound levels that result in reduced foraging ability over periods of weeks to months—minor disruptions can cause substantial reductions in available reserves over time.

Multiple lines of evidence indicate that sperm whales in the northern GOM are somewhat isolated from global sperm whale populations (Jochens *et al.,* 2008). The estimated annual rate of increase from reproduction for GOM sperm whales is less than one percent per year, while Chiquet *et al.* (2013) found that reducing the survivorship rate of mature female sperm whales by as little as 2.2 percent or the survivorship rate of mothers by as little as 4.8 percent would drop the asymptotic growth rate of the northern GOM sperm whale population below one, *i.e.,* a declining population. NOAA estimates that the DWH oil spill may have caused reproductive failure in 7 percent of female sperm whales (DWH MMIQT, 2015). Separately, NOAA estimates that 16 percent of the sperm whale population was exposed to high concentrations of oil both at the surface and sub-surface, high concentrations of volatile gases that could be inhaled at the surface, and response activities including increased vessel operations, dispersant applications, and oil burns (DWH MMIQT, 2015). Independent of other factors, the DWH oil spill may have a long-term impact of reducing the GOM sperm whale population by up to 7 percent, with an estimated time to recovery of 21 years (DWH MMIQT, 2015). Therefore, even in the absence of other future stressors, the environmental baseline for the GOM sperm whale population requires that meaningful measures be taken to minimize disruption of foraging behavior. Such measures are all the more important, as we have considered but eliminated a time-area restriction for sperm whales (described below).

We also considered requirement of shutdown upon visual detection of sperm whales. Here, we assume that acoustic detections of sperm whales would most likely be representative of the foraging behavior we intend to minimize disruption of, while visual observations of sperm whales would represent resting between bouts of such behavior. Occurrence of resting sperm whales at distances beyond the exclusion zone may not indicate a need to implement shutdown. We consider these assumptions in conjunction with an assessment of the costs and operational feasibility of these measures in ''Practicability,'' below.

• Upon observation (visual or acoustic) of a beaked whale or *Kogia* spp. These species are behaviorally sensitive deep divers and it is possible that disturbance could provoke a severe behavioral response leading to injury (*e.g.,* Wursig *et al.,* 1998; Cox *et al.,* 2006). Unlike the sperm whale, we recognize that there are generally low detection probabilities for beaked whales and *Kogia* spp., meaning that many animals of these species may go undetected. Barlow (1999) estimates such probabilities at 0.23 to 0.45 for Cuvier's and Mesoplodont beaked whales, respectively. However, Barlow and Gisiner (2006) predict a roughly 24–48 percent reduction in the probability of detecting beaked whales during seismic mitigation monitoring efforts as compared with typical research survey efforts, and Moore and Barlow (2013) noted a decrease in *g*(0) for Cuvier's beaked whales from 0.23 at BSS 0 (calm) to 0.024 at BSS 5. Similar detection probabilities have been noted for *Kogia* spp., though they typically travel in smaller groups and are less vocal, thus making detection more difficult (Barlow and Forney, 2007). As discussed previously in this document (see the ''Estimated Take'' section), there are high levels of predicted exposures for beaked whales in particular. Because it is likely that only a small proportion of beaked whales and *Kogia* spp. potentially affected by the proposed surveys would actually be detected, it is important to avoid potential impacts when practicable. Additionally for *Kogia* spp.—the one species of high-frequency cetacean likely to be encountered—auditory injury zones relative to peak pressure thresholds are significantly greater than for other cetaceans—approximately 500 m from the acoustic source, depending on the specific real world array characteristics (NMFS, 2016).

Practicability—In the bulleted subsections above, we evaluated the importance of offering expanded protections via shutdown for these species/circumstances and, as discussed, we find that avoidance to extent practicable of acute impacts for Bryde's whales, sperm whales, beaked whales, and *Kogia* spp., as well as for large whales with calves, is important to a reduction of effects for these species. In the RIA, we evaluate the annualized incremental costs of these expanded measures (note that the costs of additional shutdowns based on acoustic detections is included in our previous discussion of costs associated with expanded use of PAM). Additional requirements for shutdowns based on visual detections outside the exclusion zone result in a small cost relative to the benefits afforded by the measures. Additionally, due to the rarity of visual observations of these species groups, we do not believe that the expanded shutdowns would cause any undue operational burden.

In the GOM, we expect that the optimum detection range of sperm whales in low-noise conditions is likely to be approximately 2–3 km. This relatively short detection range is likely due to the propagation conditions resulting when a relatively warmer mixed surface layer provides a strong negative sound velocity profile, causing strong downward refraction of acoustic rays. While the maximum detection range of vocalizing marine mammals continues to be a challenging area in use of PAM for mitigation monitoring, basic signal detection theory dictates that received levels have to exceed certain noise levels in order for the signal to be detected. We consider the following sonar equations:

$EL = SL - TL$ (1)
$SNR = EL - NR$ (2)
$SE = SNR - DT$ (3)

where EL is the received level, SL the source level, TL the transmission loss, SNR the signal-to-noise ratio, NR the received noise spectral density, SE the signal excess, and DT the detection threshold.

As the signal (in this case, a sperm whale click) propagates from its source (the whale) through the environment to a receiver (a hydrophone), its intensity (acoustic power within a unit area) is reduced due to acoustic energy divergence and attenuation (absorption and scattering). By the time the whale click reaches the hydrophone, its received intensity level is greatly reduced from its original source level. In addition, for the received level to be detected by the hydrophone, the signal-to-noise ratio (received level minus the background noise spectral density) must be above a certain detection threshold, *i.e.,* there must be a positive signal excess.

Based on various studies (Madsen and Mohl, 2000; Mohl *et al.,* 2000; Thode *et al.,* 2002; Zimmer *et al.,* 2005), the source levels of sperm whale clicks fall between 202 and 223 dB re 1 μPa, with a pronounced directionality and significant energy above 10 kHz. However, these values are selected from the most intense clicks from each sequence so they are likely to have been recorded close to the acoustic axis (Mohl *et al.,* 2000). Considering all recordings, Mohl *et al.* (2000) suggest that sperm whale click maximum source levels are in the range of 175 to 200 dB re 1 μPa. By using a middle range of the maximum source level of 188 dB re 1 μPa with a 50 percent detection range at 4 km, and assume an ambient noise spectral density at 75 dB with a detection threshold of 6 dB, the transmission loss at this range would be 107 dB. By simply applying a geometric spreading model, it can be shown that the transmission loss (TL) follows $TL = 29.7\log_{10}(R)$, where R is the distance from the source in meters. Please note that this approximation is based on a very low ambient noise spectrum density (Wenz, 1962).

In the presence of an airgun survey, the background noise level is expected to be significantly increased as a result of the reverberant field generated from intense pulses (Guerra *et al.,* 2011; Guan *et al.,* 2015). It has been shown that the level of elevated inter-pulse noise levels can be as high as 20 dB within 1 km of an active firing airgun array of 640 in^3 (Guan *et al.,* 2015) to 30–45 dB for a 3,147 cu^3 airgun array (Guerra *et al.,* 2011). Given that towing hydrophones for PAM used for marine mammal monitoring would be within 1 km from the airgun source, the received noise spectral density is expected to be very high. Using a relatively low 25 dB increase from the inter-pulse noise level to compute detection with the otherwise the same parameters from the above example in the quiet environment, one would find that a 50 percent detection probability is quickly reduced to 576 m. If, given the unfavorable signal propagation conduction in the GOM in comparison to the more favorable conditions in the North Pacific (Barlow and Taylor, 2005), a 50 percent detection probability at 3 km in quiet conditions would be reduced to 462 m during the active airgun survey. A 50 percent detection probability at 2 km in quiet conditions would further reduce the detection range to 339 m.

However, we recognize that the addition of sperm whale shutdowns based on visual detections beyond the exclusion zone would result in a larger estimated additional cost per year. Based on these costs, and our previous discussion of assumptions related to acoustic versus visual detections of sperm whales, we preliminarily do not believe the addition of shutdowns for sperm whales based on visual detections at any distance to be warranted, and request any information from the public that would be relevant to this determination. For this proposed rule, we preliminarily determine that the addition of the proposed shutdown measures described above are warranted when their likely ability to reduce the probability or severity of impacts on species or stocks and their habitat is considered along with their practicability.

Other Surveys—Shutdowns for shallow penetration airgun surveys or deep-water non-airgun HRG surveys would be similar to those described for deep penetration airgun surveys, except that the exclusion zone would be defined as a 200-m radial distance around the perimeter of the acoustic source, in keeping with BOEM's exclusion zone requirements for their ''HRG survey protocol.'' The special circumstance shutdowns described above for deep penetration airgun surveys would not be required. The dolphin exception described for deep penetration airgun surveys would apply; if the survey is using a small airgun array (*i.e.,* less than or equal to 400 in^3, versus a single airgun), then power-down should be implemented as described for deep penetration airgun surveys. As described previously, no shutdowns would be required for shallow-water non-airgun HRG surveys.

Shutdown Implementation Protocols—Any PSO on duty has the authority to delay the start of survey operations or to call for shutdown of the acoustic source. When shutdown is called for by a PSO, the acoustic source must be immediately deactivated and any dispute resolved only following deactivation. The operator must establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the acoustic source to ensure that shutdown commands are conveyed swiftly while allowing PSOs to maintain watch; hand-held UHF radios are recommended. When both visual PSOs and PAM operators are on duty, all detections must be immediately communicated to the remainder of the on-duty team for potential verification of visual observations by the PAM operator or of acoustic detections by visual PSOs and initiation of dialogue as necessary. When there is certainty regarding the need for mitigation action on the basis of either visual or acoustic detection alone, the relevant PSO(s) must call for such action immediately.

Upon implementation of shutdown, the source may be reactivated after the animal(s) has been observed exiting the exclusion zone or following a 30-minute clearance period with no further observation of the animal(s). Where there is no relevant zone (*e.g.,* shutdowns at any distance), a 30-minute clearance period must be observed following the last detection of the animal(s).

If the acoustic source is shut down for reasons other than mitigation (*e.g.,* mechanical difficulty) for brief periods (*i.e.,* less than 30 minutes), it may be activated again without ramp-up if PSOs have maintained constant visual and acoustic observation and no visual detections of any marine mammal have occurred within the exclusion zone and no acoustic detections have occurred. We define ''brief periods'' in keeping with other clearance watch periods and to avoid unnecessary complexity in protocols for PSOs. For any longer shutdown (*e.g.,* during line turns), pre-clearance watch and ramp-up are required. For any shutdown at night or in periods of poor visibility (*e.g.,* BSS 4 or greater), ramp-up is required but if the shutdown period was brief and constant observation maintained, pre-clearance watch is not required.

Power-Down

Power-down, as defined here, refers to reducing the array to a single element as a substitute for full shutdown. We address use of a single airgun as a ''mitigation source'' below. In a power-down scenario, it is assumed that reducing the size of the array to a single element reduces the ensonified area such that an observed animal is outside of any area within which injury or more severe behavioral reactions could occur. Zeddies *et al.* (2015) modeled the 95 percent ranges for a single airgun as 360 m to the 160-dB rms SPL threshold and 42 m to the 180-dB rms SPL threshold. As proposed here, power-down to the single smallest array element is required when a small dolphin enters the defined EZ, but is not allowed for any other reason (*e.g.,* to avoid pre-clearance and/or ramp-up). Our rationale is that this is a necessary corollary to the dolphin exception described previously. As described previously, use of the acoustic source at full power may resume following visual observation of the animal(s) exiting the exclusion zone or 15 minutes following the last observation of the animal. If ramp-up were required, it is likely that infill of the missed line would be necessary, thereby reducing the benefit of the dolphin exception.

Mitigation Source

Mitigation sources may be separate individual airguns or may be an airgun of the smallest volume in the array, and have historically been used when the full array is not being used (*e.g.,* during line turns) in order to allow ramp-up during poor visibility. The difference between use of a single airgun in a power-down scenario and as a ''mitigation source'' is that the power-down scenario is conditional upon the presence of animals in the exclusion zone, whereas the mitigation source was historically used during times when the array would otherwise not be in use at all. The general premise is that this lower-intensity source, if operated continuously, would be sufficiently aversive to marine mammals to ensure that they are not within an exclusion zone, and therefore, ramp-up may occur at times when pre-clearance visual watch is minimally effective. There is no information to suggest that this is an effective protective strategy, yet we are certain that this technique involves input of extraneous sound energy into the marine environment, even when use of the mitigation source is limited to some maximum time period. For these reasons, we do not believe use of the mitigation source is appropriate and propose not to allow its use. However, as noted above, ramp-up may occur under periods of poor visibility assuming that no acoustic or visual detections are made during a 30-minute pre-clearance period. This is a change from how mitigation sources have been considered in the past in that the visual pre-clearance period was typically assumed to be highly effective during good visibility conditions and viewed as critical to avoiding auditory injury and, therefore, maintaining some likelihood of aversion through use of mitigation sources during poor visibility conditions was deemed valuable.

In light of the available information, we think it more appropriate to acknowledge the limitations of visual observations—even under good conditions, not all animals will be observed and cryptic species may not be observed at all—and recognize that while visual observation is a common sense measure it should not be determinative of when survey effort may occur. Given the lack of proven efficacy of visual observation in preventing auditory injury, we do not believe that its absence should imply such potentially detrimental impacts on marine mammals. Therefore, use of a mitigation source is not a sensible substitute component of seismic mitigation protocols. We also believe that consideration of mitigation sources in the past has reflected an outdated balance, in which the possible prevention of relatively few instances of auditory injury is outweighed by many more instances of unnecessary behavioral disturbance of animals and degradation of acoustic habitat.

Miscellaneous Protocols

The acoustic source must be deactivated when not acquiring data or preparing to acquire data, except as necessary for testing. Unnecessary use of the acoustic source should be avoided. Firing of the acoustic source at any volume above the stated production volume would not be authorized; the operator must provide information to the lead PSO at regular intervals confirming the firing volume.

Testing of the acoustic source involving all elements requires normal mitigation protocols (*e.g.,* ramp-up). Testing limited to individual source elements or strings does not require ramp-up but does require pre-clearance.

We encourage the applicant companies and operators to pursue the following objectives in designing, tuning, and operating acoustic sources: (1) Use the minimum amount of energy necessary to achieve operational objectives (*i.e.,* lowest practicable source level); (2) minimize horizontal propagation of sound energy; and (3) minimize the amount of energy at frequencies above those necessary for the purpose of the survey. However, we are not aware of available specific measures by which to achieve such certifications. In fact, an expert panel convened by BOEM to determine whether it would be feasible to develop standards to determine a lowest practicable source level has determined that it would not be reasonable or practicable to develop such metrics (see Appendix L in BOEM, 2017). Minimizing production of sound at frequencies higher than are necessary would likely require design, testing, and use of wholly different airguns than are proposed for use by the applicants. At minimum, notified operational capacity (not including redundant backup airguns) must not be exceeded during the survey, except where unavoidable for source testing and calibration purposes. All occasions where activated source volume exceeds notified operational capacity must be noticed to the PSO(s) on duty and fully documented for reporting. The lead PSO must be granted access to relevant instrumentation documenting acoustic source power and/or operational volume. BOEM currently requires applicants for permits to conduct geophysical surveys to submit statements indicating that existing data are not available to meet the data needs identified for the applicant's survey (*i.e.,* non-duplicative survey statement) and that the operations are using the minimal source array size/power necessary to meet the survey goals and that the array is tuned to maximize radiation of the emitted energy toward the seafloor.

Restriction Areas

Below we provide discussion of various restriction areas that were considered during development of the proposed regulations. Because the purpose of these areas is to reduce the likelihood of exposing animals within the designated areas to noise from airgun surveys that is likely to result in harassment (*i.e.,* 50 percent midpoint of the Level B harassment risk probability function), we are proposing to require that source vessels maintain minimum standoff distances (*i.e.,* buffers) from the areas. Sound propagation modeling results for a notional large airgun array were provided by Matthews *et al.* (2016), specific to each of the potential time-area restrictions evaluated therein, in order to exclude SPLs exceeding 160 dB rms from those areas. Those distances are proposed for use here and are described in each section below.

Coastal Restriction—We are proposing that no airgun surveys may occur shoreward of a line indicated by the 20-m isobath, buffered by 13 km (Matthews *et al.,* 2016), during the months of February through May (Area 1; Figure 5). Waters shoreward of the 20-m isobath, where coastal dolphin stocks occur, represent the areas of greatest abundance for bottlenose dolphins (Roberts *et al.,* 2016).

The restriction is intended specifically to avoid additional stressors to bottlenose dolphin populations during the time period believed to be of greatest importance as a reproductive period. BOEM proposed a similar coastal restriction on airgun survey effort in the petition submitted in support of industry, and NMFS agrees that this is appropriate. Coastal dolphin stocks, particularly the northern coastal stock, were heavily impacted by the DWH oil spill. As described previously, NOAA estimates that potentially 23 percent of western coastal dolphins and 82 percent of northern coastal dolphins were exposed to DWH oil, resulting in an array of long-term health impacts (including reproductive failure) and possible population reductions of 5 percent and 50 percent for the western and northern stocks, respectively (DWH MMIQT, 2015). For the northern coastal stock, it is estimated that these population-level impacts could require 39 years to recovery, in the absence of other additional stressors.

NMFS's subject matter experts identified a reasonable range that in their professional judgment encompasses an important reproductive period for bottlenose dolphins in these coastal waters. Expert interpretation of the long-term data for neonate strandings is that February–April are the primary months that animals are born in the northern GOM, and that fewer but similar numbers are born in January and May. This refers to long-term averages and in any particular year the peak reproductive period can shift earlier or later. While pregnant mothers may be susceptible to the impacts of noise, we believe that neonates and/or calves are likely most susceptible, because behavioral disruption could have more severe energetic effects for lactating mothers and/or lead to disruption of mother-calf bonding and ultimate effects on rates of neonate and/or calf survivorship. Therefore, we believe that February through May represents a reasonable best estimate of the time period of most sensitivity for bottlenose dolphins in coastal waters.

While none of the dolphin strandings or deaths have been attributed to airgun survey activities, stocks in the area are stressed, and studies have shown that marine mammals react to underwater noise. Behavioral disturbance or stress may reduce fitness for individual animals and/or may exacerbate existing declines in reproductive health and survivorship. For example, stressors such as noise and pollutants can induce responses involving the neuroendocrine system, which controls reactions to stress and regulates many body processes (NAS, 2017), and there is strong evidence that petroleum-associated chemicals can adversely affect the endocrine system, providing a potential pathway for interactions with other stressors (Mohr *et al.,* 2008, 2010). Romano *et al.,* (2004) found that upon exposure to noise from a seismic watergun, bottlenose dolphins had significantly elevated levels of a stress-related hormone and, correspondingly, a decrease in immune cells. Population-level impacts related to energetic effects or other impacts of noise are difficult to determine, but the addition of other stressors can add considerable complexity due to the potential for interaction between the stressors or their effects (NAS, 2017). When a population is at risk, as is the case for these bottlenose dolphin populations, NAS (2017) recommends identifying those stressors that may feasibly be mitigated. We cannot undo the effects of the DWH oil spill, but the potentially synergistic effects of noise due to the activities that are the subject of this proposed rule may be mitigated. The post-DWH oil spill baseline condition of these populations requires caution, and this restriction may reasonably be anticipated to provide additional protection to these populations during their peak reproductive activity. Note that, in reference to the findings of Matthews *et al.,* (2016), this proposed time-area restriction would also reduce impacts to stocks of marine mammals occurring within the restriction area through reducing effects to listening area. We request comment on our proposed seasonal closure in Area 1.

Practicability—Given survey operators' ability to plan around these seasonal restrictions, we believe it is unlikely that the restrictions will affect oil and gas productivity in the GOM. Therefore, when this practicability factor is considered in light of the expected ability of these measures to reduce the probability or severity of impacts on species or stocks and their habitat, we preliminarily determine these restrictions are warranted. We request comment on our interpretation of the impact of the proposed seasonal closure for Area 1.

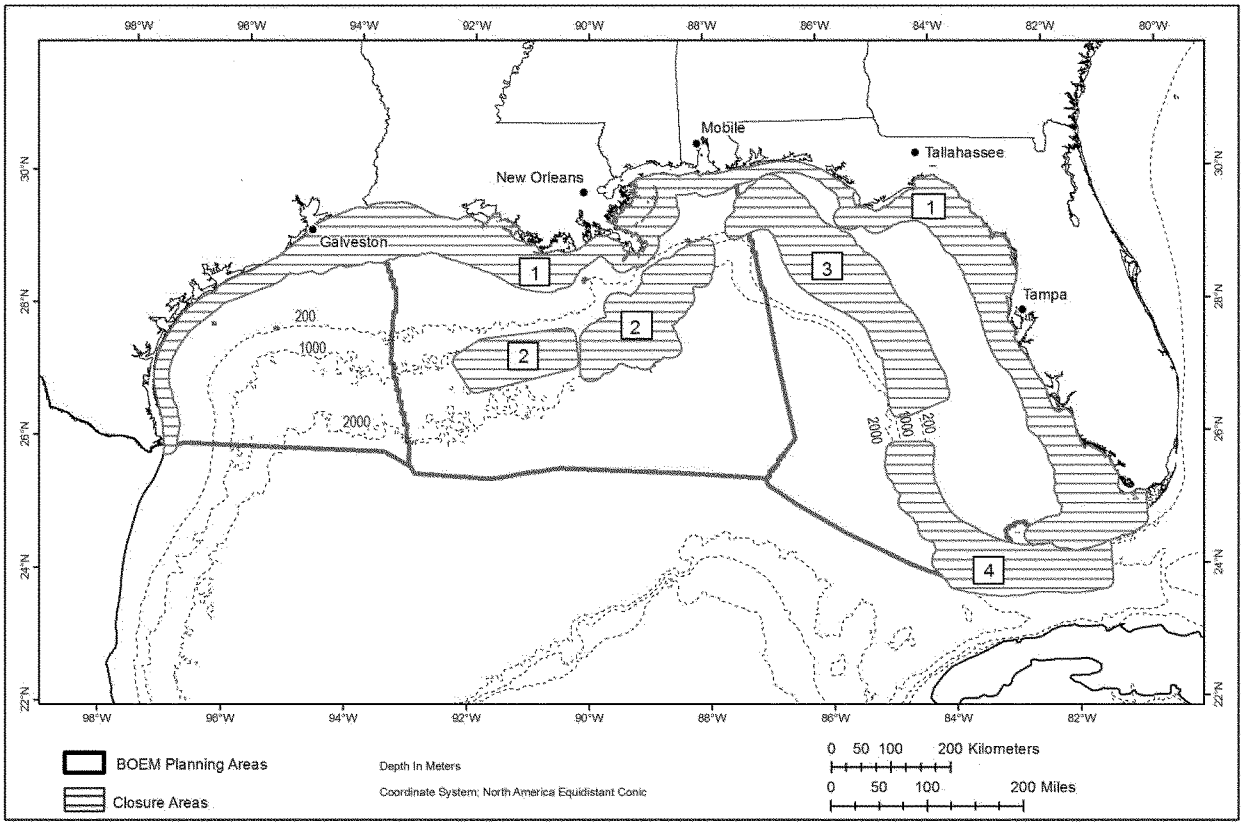


Figure 5. Proposed Time-area Restrictions. Area 2 was considered but is not proposed.

Bryde's Whale—We examined the appropriateness of restricting survey effort such that particular areas of expected importance for Bryde's whales are not ensonified by levels of sound above 160 dB rms SPL (the 50 percent midpoint for behavioral harassment) (Area 3; Figure 5). We analyzed a year-round closure of the area described herein; we request comment on this and several other alternatives. The variations in regulatory text for these proposals can be found in ''Alternative Regulatory Text,'' later in this preamble, and in the regulatory text at the end of the document. Matthews *et al.* (2016) specified a buffer distance of 5.4 km for the De Soto Canyon area, which we round to 6 km. As described previously, NOAA's status review team determined the status of the GOM Bryde's whale is considered to be precarious (described in the status review technical memorandum (Rosel *et al.* (2016)). On the basis of these findings, NMFS has proposed to list the GOM Bryde's whale as an endangered species pursuant to the ESA (81 FR 88639; December 8, 2016). These whales form a small and resident population in the northeastern GOM, with a highly restricted geographic range and a very small population abundance—recently determined by a status review team to be ''at or below the near-extinction population level'' (Rosel *et al.,* 2016). The review team stated that, aside from the restricted distribution and small population, the whales face a significant suite of anthropogenic threats, one of which is noise produced by geophysical surveys.

While various population abundance estimates are available (*e.g.,* Waring *et al.,* 2016; Roberts *et al.,* 2016; Dias and Garrison, 2016), the population abundance was almost certainly less than 100 prior to the DWH oil spill. NOAA estimated that, as a result of that event, 48 percent of the population may have been exposed to DWH oil, with 17 percent killed and 22 percent of females experiencing reproductive failure. The best estimate for maximum population reduction was 22 percent, with an estimated 69 years to recovery (to the precarious status prior to the DWH oil spill) (DWH MMIQT, 2015). It is considered likely that Bryde's whale habitat previously extended to shelf and slope areas of the western and central GOM similar to where they are found now in the eastern GOM, and that anthropogenic activity—largely energy exploration and production—concentrated in those areas could have resulted in habitat abandonment (Reeves *et al.,* 2011; Rosel and Wilcox, 2014). Further, the population exhibits very low levels of genetic diversity and significant genetic mitochondrial DNA divergence from other Bryde's whales worldwide (Rosel and Wilcox, 2014). Based on this review and further consultation with the Society for Marine Mammalogy's Committee on Taxonomy, NMFS has proposed to list the GOM Bryde's whale as an endangered species pursuant to the ESA (81 FR 88639; December 8, 2016).

The small population size, restricted range, and low genetic diversity alone place these whales at significant risk of extinction (IWC, 2017), which has been exacerbated by the effects of the DWH oil spill. Additionally, Bryde's whale dive and foraging behavior places them at heightened risk of being struck by vessels and/or entangled in fishing gear (Soldevilla *et al.,* 2017). It is in consideration of this environmental baseline and risk profile that we analyzed a year-round restriction.

LaBrecque *et al.* (2015) described a biologically important area for GOM Bryde's whales as between the 100- and

300-m isobaths in the eastern GOM, from the head of De Soto Canyon to an area northwest of Tampa Bay. The recorded Bryde's whale shipboard and aerial survey sightings between 1989 and 2015 have mainly fallen within this area (see the NOAA's status review technical memorandum (Rosel *et al.* (2016)). We are proposing to expand this area for protection of Bryde's whales following the recommendations of NOAA's status review (described in the status review technical memorandum (Rosel *et al.* (2016)), which stated that due to the depth of some sightings, the BIA for Bryde's whales in the GOM is more appropriately defined to the 400-m isobath and westward to Mobile Bay, Alabama, in order to provide some buffer around the deeper sightings and to include all sightings in the northeastern GOM. The average depth of Bryde's whale sightings is 226 m (SE = 7.9; range 199–302 m; Maze-Foley & Mullin 2006). Rice *et al.* (2014) detected sounds associated with Bryde's whales in waters south of Panama City, FL, and there are sightings of Bryde's whales along the shelf break to Tampa Bay (about 28.0° N). Bryde's whales were also detected acoustically in this area by Hildebrand *et al.* (2012). Additionally, because of past survey design, survey effort in waters less than 200 m water depth has not been as thorough as that for waters greater than 200 m; therefore, Bryde's whales may use water depths between 100–200m more regularly than we currently know. The Bryde's whale restriction is designated as the area between the 100- and 400-m isobaths, from 87.5° W to 27.5° N (Area 3; Figure 5). This area largely covers the home range (*i.e.,* 95 percent of predicted abundance) predicted by Roberts *et al.* (2016). The designated area would then be buffered by 6 km. The restriction area would also provide benefit to any other marine mammals present there—primarily Atlantic spotted dolphins and bottlenose dolphins, but possibly also including other species that may occur there in slope waters. Reporting preliminary results from a passive acoustic monitoring study, Hildebrand *et al.* (2012) found a significantly higher detection rate and a more steady presence for delphinids at this site than at four other sites (three deep-water and one shallow). Note that, in reference to the findings of Matthews *et al.* (2016), a time-area restriction would also reduce impacts to stocks of marine mammals occurring within the restriction area through reducing effects to communication space and listening area.

Given the likely condition of this population, and in the absence of a full habitat characterization and more knowledge about why Bryde's whales occur where they do, we analyzed a year-round restriction that covered the full area of Bryde's whale sightings. We request comment on our interpretation of the data and our evaluated alternative of year-round restrictions on airgun surveys in Area 3 (Figure 5). In addition, we present three less-restrictive alternatives, including seasonal restrictions and no restrictions for Area 3 with differing requirements for monitoring. We request comment on all proposals and other variations of these proposals, including our interpretation of the data and any other data that support the necessary findings regarding time-area restrictions for Bryde's whales.

- *Proposal 1:* A year-round restriction on airgun surveys in Area 3, as described above.
- *Proposal 2:* A three-month seasonal restriction on airgun surveys in Area 3. In addition to public comment on the proposal and information that may support the necessary findings in consideration of this proposal, we request information regarding the proposed duration and/or timing of such a seasonal closure, if sufficient. We note that this proposal is reflected in our proposed regulatory text, at the end of this document.
- *Proposal 3:* A three-month seasonal restriction, such as what is described just previously, but with the addition of a requirement for BOEM and/or members or representatives of the oil and gas industry to ensure real-time detection of Bryde's whales across the area of potential impact including real-time communication of detections to survey operators. This real-time detection would be used to initiate shutdowns to ensure that survey operations do not take place when a Bryde's whale is within 6 km of the acoustic source. We do not consider towed passive acoustic monitoring to be sufficient to ensure detection of the Bryde's whale and, for the three-month restriction, we propose use of a moored listening array. In addition to public comment on the proposal and information that may support the necessary findings in consideration of this proposal, as well as on the appropriate timing and/or duration of a seasonal restriction, we request information regarding appropriate alternative technologies for real-time detection of Bryde's whales.
- *Proposal 4:* No restriction, but with the addition of a requirement for BOEM and/or members or representatives of the oil and gas industry to ensure real-time detection of Bryde's whales across the area of potential impact including real-time communication of detections to survey operators. As with the previous seasonal closure with monitoring proposal, we do not consider towed passive acoustic monitoring to be sufficient to ensure detection of the Bryde's whale and seek comment on appropriate technologies for real-time detection. We request public comment on the proposal and information that may support the necessary findings in consideration of this proposal, as well as regarding appropriate alternative technologies for real-time detection of Bryde's whales.

The variations in regulatory text for these proposals can be found in ''Alternative Regulatory Text,'' later in this preamble, and in the regulatory text at the end of the document.

Practicability—There is a moratorium on leasing pursuant to GOMESA (through June 2022, or almost the entirety of the period of validity for these proposed regulations). Further, BOEM has projected very low activity levels in this area over the next 10 years (Table 1). There are two active leases in this proposed restriction area (though no platforms), and an exception to the year-round restriction requirements would be made in accordance with existing rights associated with those active leases. The RIA indicates that there is potential for effects on oil and gas productivity given delays in the ability to conduct exploratory surveys in advance of the end of the existing GOMESA moratorium (if not continued) and a year-round restriction may be warranted. As described just previously, we invite the public to evaluate and comment on the presented alternatives.

Dry Tortugas—This proposed restriction area is expected to benefit resident sperm and beaked whales. Beaked whales are acoustically sensitive, with a correspondingly high magnitude of predicted exposures, while noise from airgun surveys may have an outsize impact on sperm whale populations due to disruption of foraging behavior (as detailed previously). While the predicted impacts on these species are based on projected levels of activity elsewhere in the GOM, we acknowledge the potential importance of this area to these species and propose the restriction to ensure that this habitat is not impacted.

Sightings of both beaked whales and sperm whales are very dense in this area, and it is possible—based on unpublished observations of calves here—that sperm whales use this area as a calving area (K. Mullin, pers. comm.).

Hildebrand *et al.* (2012, 2015) conducted passive acoustic monitoring over more than 3 years (2010–2013) at three deep-water sites on the GOM slope, including within this area. In contrast with reported visual observations of sperm whales in the area, preliminary results reported by Hildebrand *et al.* (2012) showed relatively low rates of acoustic detection for sperm whales, and corresponding density estimates were lower at the Dry Tortugas site than at the other sites (*i.e.,* Mississippi Canyon and Green Canyon). However, four species of beaked whale, including an unidentified species, were detected. As reported by Hildebrand *et al.* (2015), Cuvier's beaked whale was the dominant species presence (61 percent of vocal encounters), but Gervais' beaked whales also appear to be present in significant numbers (39 percent). No Blainville's beaked whales were detected. Average densities for Cuvier's and Gervais' beaked whales were derived from vocal click counting. Combined density for the two species was very high at the Dry Tortugas site (approximately 29 whales/1,000 km^2). At two other sites where beaked whales are expected to be present in significant numbers and were detected (Mississippi Canyon and Green Canyon), the combined density value was approximately 4 whales/1,000 km^2, at both locations. Both species had a strong and consistent presence throughout the monitoring period (Hildebrand *et al.,* 2015).

The area aligns well with a portion of the predicted 25 percent core abundance area for beaked whales in the GOM, and overlaps with portions of the sperm whale 25 percent core abundance area (Roberts *et al.,* 2016; core abundance areas are explained in greater detail below in ''Central Planning Area''). The restriction area would also provide benefit to any other marine mammals present there—including other species expected to occur in deep slope waters. Hildebrand *et al.* (2012) estimated the density of *Kogia* spp. in this area at 5.9 animals/1,000 km^2. The proposed year-round restriction area includes waters bounded by the 200- to 2,000-m isobaths from the northern border of BOEM's Howell Hook leasing area to 81.5° W (Area 4; Figure 5). The defined area would be buffered by 9 km (rounded up from the 8.4 km distance provided by Matthews *et al.* (2016) for the Dry Tortugas area). Note that, in reference to the findings of Matthews *et al.* (2016), this proposed time-area restriction would also reduce impacts to stocks of marine mammals occurring within the restriction area through reducing effects to listening area. We invite the public to comment on our interpretation of the data and proposal of year-round restrictions on airgun surveys in Area 4 (Figure 5). We are interested in public comment on this proposal, including any data that may support the necessary findings regarding this proposal, including modifications that could vary the length of closure from what we proposed.

Practicability—BOEM has projected no survey activity in this area over the next 10 years. There are no active leases, and the area is subject to the GOMESA moratorium, so we do not expect that there would be any impact on industry operators. We seek comment on this assumption.

Central Planning Area (CPA)—We evaluated the possibility of implementing a restriction area in this portion of the GOM for sperm whales and for beaked whales (Area 2; Figure 5). Sperm whales, an endangered species, are considered to be acoustically sensitive and potentially subject to significant disturbance of important foraging behavior as detailed earlier in this document. Beaked whales are also considered to be behaviorally sensitive to noise exposure and are predicted to sustain a high magnitude of exposures to noise above criteria for Level B harassment. A potential CPA restriction had already been identified in BOEM (2017) on the basis of sightings data and animal telemetry studies (for sperm whales).

Based on satellite tracking studies conducted by Jochens *et al.* (2008), the home range of tagged sperm whales within the northern GOM is broad, comprising nearly the entire GOM in waters deeper than 500 m. Home range is defined as an area over which an animal or group of animals regularly travels in search of food or mates that may overlap with those of neighboring animals or groups of the same species. By contrast, the composite core area (defined as a section of the home range that is utilized more thoroughly and frequently as primary locales for activities such as feeding) of GOM sperm whales generally includes the Mississippi Canyon, Mississippi River Delta, and, to a lesser extent, the Rio Grande Slope (Jochens *et al.,* 2008). These data support the fact that sperm whales aggregate in the Mississippi Canyon area, but regularly move across the northern GOM continental slope. Reporting preliminary data from a passive acoustic monitoring study, Hildebrand *et al.* (2012) found that among three deep-water sites in the GOM, the Mississippi Canyon area was home to the greatest density of sperm whales.

Beaked whales are typically deep divers, foraging for mesopelagic squid and fish, and are often found in deep water near high-relief bathymetric features, such as slopes, canyons, and escarpments where these prey are found (*e.g.,* Madsen *et al.,* 2014; MacLeod and D'Amico, 2006; Moors-Murphy, 2014). In the GOM, all reported sightings have occurred over the continental slope or the abyss (Roberts *et al.,* 2015b). Movements or seasonal migrations of beaked whales are not known, though it is likely that their distributional patterns depend on the movement of mesoscale hydrographic features. The CPA, including waters from the slope to 2,000 m and approximately between BOEM's Atwater Valley and De Soto Canyon leasing areas, is believed to support relatively high densities of sperm whales and beaked whales (K. Mullin, pers. comm.).

In order to quantitatively evaluate this large area and produce a more refined prospective restriction area, we considered the outputs of habitat-based predictive density models (Roberts *et al.,* 2016) by creating core abundance areas, *i.e.,* an area that contains some percentage of predicted abundance for a given species or species group. Please see ''Marine Mammal Density Information,'' previously in this document, for a full description of the density models. The purpose of a core abundance area is to represent the smallest area containing some percentage of the predicted abundance of each species. Summing all the cells (pixels) in the species distribution product gives the total predicted abundance. Core area is calculated by ranking cells by their abundance value from greatest to least, then summing cells with the highest abundance values until the total is equal to or greater than the specified percentage of the total predicted abundance. For example, if a 50 percent core abundance area is produced, half of the predicted abundance falls within the identified core area, and half occurs outside of it.

To determine core abundance areas, we follow a three-step process:

- Determine the predicted total abundance of a species/time period by adding up all cells of the density raster (grid) for the species/time period. For the Roberts *et al.* (2016) density rasters, density is specified as the number of animals per 100 km^2 cell.
- Sort the cells of the species/time period density raster from highest density to the lowest.
- Sum and select the raster cells from highest to lowest until a certain percentage of the total abundance is reached.

The selected cells represent the smallest area that represents a given percentage of abundance. We created a range of core abundance areas for sperm and beaked whales, and found that there was good agreement between the outputs of the two models at a range of approximately 15 to 20 percent core abundance for sperm whales in concert with a 25 percent core abundance threshold for beaked whales. On this basis, we defined a restriction area for evaluation as follows, in two adjacent but distinct areas (which would likely be joined from an operational perspective): (1) An area bounded by 90° W and 88° W (E–W) and the 500- and 1,000-fathom isobaths (N–S), and (2) an area bounded by five sets of coordinates (Area 2, Figure 5).

Practicability—We provided a description of this area for evaluation in the RIA associated with this rule. This analysis found that our proposed CPA restriction area overlaid approximately 21 percent of active GOM leases (including 95 active production platforms) and that a significant number of wells have been spudded in the CPA restriction area in the past five years. These leases accounted for approximately 50 and 24 percent of total GOM production of oil and gas, respectively, from 2012–2016. A significant amount of the projected survey activity considered herein would be conducted in the potential CPA restriction area. Compliance costs, in terms of operational mitigation protocols such as shutdown requirements, generally would not be expected to reduce the level of oil and gas development in the GOM, given that the costs of survey activities are relatively minor compared to expenditures on drilling, engineering, installation of platforms, and production operations. However, in contrast to the findings related to operational mitigation protocols, area restrictions may lead to reductions in leasing and exploration activity. The length of time associated with the restriction is a key concern; the longer the restriction period, the more difficult for operators to plan surveys to comply and increasing the likelihood that some portion of planned surveys are delayed to future years. There is no information available in the GOM on which to base a definition of seasonality for the CPA restriction area that we evaluated. The analysis suggests the possibility that closing the CPA area could affect the broader contribution of the GOM to U.S. oil and gas activity, with shifts in effort potentially reducing domestic oil and gas production, industry income, and employment, ultimately concluding that the economic impact on the regional economy could be significant. Given that the evaluated area restrictions account for an estimated 57 percent of oil reserves and 37 percent of gas reserves, these areas account for a sizable contribution to regional economic productivity and employment. On the basis of this analysis, and in consideration of other mitigation required with regard to sperm whales (*i.e.,* expanded shutdown requirements), we preliminarily find that implementation of this restriction area is not warranted when the potential benefits to marine mammals species or stocks and their habitat are weighed against the significant costs and impracticality. We request comment on this, preliminary determination, including our interpretation of the data, our preliminary finding that inclusion of this measure is not warranted due to the significant costs and impracticality, and any other data that may support the necessary findings.

Entanglement Avoidance

We are not aware of any records of marine mammal entanglement in towed arrays, streamers, or other towed acoustic sources. Therefore, we do not believe there is evidence to indicate that there is any meaningful entanglement risk posed by those activities. However, the use of OBNs or similar equipment requiring the use of tethers or connecting lines does pose a meaningful entanglement risk. Multiple marine taxa are susceptible to entanglement in underwater lines and, in 2014, an Atlantic spotted dolphin was entangled in a nylon nodal tether line and killed during a GOM OBN survey.

In order to avoid the reasonable potential for entanglement in such lines, one must generally seek to apply common sense, including use of stiffer lines that are taut and are not positively-buoyant, and are therefore less likely to wrap or loop around animals, and secure bottom lines. Specifically, we propose that operators conducting OBN surveys adhere to the following requirements: (1) Use negatively buoyant coated wire-core tether cable (*e.g.,* ¾″ polyurethane-coated cable with ½″ wire core); (2) retrieve all lines immediately following completion of the survey; (3) attach acoustic pingers directly to the coated tether cable; acoustic releases should not be used; and (4) employ a third-party PSO aboard the node retrieval vessel in order to document any unexpected marine mammal entanglement. No unnecessary release lines or lanyards may be used and nylon rope may not be used for any component of the OBN system. Pingers must be attached directly to the nodal tether cable via shackle, with cables retrieved via grapnel. If a lanyard is required it must be as short as possible and made as stiff as possible, *e.g.,* by placing inside a hose sleeve. Similar measures, including the commonly referred to ''orange coated rope,'' have been required by BOEM as permit conditions and have proven successful in preventing further entanglements.

Vessel Strike Avoidance

These proposed measures generally follow those described in BOEM's PEIS (BOEM, 2017). These measures apply to all vessels associated with any proposed survey activity (*e.g.,* source vessels, streamer vessels, chase vessels, supply vessels); however, we note that these requirements do not apply in any case where compliance would create an imminent and serious threat to a person or vessel or to the extent that a vessel is restricted in its ability to maneuver and, because of the restriction, cannot comply. The proposed measures include the following:

1. Vessel operators and crews must maintain a vigilant watch for all marine mammals and slow down or stop their vessel or alter course, as appropriate and regardless of vessel size, to avoid striking any marine mammal. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel, according to the parameters stated below, to ensure the potential for strike is minimized. Visual observers monitoring the vessel strike avoidance zone can be either third-party observers or crew members, but crew members responsible for these duties must be provided sufficient training to distinguish marine mammals from other phenomena and broadly to identify a marine mammal as a baleen whale, sperm whale, or other marine mammal.

2. All vessels, regardless of size, must observe a 10 kn speed restriction within the EPA restriction area described previously. It is critically important to avoid vessel strike of a Bryde's whale, as single mortalities over time can be devastating for such small populations. Further, Bryde's whales engage in shallow nocturnal diving, spending significant amounts of time near the surface at night and increasing the risk of strike when vessels are transiting Bryde's whale habitat (Soldevilla *et al.,* 2017).

3. Vessel speeds must also be reduced to 10 kn or less when mother/calf pairs, pods, or large assemblages of cetaceans are observed near a vessel. A single cetacean at the surface may indicate the presence of submerged animals in the

vicinity of the vessel; therefore, precautionary measures should be exercised when an animal is observed.

4. All vessels must maintain a minimum separation distance of 500 yards (yd) (457 m) from baleen whales. Our intention is to be precautionary in prescribing avoidance measures to avoid the potential for strike of Bryde's whales—the only baleen whale that would be expected with any regularity in the GOM—but we do not expect that crew members standing watch would be able to reliably identify baleen whales to species in the GOM. The following avoidance measures should be taken if a baleen whale is within 500 yd of any vessel:

a. While underway, the vessel operator should steer a course away from the whale at 10 kn or less until the minimum separation distance has been established.

b. If a whale is spotted in the path of a vessel or within 500 yd of a vessel underway, the operator should reduce speed and shift engines to neutral. The operator should re-engage engines only after the whale has moved out of the path of the vessel and is more than 500 yd away. If the whale is still within 500 yd of the vessel, the vessel should select a course away from the whale's course at a speed of 10 kn or less. The recommendation to shift engines to neutral does not apply to any vessel towing gear due to safety concerns.

c. This procedure should also be followed if a whale is spotted while a vessel is stationary. Whenever possible, a vessel should remain parallel to the whale's course while maintaining the 500-yd distance as it travels, avoiding abrupt changes in direction until the whale is no longer in the area.

5. All vessels must maintain a minimum separation distance of 100 yd (91 m) from sperm whales. The following avoidance measures should be taken if a sperm whale is within 100 yd of any vessel:

a. The vessel underway should reduce speed and shift the engine to neutral, and should not engage the engines until the whale has moved outside of the vessel's path and the minimum separation distance has been established. This does not apply to any vessel towing gear.

b. If a vessel is stationary, the vessel should not engage engines until the whale has moved out of the vessel's path and beyond 100 yd.

6. All vessels must attempt to maintain a minimum separation distance of 50 yd (46 m) from all other marine mammals, with an exception made for those animals that approach the vessel. If an animal is encountered during transit, a vessel should attempt to remain parallel to the animal's course, avoiding excessive speed or abrupt changes in course.

Marine Debris

Any permits issued by BOEM would include guidance for the handling and disposal of marine trash and debris, similar to BSEE NTL 2015–G03 (''Marine Trash and Debris Awareness and Elimination'') (BSEE, 2015; BOEM, 2017). If there were an LOA applicant for an activity not requiring a BOEM permit, NMFS would also require adherence to this guidance.

TABLE 11—SUMMARY OF MITIGATION MEASURES WITH ALTERNATIVES FOR CONSIDERATION

Measure	Proposal	Proposal preliminarily determined to support ''least practicable adverse impact'' and ''negligible impact'' findings?	Proposal included in proposed regulatory text?
Dolphin shutdown exception	Power-down	Yes	Yes.
	No power-down	No	No.
Extended distance shutdown in certain circumstances.	Shutdown for detections at any distance	Yes	Yes.
	Shutdown for detections within 1 km	No	No.
Time-area restriction for Bryde's whales	Year-round	Yes	No.
	Seasonal	No	Yes.
	Seasonal with real-time detection	No	No.
	No restriction with real-time detection	No	No.

Based on our evaluation of the mitigation measures described in this section, as well as other measures considered by NMFS, we have preliminarily determined those mitigation measures that provide the means of effecting the least practicable adverse impact on the affected species or stocks and their habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance. We request comment on all proposals and other variations of these proposals, including our interpretation of the data and any other data that support the necessary findings.

Proposed Monitoring and Reporting

In order to issue an LOA for an activity, Section 101(a)(5)(A) of the MMPA states that NMFS must set forth requirements pertaining to the monitoring and reporting of the authorized taking. NMFS's MMPA implementing regulations further describe the information that an applicant should provide when requesting an authorization (50 CFR 216.104(a)(13)), including the means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species and the level of taking or impacts on populations of marine mammals.

Section 101(a)(5)(A) allows that incidental taking may be authorized only if the total of such taking contemplated over the course of five years will have a negligible impact on affected species or stocks (a finding based on impacts to annual rates of recruitment and survival) and, further, section 101(a)(5)(B) requires that authorizations issued pursuant to 101(a)(5)(A) be withdrawn or suspended if the total taking is having, or may have, more than a negligible impact (or such information may inform decisions on requests for LOAs under the specific regulations). Therefore, it is clear that the necessary requirements pertaining to monitoring and reporting must address the total annual impacts to marine mammal species or stocks. Effective reporting is critical both to compliance as well as ensuring that the most value is obtained from the required monitoring.

These proposed requirements are described below under ''Data Collection'' and ''LOA Reporting.'' Additional comprehensive reporting, across LOA-holders on an annual basis, is also proposed and is described below under ''Comprehensive Reporting.''

More specifically, monitoring and reporting requirements should contribute to improved understanding of one or more of the following:

- Occurrence of marine mammal species in action area (*e.g.,* presence, abundance, distribution, density).
- Nature, scope, or context of likely marine mammal exposure to potential stressors/impacts (individual or cumulative, acute or chronic), through better understanding of: (1) Action or environment (*e.g.,* source characterization, propagation, ambient noise); (2) affected species (*e.g.,* life history, dive patterns); (3) co-occurrence of marine mammal species with the action; or (4) biological or behavioral context of exposure (*e.g.,* age, calving or feeding areas).
- Individual marine mammal responses (behavioral or physiological) to acoustic stressors (acute, chronic, or cumulative), other stressors, or cumulative impacts from multiple stressors.
- How anticipated responses to stressors impact either: (1) Long-term fitness and survival of individual marine mammals; or (2) populations, species, or stocks.
- Effects on marine mammal habitat (*e.g.,* marine mammal prey species, acoustic habitat, or important physical components of marine mammal habitat).
- Mitigation and monitoring effectiveness.

PSO Eligibility and Qualifications

All PSO resumes must be submitted to NMFS, and PSOs must be approved by NMFS after a review of their qualifications. NMFS expects to maintain a list of approved PSOs, which will minimize review time for previously approved PSOs with current experience. These qualifications include whether the individual has successfully completed the necessary training (see ''Training,'' below) and, if relevant, whether the individual has the requisite experience (and is in good standing). PSOs should provide a current resume and information related to PSO training; submitted resumes should not include superfluous information. Information related to PSO training should include (1) a course information packet that includes the name and qualifications (*e.g.,* experience, training, or education) of the instructor(s), the course outline or syllabus, and course reference material; and (2) a document stating the PSO's successful completion of the course. PSOs must be trained biologists, with the following minimum qualifications:

- A bachelor's degree from an accredited college or university with a major in one of the natural sciences and a minimum of 30 semester hours or equivalent in the biological sciences and at least one undergraduate course in math or statistics;
- Experience and ability to conduct field observations and collect data according to assigned protocols (may include academic experience; required for visual PSOs only) and experience with data entry on computers;
- Visual acuity in both eyes (correction is permissible) sufficient for discernment of moving targets at the water's surface with ability to estimate target size and distance; use of binoculars may be necessary to correctly identify the target (required for visual PSOs only);
- Experience or training in the field identification of marine mammals, including the identification of behaviors (required for visual PSOs only);
- Sufficient training, orientation, or experience with the survey operation to ensure personal safety during observations;
- Writing skills sufficient to prepare a report of observations (*e.g.,* description, summary, interpretation, analysis) including but not limited to the number and species of marine mammals observed; marine mammal behavior; and descriptions of activity conducted and implementation of mitigation;
- Ability to communicate orally, by radio or in person, with survey personnel to provide real-time information on marine mammals observed in the area as necessary; and
- Successful completion of relevant training (described below), including completion of all required coursework and passing (80 percent or greater) a written and/or oral examination developed for the training program.

The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver must include written justification, and prospective PSOs granted waivers must satisfy training requirements described below. Alternate experience that may be considered includes, but is not limited to, the following:

- Secondary education and/or experience comparable to PSO duties;
- Previous work experience conducting academic, commercial, or government-sponsored marine mammal surveys; and
- Previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.

Training—NMFS expects to provide informal approval for specific training courses in consultation with BOEM and BSEE as needed to approve PSO staffing plans. NMFS does not propose to formally administer any training program or to sanction any specific provider, but will approve courses that meet the curriculum and trainer requirements specified herein. These requirements adhere generally to the recommendations provided by Baker *et al.* (2013). Those recommendations include the following topics for training programs:

- Life at sea, duties, and authorities;
- Ethics, conflicts of interest, standards of conduct, and data confidentiality;
- Offshore survival and safety training;
- Overview of oil and gas activities (including geophysical data acquisition operations, theory, and principles) and types of relevant sound source technology and equipment;
- Overview of the MMPA and ESA as they relate to protection of marine mammals;
- Mitigation, monitoring, and reporting requirements as they pertain to geophysical surveys;
- Marine mammal identification, biology and behavior;
- Background on underwater sound;
- Visual surveying protocols, distance calculations and determination, cues, and search methods for locating and tracking different marine mammal species (visual PSOs only);
- Optimized deployment and configuration of PAM equipment to ensure effective detections of cetaceans for mitigation purposes (PAM operators only);
- Detection and identification of vocalizing species or cetacean groups (PAM operators only);
- Measuring distance and bearing of vocalizing cetaceans while accounting for vessel movement (PAM operators only);
- Data recording and protocols, including standard forms and reports, determining range, distance, direction, and bearing of marine mammals and vessels; recording GPS location coordinates, weather conditions, Beaufort wind force and sea state, etc.;
- Proficiency with relevant software tools;
- Field communication/support with appropriate personnel, and using communication devices (*e.g.,* two-way radios, satellite phones, internet, email, facsimile);
- Reporting of violations, noncompliance, and coercion; and
- Conflict resolution.

PAM operators should regularly refresh their detection skills through practice with simulation-modeling software, and should keep up to date with training on the latest software/hardware advances.

Visual Monitoring

The lead PSO is responsible for establishing and maintaining clear lines of communication with vessel crew. The vessel operator shall work with the lead PSO to accomplish this and shall ensure any necessary briefings are provided for vessel crew to understand mitigation requirements and protocols. While on duty, PSOs will continually scan the water surface in all directions around the acoustic source and vessel for presence of marine mammals, using a combination of the naked eye and high-quality binoculars (bigeye binoculars must be provided during deep penetration airgun surveys; see below), from optimum vantage points for unimpaired visual observations with minimum distractions. PSOs will collect observational data for all marine mammals observed, regardless of distance from the vessel, including species, group size, presence of calves, distance from vessel and direction of travel, and any observed behavior (including an assessment of behavioral responses to survey activity). Upon observation of marine mammal(s), a PSO will record the observation and monitor the animal's position (including latitude/longitude of the vessel and relative bearing and estimated distance to the animal) until the animal dives or moves out of visual range of the observer, and a PSO will continue to observe the area to watch for the animal to resurface or for additional animals that may surface in the area. PSOs will also record environmental conditions at the beginning and end of the observation period and at the time of any observations, as well as whenever conditions change significantly in the judgment of the PSO on duty.

For all deep penetration airgun surveys and deep-water surveys (*i.e.,* water depths greater than 200 m) generally, the vessel operator must provide bigeye binoculars (*e.g.,* 25 × 150; 2.7 view angle; individual ocular focus; height control) of appropriate quality (*i.e.,* Fujinon or equivalent) solely for PSO use. These should be pedestal-mounted on the deck at the most appropriate vantage point that provides for optimal sea surface observation, PSO safety, and safe operation of the vessel. The operator must also provide a night-vision device suited for the marine environment for use during nighttime ramp-up pre-clearance, at the discretion of the PSOs. NVDs may include night vision binoculars or monocular or forward-looking infrared device (*e.g.,* Exelis PVS–7 night vision goggles; Night Optics D–300 night vision monocular; FLIR M324XP thermal imaging camera or equivalents). At minimum, the device should feature automatic brightness and gain control, bright light protection, infrared illumination, and optics suited for low-light situations. This equipment is not required for shallow penetration airgun surveys or non-airgun HRG surveys that occur in shallow water.

Other required equipment, which should be made available to PSOs by the third-party observer provider, includes reticle binoculars (*e.g.,* 7 × 50) of appropriate quality (*i.e.,* Fujinon or equivalent), GPS, digital single-lens reflex camera of appropriate quality (*i.e.,* Canon or equivalent), compass, and any other tools necessary to adequately perform the tasks described above, including accurate determination of distance and bearing to observed marine mammals.

Individuals implementing the monitoring protocol will assess its effectiveness using an adaptive approach. Monitoring biologists will use their best professional judgment throughout implementation and seek improvements to these methods when deemed appropriate. Any modifications to protocol will be coordinated through an adaptive management process.

Acoustic Monitoring

Use of PAM is required for deep penetration airgun surveys. Monitoring of a towed PAM system is required at all times, from 30 minutes prior to ramp-up and throughout all use of the acoustic source. Towed PAM systems generally consist of hardware (*e.g.,* hydrophone array, cables) and software (*e.g.,* data processing and monitoring system). Some type of automated detection software must be used; while not required, we recommend use of industry standard software (*e.g.,* PAMguard, which is open source). Hydrophone signals are processed for output to the PAM operator with software designed to detect marine mammal vocalizations. Current PAM technology has some limitations (*e.g.,* limited directional capabilities and detection range, masking of signals due to noise from the vessel, source, and/or flow, localization) and there are no formal guidelines currently in place regarding specifications for hardware, software, or operator training requirements. However, a working group (led by A.M. Thode) is developing formal standards under the auspices of the Acoustical Society of America's (ASA) Accredited Standards Committee on Animal Bioacoustics (ANSI S3/SC1/WG3; ''Towed Array Passive Acoustic Operations for Bioacoustics Applications''). While no formal standards have yet been completed, a ''roadmap'' was developed during a 2016 workshop held for the express purpose of continuing development of such standards. A workshop report (Thode *et al.,* 2017) provides a highly detailed preview of what the scope and structure of the standard would be, including operator training, planning, hardware, real-time operations, localization, and performance validation. NMFS expects that LOA applicants will incorporate these considerations in developing or refining PAM plans (described below), as appropriate. NMFS proposes to adopt such standards in governing the development of PAM plans following finalization.

Our requirement to use PAM refers to the use of calibrated hydrophone arrays with full system redundancy to detect, identify and estimate distance and bearing to vocalizing cetaceans, to the extent possible. Multi-hydrophone (*i.e.,* more than four) arrays are required to allow for potential determination of bearing and range to detected animals. With regard to calibration, the PAM system should have at least one calibrated hydrophone, sufficient for determining whether background noise levels on the towed PAM system are sufficiently low to meet performance expectations. Additionally, if multiple hydrophone types occur in a system (*i.e.,* monitor different bandwidths), then one hydrophone from each such type should be calibrated, and whenever sets of hydrophones (of the same type) are sufficiently spatially separated such that they would be expected to experience ambient noise environments that differ by 6 dB or more across any integrated species cluster bandwidth, then at least one hydrophone from each set should be calibrated. The arrays should incorporate appropriate hydrophone elements (1 Hz to 180 kHz range) and sound data acquisition card technology for sampling relevant frequencies (*i.e.,* to 360 kHz). This hardware should be coupled with appropriate software to aid monitoring and listening by a PAM operator skilled in bioacoustics analysis and computer system specifications capable of running appropriate software.

In the absence of a formally defined set of prescriptions addressing any of these three facets of PAM technology, all applicants must provide a PAM plan including description of the hardware and software proposed for use prior to proceeding with any survey where PAM is required. As recommended by Thode *et al.* (2017), the plans should, at minimum, adequately address and describe (1) the hardware and software planned for use, including a hardware performance diagram demonstrating that the sensitivity and dynamic range of the hardware is appropriate for the operation; (2) deployment methodology, including target depth/tow distance; (3) definitions of expected operational conditions, used to summarize background noise statistics; (4) proposed detection-classification-localization methodology, including anticipated species clusters (using a cluster definition table), target minimum detection range for each cluster, and the proposed localization method for each cluster; (5) operation plans, including the background noise sampling schedule; (6) array design considerations for noise abatement; and (7) cluster-specific details regarding which real-time displays and automated detectors the operator would monitor. Where relevant, the plan should address the potential for PAM deployment on a receiver vessel or other associated vessel separate from the acoustic source.

In coordination with vessel crew, the lead PAM operator will be responsible for deployment, retrieval, and testing and optimization of the hydrophone array. While on duty, the PAM operator must diligently listen to received signals and/or monitoring display screens in order to detect vocalizing cetaceans, except as required to attend to PAM equipment. The PAM operator must use appropriate sample analysis and filtering techniques and, as described below, must report all cetacean detections. While not required prior to development of formal standards for PAM use, we recommend that vessel self-noise assessments are undertaken during mobilization in order to optimize PAM array configuration according to the specific noise characteristics of the vessel and equipment involved, and to refine expectations for distance/bearing estimations for cetacean species during the survey. Copies of any vessel self-noise assessment reports must be included with the summary trip report.

Data Collection

PSOs must use standardized data forms, whether hard copy or electronic. PSOs will record detailed information about any implementation of mitigation requirements, including the distance of animals to the acoustic source and description of specific actions that ensued, the behavior of the animal(s), any observed changes in behavior before and after implementation of mitigation, and if shutdown was implemented, the length of time before any subsequent ramp-up of the acoustic source to resume survey. If required mitigation was not implemented, PSOs should submit a description of the circumstances. We require that, at a minimum, the following information be reported:

- Vessel names (source vessel and other vessels associated with survey) and call signs;
- PSO names and affiliations;
- Dates of departures and returns to port with port name;
- Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort;
- Vessel location (latitude/longitude) when survey effort begins and ends; vessel location at beginning and end of visual PSO duty shifts;
- Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change;
- Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions change significantly), including wind speed and direction, Beaufort sea state, Beaufort wind force, swell height, weather conditions, cloud cover, sun glare, and overall visibility to the horizon;
- Factors that may be contributing to impaired observations during each PSO shift change or as needed as environmental conditions change (*e.g.,* vessel traffic, equipment malfunctions);
- Survey activity information, such as acoustic source power output while in operation, number and volume of airguns operating in the array, tow depth of the array, and any other notes of significance (*i.e.,* pre-ramp-up survey, ramp-up, shutdown, testing, shooting, ramp-up completion, end of operations, streamers, etc.) (if the survey is a non-airgun survey, information relevant to the acoustic source used should be provided);
- If a marine mammal is sighted, the following information should be recorded:
  - Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);
  - PSO who sighted the animal;
  - Time of sighting;
  - Vessel location at time of sighting;
  - Water depth;
  - Direction of vessel's travel (compass direction);
  - Direction of animal's travel relative to the vessel;
  - Pace of the animal;
  - Estimated distance to the animal and its heading relative to vessel at initial sighting;
  - Identification of the animal (*e.g.,* genus/species, lowest possible taxonomic level, or unidentified); also note the composition of the group if there is a mix of species;
  - Estimated number of animals (high/low/best);
  - Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);
  - Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or markings, shape and size of dorsal fin, shape of head, and blow characteristics);
  - Detailed behavior observations (*e.g.,* number of blows, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior);
  - Animal's closest point of approach (CPA) and/or closest distance from the acoustic source;
  - Platform activity at time of sighting (*e.g.,* deploying, recovering, testing, shooting, data acquisition, other); and
  - Description of any actions implemented in response to the sighting (*e.g.,* delays, shutdown, ramp-up, speed or course alteration, etc.); time and location of the action should also be recorded; and
- If a marine mammal is detected while using the PAM system, the following information should be recorded:
  - An acoustic encounter identification number, and whether the detection was linked with a visual sighting;
  - Time when first and last heard;
  - Types and nature of sounds heard (*e.g.,* clicks, whistles, creaks, burst pulses, continuous, sporadic, strength of signal, etc.); and
  - Any additional information recorded such as water depth of the hydrophone array, bearing of the animal to the vessel (if determinable), species or taxonomic group (if determinable), spectrogram screenshot, and any other notable information.

LOA Reporting

PSO effort, survey details, and sightings data should be recorded continuously during surveys and reports prepared each day during which survey effort is conducted. These reports would include amount and location of line-kms surveyed, all marine mammal observations with closest approach distance, and corrected numbers of marine mammals ''taken.'' We propose submission of such reports to NMFS within 90 days of survey completion or following expiration of an issued LOA. In the event that an LOA is issued for a period exceeding one year, annual reports would be submitted during the period of validity.

There are multiple reasons why marine mammals may be present and yet be undetected by observers. Animals are missed because they are underwater (availability bias) or because they are available to be seen, but are missed by observers (perception and detection biases) (*e.g.,* Marsh and Sinclair, 1989). Negative bias on perception or detection of an available animal may result from environmental conditions, limitations inherent to the observation platform, or observer ability. In this case, we do not have prior knowledge of any potential negative bias on detection probability due to observation platform or observer ability. Therefore, observational data corrections must be made with respect to assumed species-specific detection probability as evaluated through consideration of environmental factors (*e.g.,* $f(0)$). In order to make these corrections, we propose a method recommended by the Marine Mammal Commission for estimating the number of cetaceans in the vicinity of geophysical surveys based on the number of groups detected.

This method incorporates $f(0)$ and BSS-specific $g(0)$ values from Barlow (2015) that were derived using Distance sampling methods (Buckland *et al.,* 2001) and sightings data. If we know that we have detected n groups, and the probability of detecting each group is p, a standard way to estimate the total number of groups is n/p. We know n for each species from the data collected during each survey, so the problem is to find p for each species. During scientific marine mammal surveys, p is estimated from the data collected on each survey as part of a line-transect analysis. The probability p for each species depends principally on the distance of the animals from the observer, but may also depend on other factors such as group size and sea state.

In the absence of a line-transect analysis, the Commission suggests taking estimates of p from other studies which use ships of similar size and searching methods. For line-transect analysis, p is a product of the probability of detecting a group of animals directly on the trackline ($g(0)$) and the probability of detecting a group of animals within the half-strip width on each side of the trackline (μ/w, where w is the transect truncation distance beyond which data are not recorded and μ is the effective strip half-width). The effective strip half-width also may be expressed as $\mu = 1/f(0)$, where $f(0)$ is the estimated probability density function of observed perpendicular distances y evaluated at $y = 0$.

The species discussed in Barlow (2015) may be different from those observed during a geophysical survey, but data from similar species can be used. Since $g(0)$ and $f(0)$ values for each species or genera depend on group size, BSS, swell height and other factors, those factors should be taken into account if possible.

The probability of detecting a group of cetaceans can therefore be expressed as:

$$p = g(0)\frac{\mu}{w} = \frac{g(0)}{wf(0)}$$

If there are n sightings of a species along a section of trackline, the estimated number of Groups for a given BSS, within a perpendicular distance w on each side of the trackline, and within the Level B harassment zone is:

$$N_{groups} = \frac{n}{p} = \frac{nwf(0)}{g(0)} = \frac{nw}{\mu g(0)}$$

and the estimated number of individual animals in that given BSS then is:

$$N = \frac{n}{p}S = \frac{nw}{\mu g(0)}S$$

where S is the mean group size for the species.

The number of animals seen within each BSS should be summed for each Level B harassment zone. That total number then must be scaled by the distance to the Level B harassment threshold relative to the truncation distance to estimate the total number of animals potentially taken during a given survey. Examples of the application of this process are given in the Commission's letter, relevant portions of which are available online at: *www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-oil-and-gas.*

As noted, a draft report must be submitted to NMFS within 90 days of the completion of survey effort or following expiration of the LOA (whichever comes first), or annually (if a multi-year LOA is issued), and must include all information described above under ''Data Collection.'' The report will describe the operations conducted and sightings of marine mammals near the operations. The report will provide full documentation of methods, results, and interpretation pertaining to all monitoring. The report will summarize the dates and locations of survey operations, and all marine mammal sightings (dates, times, locations, activities, associated survey activities); information regarding locations where the acoustic source was used must be provided. The LOA-holder shall provide geo-referenced time-stamped vessel tracklines for all time periods in which airguns (full array or single) were operating. Tracklines should include points recording any change in airgun status (*e.g.,* when the airguns began operating, when they were turned off, or when they changed from full array to single gun or vice versa). GIS files shall be provided in ESRI shapefile format and include the UTC date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates should be referenced to the WGS84 geographic coordinate system. In addition to the report, all raw observational data shall be made available to NMFS. This report must also include a validation document concerning the use of PAM (if PAM was required), which should include necessary noise validation diagrams and demonstrate whether background noise levels on the PAM deployment limited achievement of the planned detection goals.

The report will also include estimates of the number of takes based on the observations and in consideration of the detectability of the marine mammal species observed (as described above). Applicants must provide an estimate of the number (by species) of marine mammals that may have been exposed (based on observational data and accounting for animals present but unavailable for sighting) to the survey activity within areas associated with the relevant frequency-weighted sound fields (*i.e.,* 140/160/180 dB rms). The draft report must be accompanied by a certification from the lead PSO as to the accuracy of the report. A final report must be submitted within 30 days following resolution of any comments on the draft report.

Comprehensive Reporting

Individual LOA-holders will be responsible for collecting and submitting monitoring data to NMFS, as described above. In addition, on an annual basis, LOA holders will also collectively be responsible for compilation and analysis of those data for inclusion in subsequent annual synthesis reports. Individual LOA-holders may collaborate to produce this report or may elect to have their trade associations support the production of such a report. These reports would summarize the data presented in the individual LOA-holder reports, provide analysis of these synthesized results, discuss the implementation of required mitigation, and present any recommendations. This comprehensive annual report would be the basis of an annual adaptive management process (described below in ''Adaptive Management''). The following topics should be described in comprehensive reporting:

- Summary of geophysical survey activity by survey type, geographic zone (*i.e.,* the seven zones described in the modeling report), month, and acoustic source status (*e.g.,* inactive, ramp-up, full-power, power-down);
- Summary of monitoring effort (on-effort hours and/or distance) by acoustic source status, location, and visibility conditions (for both visual and acoustic monitoring);
- Summary of mitigation measures implemented (*e.g.,* delayed ramp-ups, shutdowns, course alterations for vessel strike avoidance) by survey type and location;
- Sighting rates of marine mammals during periods with and without acoustic source activities and other variables that could affect detectability of marine mammals, such as:
  - Initial sighting distances of marine mammals relative to source status;
  - Closest point of approach of marine mammals relative to source status;
  - Observed behaviors and types of movements of marine mammals relative to source status;
  - Distribution/presence of marine mammals around the survey vessel relative to source status;
  - Analysis of the effects of various factors influencing the detectability of marine mammals (*e.g.,* wind speed, sea state, swell height, presence of glare or fog); and
  - Estimates of the number of marine mammals taken by harassment, corrected for animals potentially missed by observers;
- Summary and conclusions from monitoring in previous year; and
- Recommendations for adaptive management.

Each annual comprehensive report should cover one full year of monitoring effort and must be submitted for review by October 1 of each year. Therefore, to allow for adequate preparation, each report should analyze survey and monitoring effort described in reports submitted by individual LOA-holders from July 1 of one year through June 30 of the next. Of necessity, the first annual report may cover a different period of time, *e.g.,* from the date of issuance of a rule until October 1 of the next year.

Reporting Injured or Dead Marine Mammals

In the event that the specified activity clearly causes the take of a marine mammal in a manner not permitted by the authorization (if issued), such as a serious injury or mortality, the LOA-holder shall immediately cease the specified activities and immediately report the take to NMFS. The report must include the following information:

- Time, date, and location (latitude/longitude) of the incident;
- Name and type of vessel involved;
- Vessel's speed during and leading up to the incident;
- Description of the incident;
- Status of all sound source use in the 24 hours preceding the incident;
- Water depth;
- Environmental conditions (*e.g.,* wind speed and direction, Beaufort sea state, cloud cover, and visibility);
- Description of all marine mammal observations in the 24 hours preceding the incident;
- Species identification or description of the animal(s) involved;
- Fate of the animal(s); and
- Photographs or video footage of the animal(s) (if equipment is available).

The LOA-holder shall not resume its activities until NMFS is able to review the circumstances of the prohibited take. NMFS would work with the LOA-holder to determine what is necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. The LOA-holder may not resume their activities until notified by NMFS.

In the event that the LOA-holder discovers an injured or dead marine mammal, and the lead PSO determines that the cause of the injury or death is unknown and the death is relatively recent (*i.e.,* in less than a moderate state of decomposition as we describe in the next paragraph), the LOA-holder will immediately report the incident to NMFS. The report must include the same information identified in the paragraph above this section. Activities may continue while NMFS reviews the circumstances of the incident. NMFS would work with the LOA-holder to determine whether modifications to the activities are appropriate.

In the event that the LOA-holder discovers an injured or dead marine mammal, and the lead PSO determines that the injury or death is not associated with or related to the specified activities (*e.g.,* previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), the LOA-holder would report the incident to NMFS within 24 hours of the discovery. The LOA-holder would provide photographs or video footage (if available) or other documentation of the animal to NMFS.

Negligible Impact Analysis and Preliminary Determination

NMFS has defined negligible impact as an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival (50 CFR 216.103). A negligible impact finding is based on the lack of likely adverse effects on annual rates of recruitment or survival (*i.e.,* population-level effects). An estimate of the number of takes alone is not enough information on which to base an impact determination. In addition to considering estimates of the number of marine mammals that might be ''taken,'' NMFS considers other factors, such as the type of take (*e.g.,* mortality, injury), the likely nature of any responses (*e.g.,* intensity, duration), the context of any responses (*e.g.,* critical reproductive time or location, migration), as well as effects on habitat, and the likely effectiveness of the mitigation. We also assess the number, intensity, and context of estimated takes by evaluating this information relative to population status. Consistent with the 1989 preamble for NMFS's implementing regulations (54 FR 40338; September 29, 1989), the impacts from other past and ongoing anthropogenic activities are incorporated into this analysis via their impacts on the environmental baseline (*e.g.,* as reflected in the regulatory status of the species, population size and growth rate where known, ongoing sources of human-caused mortality, or ambient noise levels).

For each potential activity-related stressor, we consider the potential impacts on affected marine mammals and the likely significance of those impacts to the affected stock or population as a whole. Potential risk due to vessel collision and related mitigation measures as well as potential risk due to entanglement and contaminant spills were addressed under ''Proposed Mitigation'' and ''Potential Effects of the Specified Activity on Marine Mammals'' and are not discussed further, as there are minimal risks expected from these potential stressors.

The ''specified activity'' for these regulations is a broad program of geophysical survey activity that could occur at any time of year in U.S. waters of the GOM. In recognition of the broad scale of this activity in terms of geographic and temporal scales, we propose use of a new analytical framework—first described by Ellison *et al.* (2015)—through which an explicit, systematic risk assessment methodology is applied to evaluate potential effects of aggregated discrete acoustic exposure events (*i.e.,* proposed geophysical survey activities) on marine mammals. We believe the approach described here addresses the scope and scale of potential impacts to marine mammal populations from these activities. Development of the approach was supported collaboratively by BOEM and NMFS, which together provided guidance to an expert working group (EWG) in terms of application to relevant regulatory processes. The framework and preliminary results are described by Southall *et al.* (2017), which is available online at: *www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-oil-and-gas.* That document is a companion to this analysis, and is referred to hereafter as the ''EWG report.'' The risk assessment framework described below was developed and preliminarily implemented by Southall *et al.* (2017) in relation to the specified activity described herein; we incorporate the framework and its results into our analysis as appropriate.

As described previously, Zeddies *et al.* (2015, 2017a) provided marine mammal noise exposure estimates based on BOEM-provided projections of future survey effort and based on best available modeling of sound propagation, animal distribution, and animal movement. This provided a conservative but reasonable best estimate of potential acute noise exposure events that may result from the described suite of activities. The primary goal in this new analytical effort was to develop a systematic framework that would use those modeling results to put into biologically-relevant context the level of potential risk of injury and/or disturbance to marine mammals. The framework considers both the aggregation of acute effects as well as the broad temporal and spatial scales over which chronic effects may occur. Previously, Wood *et al.* (2012) conducted an analysis of a proposed airgun survey, in which they derived a qualitative risk assessment method of considering the biological significance of exposures predicted to be consistent with the onset of physical injury and behavioral disturbance (the latter determined according to the same approach used here). Subsequently, Ellison *et al.* (2015) described development of a more systematic and (in some cases) quantitative basis for a risk-assessment approach to assess the biological significance and potential population consequences of predicted noise exposures. The approach here, which incorporated the results of Zeddies *et al.* (2015, 2017a) as an input, includes certain modifications to and departures from the conceptual approach described by Ellison *et al.* (2015). These are described in greater detail in the EWG report.

Generally, this approach is a relativistic risk assessment that provides an interpretation of the exposure estimates within the context of key biological and population parameters (*e.g.,* population size, life history factors, compensatory ability of the species, animal behavioral state, aversion), as well as other biological, environmental, and anthropogenic factors. The analysis is performed specifically on a species-specific basis for each effort scenario (''high,'' ''moderate,'' and ''low'') within each modeling zone (Figure 2). The end result provides an indication of the biological significance of these exposure numbers for each affected marine mammal stock (*i.e.,* yielding the severity of impact and vulnerability of stock/population information), as well as forecasting the likelihood of any such impact. This result is expressed as relative impact ratings of overall risk that couple potential severity of effect on a stock and likely vulnerability of the population to the consequences of those effects, given biologically relevant information (*e.g.,* compensatory ability).

Spectral, temporal, and spatial overlaps between survey activities and animal distribution are the primary factors that drive the type, magnitude, and severity of potential effects on marine mammals, and these considerations are integrated into both the severity and vulnerability assessments. In discussion with BOEM and NMFS, the EWG developed a strategic approach to balance the weight of these considerations between the two assessments, specifying and clarifying where and how the interactions between potential disturbance and species within these dimensions are evaluated. Overall ratings are then considered in conjunction with our proposed mitigation strategy (and any additional relevant contextual information) to ultimately inform our preliminary determinations. Elements of this approach are subjective and relative within the context of this program of projected actions and, overall, the analysis necessarily requires the application of professional judgment.

Severity of Effect

Level A Harassment—In order to evaluate the potential severity of the expected potential takes by Level A harassment (Table 9) on the species or stock, the EWG report uses a PBR-equivalent metric. As described previously, PBR is defined by the MMPA as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. To be clear, NMFS does not expect any of the potential occurrences of injury (*i.e.,* PTS) that may be authorized under this rule to result in mortality of marine mammals, nor do we believe that Level A harassment should be considered a ''removal'' in the context of PBR when used to inform a negligible impact determination. PTS is not appropriately considered equivalent to serious injury. However, PBR can serve as a gross indicator of the status of the species and a good surrogate for population vulnerability/health and, accordingly, PBR or a related metric can be used appropriately to inform a separate analysis to evaluate the potential relative severity to the population of a permanent impact such as PTS on a given number of individuals. This analysis is used to assess relative risks to populations as a result of PTS; NMFS does not expect that Level A harassment could directly result in mortality and our use of the PBR metric in this context should not be interpreted as such.

However, because habitat-based density models (Roberts *et al.,* 2016) were used to predict cetacean distribution and abundance in the GOM, exposure estimates cannot appropriately be directly related to the PBR values found in NMFS's SARs. Therefore, a modified PBR value was derived on the basis of the typical pattern for NMFS's PBR values, where the value varies between approximately 0.6–0.9 percent of the minimum population abundance depending upon population confidence limits (higher with increasing confidence). For endangered species, PBR values are typically ⅕ of the values for non-endangered species due to assumption of a lower recovery factor—endangered species are typically assigned recovery factors of 0.1, while species of unknown status relative to the optimum sustainable population level (*i.e.,* most species) are typically assigned factors of 0.5. This basic relationship of population size relative to PBR (*e.g.,* considered equivalent to estimated X percent of PBR) was used to define the following relative risk levels due to Level A harassment.

- Very high—Level A takes greater than 1.5 or 0.3 percent (the latter figure is used for endangered species) of zone-specific estimated population abundance.
- High—0.75–1.5 or 0.15–0.3 percent of zone-specific population.
- Moderate—0.375–0.75 or 0.075–0.15 percent of zone-specific population.
- Low—0.075–0.375 or 0.015–0.075 percent of zone-specific population.
- Very low—less than 0.075 or less than 0.015 percent of zone-specific population.

Relative severity scores by zone (Figure 2) and species for high, moderate, and low annual activity scenarios are shown in Tables 4–7 of the EWG report. However, as described previously, we do not believe that Level A harassment is likely to actually occur for mid-frequency cetaceans and therefore do not predict any take by Level A harassment for these species. The risk presented by Level A harassment to mid-frequency species is therefore expected to be none to very low.

Due to the combination of density estimates and effort projections, the predicted takes by Level A harassment (accounting for aversion) for both Bryde's whale and *Kogia* spp. are expected to represent a ''very high'' risk for the moderate and low effort scenarios in Zone 4 (note that the ''high'' effort scenario, while including the most survey days when aggregating across the entire GOM, includes no projected survey days in Zone 4). For *Kogia* spp. only, all three effort scenarios represent a ''very high'' risk in Zones 6 and 7. All other combinations of effort and zone result in overall evaluated risk of none to low for these species. We note that regardless of the relative risk assessed in this framework, because of the anticipated received levels and duration of sound exposure expected for any marine mammals exposed above Level A harassment criteria, no individuals of any species or stock are expected to receive more than a relatively minor degree of PTS, which would not be expected to meaningfully increase the likelihood or severity of any potential population-level effects.

Level B Harassment—As described above in ''Estimated Take,'' a significant model assumption was that populations of animals were reset for each 24-hr period. Exposure estimates for the 24-hr period were then aggregated across all assumed survey days as completely independent events, assuming populations turn over completely within each large zone on a daily basis. While the modeling provides reasonable estimates of the total number of instances of exposure exceeding Level B harassment criteria, it is likely that it leads to substantial overestimates of the numbers of individuals potentially disturbed, given that all animals within the areas modeled are unlikely to be completely replaced on a daily basis. Therefore, in assuming an increased number of individuals impacted, these results would lead to an overestimation of the potential population-level consequences of the estimated exposures. In order to evaluate modeled daily exposures and determine more realistic exposure probabilities for individuals across multiple days, we use information on species-typical movement behavior to determine a species-typical offset of modeled daily exposures, using the exploratory analysis discussed under ''Estimated Take'' (*i.e.,* Test Scenario 1). In this test scenario, modeled results were compared for a 30-day period versus the aggregation of 24-hr population reset intervals. When conducting computationally-intensive modeling over the full assumed 30-day survey period (versus aggregating the smaller 24-hr periods for 30 days), results showed about 10–45 percent of the total number of takes calculated using a 24-hr reset of the population, with differences relating to species-typical movement and residency patterns. Given that many of the evaluated survey activities occur for 30-day or longer periods, particularly some of the larger surveys for which the majority of the modeled exposures occur, using such a scaling process is appropriate in order to evaluate the likely severity of the predicted exposures. However, as noted earlier, even with this correction factor the resulting number of predicted takes of individuals is still an overestimate because individuals are expected to be exposed to multiple surveys in a year and many surveys are longer than 30 days. This approach is also discussed in more detail in the EWG report.

The test scenario modeled six representative GOM species/guilds: Bryde's whale, sperm whale, beaked whales, bottlenose dolphin, *Kogia* spp., and short-finned pilot whale. For purposes of this analysis, bottlenose dolphin was used as a proxy for other small dolphin species, and short-finned pilot whale was used as a proxy for other large delphinids. Tables 22–23 in the modeling report provide information regarding the number of modeled animals receiving exposure above criteria for average 24-hr sliding windows scaled to the full 30-day duration and percent change in comparison to the same number evaluated when modeling the full 30-day duration. This information was used to derive 30-day scalar ratios which, when applied to the total instances of exposure given in Table 9, captures repeated takes of individuals at a 30-day sampling level. Scalar ratios are as follows: Bryde's whale, 0.189; sperm whale, 0.423; beaked whales, 0.101; bottlenose dolphin, 0.287; *Kogia* spp., 0.321; and short-finned pilot whale, 0.295. Application of the re-scaling method reduced the overall magnitude of modeled takes for all species by slightly more than double to up to ten-fold. This output was used in a severity assessment.

TABLE 12—SCENARIO-SPECIFIC EXPECTED TAKE NUMBERS, INSTANCES AND INDIVIDUALS [1]

Species	Survey effort scenario [2]									
	High		Moderate #1		Moderate #2		Low #1		Low #2	
	Ins.	Ind.	Ins.	Ind.	Ins.	Ind.	Ins.	Ind.	Ins.	Ind.
Bryde's whale	560	106	413	78	498	94	386	73	402	76
Sperm whale	43,504	18,395	27,271	11,531	33,340	14,097	26,651	11,269	27,657	11,694
Kogia spp.	16,189	5,189	11,428	3,663	13,644	4,373	10,743	3,443	11,165	3,579
Beaked whale	235,615	23,704	162,134	16,311	190,777	19,193	151,708	15,262	156,584	15,753
Rough-toothed dolphin	37,666	10,793	30,192	8,651	31,103	8,912	28,663	8,213	26,315	7,540
Bottlenose dolphin	653,405	187,222	977,108	279,974	596,824	171,010	938,322	268,860	579,403	166,018
Clymene dolphin	110,742	31,731	72,913	20,892	87,615	25,105	69,609	19,945	72,741	20,843
Atlantic spotted dolphin	133,427	38,231	174,705	50,059	116,698	33,438	164,824	47,228	109,857	31,478
Pantropical spotted dolphin	606,729	173,848	419,738	120,269	511,037	146,429	399,581	114,493	419,824	120,293
Spinner dolphin	82,779	23,719	59,623	17,084	73,013	20,921	56,546	16,202	59,253	16,978
Striped dolphin	44,038	12,618	29,936	8,578	36,267	10,392	28,522	8,172	29,890	8,564
Fraser's dolphin	13,858	3,971	9,654	2,766	11,394	3,265	9,127	2,615	9,391	2,691
Risso's dolphin	27,062	7,754	18,124	5,193	21,914	6,279	17,309	4,960	18,092	5,184
Melon-headed whale	68,900	20,355	47,548	14,047	56,791	16,777	44,842	13,247	46,631	13,776
Pygmy killer whale	18,029	5,326	12,278	3,627	14,788	4,369	11,677	3,450	12,141	3,587
False killer whale	25,511	7,536	17,631	5,209	20,828	6,153	16,774	4,955	17,163	5,070
Killer whale	1,493	441	1,031	305	1,258	372	984	291	1,036	306
Short-finned pilot whale	19,258	5,689	12,155	3,591	14,163	4,184	11,523	3,404	11,900	3,516

[1] Instances of take (''Ins.'') reflects expected scenario-based takes by Level B harassment given previously in Table 9. Scalar ratios were applied as described in preceding text to derive expected numbers of individuals taken (''Ind.'').
[2] High survey effort scenario correspond level of effort projections given previously for Year 1 (Table 1). Moderate #1 and #2 and Low #1 and #2 correspond with Years 4, 5, 8, and 9, respectively.

As was done in evaluating severity of Level A harassment, the scaled Level B harassment takes were rated through a population-dependent binning system. For each species, scaled takes were divided by the zone-specific predicted abundance, and these proportions were used to evaluate the relative severity of modeled exposures based on the distribution of values across species to evaluate behavioral risk across species—a simple, logical means of evaluating relative risk across species and areas. Relative risk ratings using percent of area population size were defined as follows:

- Very high—Adjusted behavioral takes greater than 800 percent of zone-specific population;
- High—Adjusted behavioral takes 400–800 percent of zone-specific population;
- Moderate—Adjusted behavioral takes 200–400 percent of zone-specific population;
- Low—Adjusted behavioral takes 100–200 percent of zone-specific population; and
- Very low—Adjusted behavioral takes less than 100 percent of zone-specific population.

Results of severity ranking for Level B harassment are shown in Tables 8–10 of Southall *et al.* (2017). Note that these have been adjusted here to account for the erroneous density value that underlies the exposure predictions given by Zeddies *et al.* (2015, 2017b) for Bryde's whales in Zone 6.

Vulnerability of Affected Population

Vulnerability rating seeks to evaluate the relative risk of a predicted effect given species-typical and population-specific parameters (*e.g.,* species-specific life history, population factors) and other relevant interacting factors (*e.g.,* human or other environmental stressors). The assessment includes consideration of four categories within two overarching risk factors (species-specific biological and environmental risk factors). These values were selected to capture key aspects of the importance of spatial (geographic), spectral (frequency content of noise in relation to species-typical hearing and sound communications), and temporal relationships between sound and receivers. Explicit numerical criteria for identifying severity scores were specified where possible, but in some cases qualitative judgments based on a reasonable interpretation of given aspects of the proposed activity and how it relates to the species in question and the environment within the specified area were required. Factors considered in the vulnerability assessment were detailed in Southall *et al.* (2017) and are reproduced here (Table 13); note that the effects of the DWH oil spill are accounted for through the non-noise chronic anthropogenic risk factor identified below, while the effects to acoustic habitat and on individual animal behavior via masking described in ''Potential Effects of the Specified Activity on Marine Mammals and Their Habitat'' are accounted for through the masking chronic anthropogenic noise risk factors. Species-specific vulnerability scoring according to this scheme is shown in Table 14. Based on the range in vulnerability assessment scoring, an overall vulnerability rating was selected from the zone- and species-specific aggregate vulnerability score as shown in Table 15.

TABLE 13—VULNERABILITY ASSESSMENT FACTORS

	Score
Masking: Degree of spectral overlap between biologically important acoustic signals and predominant noise source of proposed activity (max: 7 out of 30):	
Communication masking: Predominant noise energy directly/partially overlaps [1] species-specific signals utilized for communication	+3/+1
Foraging masking: Predominant noise energy directly/partially overlaps [1] species-specific signals utilized in foraging (including echolocation and other foraging coordination signals)	+2/+1
Navigation/Orientation signal masking: Predominant noise energy directly/partially overlaps [1] signals likely utilized in spatial orientation to which species is well capable of hearing	+2/+1
Species population: Stock status, trend, and size (max: 7 out of 30):	
Population status: Endangered (ESA) and/or depleted (MMPA) (Y/N)	+3/0
Trend rating: Decreasing/unknown or data deficient/stable (*i.e.,* within 5 percent)/increasing (last three SARs for which new population estimates were updated)	+2/+1/0/−1
Population size: Small (less than 2,500)	+2
Species habitat use and compensatory abilities: Degree to which activity within a specified area [2] overlaps with species habitat and distribution (max: 7 out of 30):	
Habitat use: Survey area contains greater than 30/15–30/5–15/less than 5 percent of total region-wide estimated population (during defined survey period)	+4/+2/+1/0
Temporal sensitivity: Survey overlaps temporally with well-defined species-specific biologically-important period (*e.g.,* calving)	Up to +3
Other (chronic) noise and non-noise stressors: Magnitude of other potential sources of disturbance or other stressors that may influence a species response to additional noise and disturbance of the proposed activity (max: 9 out of 30):	
Chronic anthropogenic noise: Species subject to high/moderate degree of current or known future (overlapping activity) chronic anthropogenic noise	+2/+1
Chronic anthropogenic risk factors (non-noise): Species subject to high/moderate degree of current or known future risk from other chronic, non-noise anthropogenic activities (*e.g.,* fisheries interactions, ship strike)	Up to +4/+2
Chronic biological risk factors (non-noise): Known presence of disease, parasites, prey limitation, or high predation pressure	Up to +3

[1] Direct or partial overlap means that the predominant spectral content of received noise exposure from activity specific sources is expected to occur at identical frequencies as signals of interest, or that secondary (lower-level) spectral content of received noise exposure from activity specific sources is expected to occur at identical frequencies as signals of interest.
[2] This is the area over which a specified activity is evaluated and a local population is determined, in this case the seven modeling zones.

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Table 14. Vulnerability Assessment Scoring[1].

Species	Communication	Foraging	Navigation	Status	Trend	Size	Habitat	Time	Chronic noise	Chronic other	Biological risk	Range	Overall
Bryde's whale	3	2	2	3	2	2	0-4	0-1	1-2	0-3	0	16-23	23
Sperm whale	1	1	2	3	2	2	0-4	0-1	1-2	0-3	0	14-18	17
Kogia spp.	0	0	1	0	2	2	0-4	0-1	1-2	0-3	0	8-13	11
Beaked whale	0	0	1	0	1	0	0-4	0-1	1-2	0-3	1	6-13	9
Rough-toothed dolphin	0	0	1	0	2	0	1-4	0-1	1-2	0-3	0	6-10	8
Bottlenose dolphin	1	0	1	0	-1	0	0-4	0-1	1-2	0-3	0	2-10	8
Clymene dolphin	0	0	1	0	2	0	0-4	0-1	1-2	0-3	0	6-10	9
Atlantic spotted dolphin	1	0	1	0	1	0	0-4	0-1	1-2	0-3	2	6-14	13
Pantropical spotted dolphin	0	0	1	0	2	0	0-4	0-1	1-2	0-3	0	6-10	9
Spinner dolphin	0	0	1	0	0	0	0-4	0-1	1-2	0-3	0	3-9	8
Striped dolphin	0	0	1	0	2	0	0-4	0-1	1-2	0-3	0	6-10	9
Fraser's dolphin	0	0	1	0	1	2	0-4	0-1	1-2	0-3	0	7-11	10
Risso's dolphin	0	0	1	0	-1	0	0-4	0-1	1-2	0-3	1	4-9	7
Melon-headed whale	0	0	1	0	2	0	0-4	0-1	1-2	0-3	0	6-10	9
Pygmy killer whale	0	0	1	0	2	2	0-4	0-1	1-2	0-3	0	8-12	11
False killer whale	0	0	1	0	-1	0	0-4	0-1	1-2	0-3	0	3-7	6
Killer whale	1	0	1	0	2	2	0-4	0-1	1-2	0-3	0	9-12	12
Short-finned pilot whale	1	0	1	0	0	2	0-4	0-1	1-2	0-3	1	7-13	11

[1]Factors with a single value presented are those that remain constant across zones; other factors vary based on zone and a range of values is presented.

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TABLE 15—VULNERABILITY RATING SCHEME

Total score	Risk probability (% of total)	Vulnerability rating
24–30	80–100	Very high
18–23	60–79	High
12–17	40–59	Moderate
6–11	20–39	Low
0–5	0–19	Very low

Risk

In the final step of the framework, severity and vulnerability ratings are integrated to provide relative impact ratings of overall risk. The likely severity of effect was assessed as the percentage of total population affected based on scaled modeled Level B harassment takes relative to zone population size. There is no risk when there is no survey activity in a given zone for a given effort scenario, and zones predicted to contain abundance of less of five or less individuals of a species were also considered to have de minimis risk. Severity and vulnerability assessments each produce a numerical rating (1–5) corresponding with the qualitative rating (*i.e.,* very low, low, moderate, high, very high). A matrix is then used to integrate these two scores to provide an overall risk assessment. The matrix is shown in Table 2 of Southall *et al.* (2017). Please see Tables 8–10 of the EWG report for species- and zone-specific severity and vulnerability ratings for each of three activity scenarios. Tables 16–17 provide relative impact ratings by zone, and Table 18 provides GOM-wide relative impact ratings, for overall risk associated with predicted takes by Level B harassment, for each of three activity scenarios.

TABLE 16—OVERALL EVALUATED RISK BY ZONE AND ACTIVITY SCENARIO

[Zones 1–4]

Species	Zone 1 [1]	Zone 2			Zone 3			Zone 4 [1]	
	High	High	Moderate	Low	High	Moderate	Low	Moderate	Low
Bryde's whale	Low	n/a	n/a	n/a	n/a	n/a	n/a	Moderate	Moderate.
Sperm whale	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Moderate	Low.
Kogia spp.	Low	n/a	n/a	n/a	n/a	n/a	n/a	Low	Low.
Beaked whale	n/a	n/a	n/a	n/a	n/a	n/a	n/a	High	Low.
Rough-toothed dolphin	Low	Moderate	High	High	Very low	Very low	Very low	Low	Very low.
Bottlenose dolphin	Low	Low	High	Moderate	Very low	Very low	Very low	Very low	Very low.
Clymene dolphin	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Moderate	Low.
Atlantic spotted dolphin	Low	Moderate	High	High	Very low	Very low	Very low	Very low	Very low.
Pantropical spotted dolphin	Low	n/a	n/a	n/a	n/a	n/a	n/a	Very low	Very low.
Spinner dolphin	Very low	n/a	n/a	n/a	n/a	n/a	n/a	Very low	Very low.
Striped dolphin	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Low	Very low.
Fraser's dolphin	Low	Low	High	Moderate	n/a	n/a	n/a	Low	Very low.
Risso's dolphin	Low	n/a	n/a	n/a	n/a	n/a	n/a	Very low	Very low.
Melon-headed whale	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Moderate	Moderate.
Pygmy killer whale	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Low	Very low.
False killer whale	Low	Low	Moderate	Moderate	Very low	Very low	Very low	Very low	Very low.
Killer whale	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Low	Very low.
Short-finned pilot whale	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Low	Very low.

n/a = no activity projected for zone or five or less individuals predicted in zone.

[1] No activity is projected in Zone 1 under the moderate and low activity scenarios, and no activity is projected in Zone 4 under the high activity scenario.

TABLE 17—OVERALL EVALUATED RISK BY ZONE AND ACTIVITY SCENARIO

[Zones 5–7]

Species	Zone 5			Zone 6			Zone 7		
	High	Moderate	Low	High	Moderate	Low	High	Moderate	Low
Bryde's whale	Very high	Very high	Very high	n/a	n/a	n/a	n/a	n/a	n/a.
Sperm whale	Very high	Very high	Very high	Very high	Very high	High	Moderate	Moderate	Moderate.
Kogia spp.	High	High	Moderate	Moderate	Moderate	Low	Moderate	Low	Low.
Beaked whale	Very high	Very high	Very high	High	Moderate	Moderate	High	High	High.
Rough-toothed dolphin	High	High	Moderate	Moderate	Low	Low	Low	Low	Low.
Bottlenose dolphin	High	High	Moderate	Low	Very low	Very low	Low	Very low	Very low.
Clymene dolphin	High	High	Moderate	Moderate	Low	Low	Low	Low	Low.
Atlantic spotted dolphin	High	High	High	Moderate	Low	Low	n/a	n/a	n/a.
Pantropical spotted dolphin	High	High	Moderate	Moderate	Low	Low	Low	Low	Low.
Spinner dolphin	High	High	Moderate	Low	Very low	Very low	Low	Very low	Very low.
Striped dolphin	High	High	Moderate	Moderate	Low	Low	Low	Low	Low.
Fraser's dolphin	High	High	Moderate	Moderate	Low	Low	Low	Low	Low.
Risso's dolphin	High	High	High	Low	Very low	Very low	Very low	Very low	Very low.
Melon-headed whale	High	High	Moderate	Moderate	Low	Low	Moderate	Low	Low.
Pygmy killer whale	High	High	Moderate	Moderate	Low	Low	Low	Low	Low.
False killer whale	High	High	Moderate	Low	Very low	Very low	Low	Low	Low.
Killer whale	High	High	High	Moderate	Low	Low	Low	Low	Low.
Short-finned pilot whale	High	High	Moderate	Moderate	Low	Moderate	Moderate	Low	Low.

n/a = no activity projected for zone or five or less individuals predicted in zone.

TABLE 18—OVERALL EVALUATED RISK BY ACTIVITY SCENARIO, GOM-WIDE

Species	High activity scenario	Moderate activity scenario	Low activity scenario
Bryde's whale	Moderate	Moderate	Moderate.
Sperm whale	Very high	High	High.
Kogia spp.	Moderate	Low	Low.
Beaked whale	Very high	High	High.
Rough-toothed dolphin	Moderate	Low	Low.
Bottlenose dolphin	Low	Moderate	Low.
Clymene dolphin	Moderate	Low	Low.
Atlantic spotted dolphin	Low	Low	Low.
Pantropical spotted dolphin	Moderate	Low	Low.
Spinner dolphin	Low	Low	Low.
Striped dolphin	Moderate	Low	Low.
Fraser's dolphin	Moderate	Low	Low.
Risso's dolphin	Moderate	Low	Low.
Melon-headed whale	Moderate	Moderate	Moderate.
Pygmy killer whale	Moderate	Low	Low.
False killer whale	Moderate	Low	Low.
Killer whale	Moderate	Low	Low.
Short-finned pilot whale	Moderate	Low	Low.

Overall, the results of the risk assessment show that (as expected), risk is highly correlated with effort and density. Areas where little or no survey activity is predicted to occur or areas within which few or no animals of a particular species are believed to occur have very low or no potential risk of negatively affecting marine mammals, as seen across activity scenarios in Zones 1, 3, and 4. Areas with consistently high levels of effort (Zones 2, 5, 6, and 7) are generally predicted to have higher overall evaluated risk across all species. However, fewer species of animals are expected to be present in Zone 2, where we primarily expect shelf species such as bottlenose and Atlantic spotted dolphins. In Zone 7, animals are expected to be subject to less other chronic noise and non-noise stressors, which is reflected in the vulnerability scoring for that zone. Therefore, despite consistently high levels of projected effort, overall rankings for that zone are lower than for Zones 5 and 6.

Zones 5 and 6 were the only zones with ''very high'' levels of risk due to behavioral disturbance, identified for three species of particular concern in Zone 5 (Bryde's, beaked, and sperm whales) and two in Zone 6 (beaked and sperm whales). Projected effort levels were sufficiently high in Zone 5 that the rankings were not generally sensitive to activity scenario, while in Zone 6 the highest rankings were associated with the high activity scenario. As particularly sensitive species, beaked whales and sperm whales consistently receive relatively high severity scores. Bryde's whales receive very high vulnerability scoring across zones, due in large part to the differential susceptibility to masking, while sperm whales were also typically ranked as being highly vulnerable. Relatively high levels of risk were also identified for other species in some contexts, and these are generally explained by the interaction of specific factors related to survey effort concentration and areas of heightened geographic distribution or specific factors related to population trends or zone-related differences in vulnerability. When considered across the entire GOM and all activity scenarios, the only species considered to have relatively high risk are the sperm whale and beaked whales, while the Bryde's whale and melon-headed whales have relatively moderate risk.

Although the scores generated by the EWG framework, and further aggregated across zones as described by NMFS above, are species-specific, additional stock-specific information can be gleaned through the zone-specific nature of the analysis in that, for example with bottlenose dolphins, the zones align with stock range edges. These species-specific risk scores are broadly applied in NMFS's negligible impact analysis to all of the multiple stocks that are analyzed in this rule (Table 3), however, NMFS is also considering additional stock-specific information in our analysis, where appropriate, as indicated in our ''Description of Marine Mammals in the Area of the Specified Activity,'' ''Potential Effects of the Specified Activity on Marine Mammals and Their Habitat,'' and ''Proposed Mitigation'' sections (*e.g.,* coastal bottlenose dolphins were heavily impacted by the DWH oil spill and we have therefore recommended a time/area restriction to reduce impacts).

In order to more fully place the predicted amount of take into meaningful context, it is useful to understand the duration of exposure at or above a given level of received sound, as well as the likely number of repeated exposures across days. While a momentary exposure above the criteria for Level B harassment counts as an instance of take, that accounting does not make any distinction between fleeting exposures and more severe encounters in which an animal may be exposed to that received level of sound for a longer period of time. However, this information is meaningful to an understanding of the likely severity of the exposure, which is relevant to the negligible impact evaluation, and is not directly incorporated into the risk assessment framework described above. For example, for bottlenose dolphin exposed to noise from 3D WAZ surveys in Zone 6, the modeling report shows that approximately 72 takes (Level B harassment) would be expected to occur in a 24-hr period. However, each animat modeled has a record or time history of received levels of sound over the course of the modeled 24-hr period. The 50th percentile of the cumulative distribution function indicates that the time spent exposed to levels of sound above 160 dB rms SPL (*i.e.,* the 50 percent midpoint for behavioral harassment) would be only 1.8 minutes—a minimal amount of exposure carrying little potential for significant disruption of behavioral activity. We provide summary information regarding the total time in a 24-hr period that an animal would spend in this received level condition in Table 19.

Additionally, as we discussed in the ''Estimated Take'' section for Test Scenario 1, by comparing exposure estimates generated by multiplying 24-hr exposure estimates by the total number of survey days versus modeling for a full 30-day survey duration for six representative species, we were able to refine the exposure estimates to better reflect the number of individuals exposed above threshold. Using this same comparison and scalar ratios described above, we are able to predict an average number of days each of the representative species modeled in the test scenario were exposed above the Level B harassment thresholds. As with the duration of exposures discussed above, the number of repeated exposures is important to our understanding of the severity of effects. Specifically, for example, the ratio for beaked whales indicates that the 30-day modeling showed that approximately 10 percent as many individual beaked whales could be expected to be exposed above harassment thresholds as was reflected in the results given by multiplying average 24-hr exposure results by the survey duration (*i.e.,* 30 days). However, the approach of scaling up the 24-hour exposure estimates appropriately reflects the instances of exposure above threshold (which cannot be more than 1 in 24 hours), so the inverse of the scalar ratio suggests the average number of days in the 30-day modeling period that beaked whales are exposed above threshold is approximately ten. It is important to remember that this is an average and that it is likely some individuals would be exposed on fewer days and some on more. Table 19 reflects the average days exposed above threshold for the indicated species having applied the scalar ratios described previously.

TABLE 19—TIME IN MINUTES (PER DAY) SPENT ABOVE 160 dB RMS SPL (50TH PERCENTILE) AND AVERAGE NUMBER OF DAYS INDIVIDUALS EXPOSED ABOVE THRESHOLD DURING 30-DAY SURVEY

Species	Survey type and time (min/day) above 160 dB rms				Average number of days exposed above threshold during 30-day survey
	2D	3D NAZ	3D WAZ	Coil	5.3
Bryde's whale	5.1	11.8	4.6	19.5	2.4
Sperm whale	4.7	9.5	4.0	17.2	3.1
Kogia spp.	3.3	8.0	3.0	16.3	9.9
Beaked whale	4.8	10.1	4.0	20.3	3.5
Rough-toothed dolphin	3.6	7.8	3.1	14.2	3.5
Bottlenose dolphin	3.3	8.4	2.9	15.1	3.5
Clymene dolphin	3.2	7.9	2.9	13.7	3.5
Atlantic spotted dolphin	5.5	12.8	5.0	23.6	3.5
Pantropical spotted dolphin	3.2	7.9	2.9	13.7	3.5
Spinner dolphin	3.2	7.9	2.9	13.7	3.5
Striped dolphin	3.2	7.9	2.9	13.7	3.5
Fraser's dolphin	3.3	8.0	3.0	16.3	3.5
Risso's dolphin	4.5	10.9	3.9	18.6	3.5
Melon-headed whale	3.3	8.0	3.0	16.3	3.1
Pygmy killer whale	3.6	7.7	3.1	14.2	3.1
False killer whale	3.6	7.7	3.1	14.2	3.1
Killer whale	9.3	23.3	8.0	35.4	3.1
Short-finned pilot whale	3.3	8.0	3.0	14.7	3.1

We expect that Level A harassment could occur for low-frequency species (*i.e.,* Bryde's whale)—due to these species' heightened sensitivity to frequencies in the range output by airguns, as shown by their auditory weighting function—and for high-frequency species, due to their heightened sensitivity to noise in general (as shown by their lower threshold for the onset of PTS) (NMFS, 2016). However, to the extent that Level A harassment occurs it will be in the form of PTS, and the degree of injury is expected to be mild. If hearing impairment occurs, it is most likely that the affected animal would lose a few dB in its hearing sensitivity, which in most cases is not likely to affect its ability to survive and reproduce. Hearing impairment that occurs for these individual animals would be limited to at and slightly above the dominant frequency of the noise sources, *i.e.,* in the low-frequency region below 2–4 kHz. Therefore, the degree of PTS is not likely to affect the echolocation performance of the *Kogia* spp., which use frequencies between 60–120 kHz (Wartzok and Ketten, 1999). Further, modeled exceedance of Level A harassment criteria typically resulted from being near an individual source once rather than accumulating energy from multiple sources. Overall, the modeling indicated that exceeding the SEL threshold is a rare event and having four vessels close to each other (350 m between tracks) did not cause appreciable accumulation of energy at the ranges relevant for injury exposures. Accumulation of energy from independent surveys is expected to be negligible. For *Kogia* spp., because of expected sensitivity, we expect that aversion may play a stronger role in avoiding exposures above the peak pressure threshold than we have accounted for. For these reasons, and in conjunction with our proposed mitigation plan, we do not believe that Level A harassment will play a meaningful role in the overall degree of impact experienced by marine mammal populations as a result of the projected survey activity.

We consider the relative impact ratings described above in conjunction with our proposed mitigation and other relevant contextual information in order to produce a final assessment of impact to the stock or species, *i.e.,* our preliminary negligible impact determination. Annual levels of human-caused mortality are less than PBR for all GOM stocks aside from the Bryde's whale and, for most species, are zero (Hayes *et al.,* 2017). The effects of the DWH oil spill, which is not reflected in NMFS's published values for annual human-caused mortality, are accounted for through our vulnerability scoring (Table 14). We developed mitigation requirements, including time-area restrictions, designed specifically to provide benefit to certain populations for which we predict a relatively high amount of risk in relation to exposure to survey noise. The proposed time-area restrictions, described in detail in ''Proposed Mitigation'' and depicted in Figure 5, are designed specifically to provide benefit to the bottlenose dolphin, Bryde's whale, and beaked and sperm whales, with additional benefits to *Kogia* spp., which are often found in higher densities in the same locations of greater abundance for beaked and sperm whales. In addition, we expect these areas to provide some subsidiary benefit to additional species that may be present. The Atlantic spotted dolphin would also benefit from the coastal restriction proposed for bottlenose dolphins, and multiple shelf-break associated species would benefit from both the Bryde's whale and Dry Tortugas restrictions. The output of the Roberts *et al.* (2016) models, as used in core abundance area analyses (described in detail in ''Proposed Mitigation''), provides information about species most likely to derive subsidiary benefit from the proposed restrictions. Notably, high densities of *Kogia* spp. are predicted in the area of the Dry Tortugas restriction. Other shelf-break/pelagic species that are abundant in the eastern GOM include the melon-headed whale, Risso's dolphin, and rough-toothed dolphin, but numerous other species would be expected to be present in varying numbers at various times.

These proposed measures benefit both the primary species for which they were designed and the species that may benefit secondarily by likely reducing the number of individuals exposed to survey noise and, for resident species in areas where seasonal restrictions are proposed, reducing the numbers of times that individuals are exposed to survey noise. However, and perhaps of greater importance, we expect that these restrictions will reduce disturbance of these species in the places most important to them for critical behaviors such as foraging and socialization. The Bryde's whale area is the only known habitat of the species in the GOM, while the Dry Tortugas area is assumed to be an area important for beaked whale foraging and sperm whale reproduction. The coastal restriction would provide protection for the bottlenose dolphin populations most severely impacted by the DWH oil spill during a time of importance for reproduction. Further detail regarding rationale for these restrictions is provided under ''Proposed Mitigation.''

The endangered sperm whale and the Bryde's whale received special consideration in our development of proposed mitigation. The alternative of a year-round closure alternative with a 6-km buffer is designed to avoid impacts to the Bryde's whale by completely avoiding known habitat. Survey activities must avoid all areas where the Bryde's whale is found, and we propose to require shutdown of the acoustic source upon observation of any Bryde's whale at any distance. The Bryde's whale is proposed for listing as endangered, has a very low population size, is more sensitive to the low frequencies output by airguns, and faces significant additional stressors. Therefore, regardless of impact rating, we believe that the year-round closure alternative and 6-km buffer described previously would allow us to make the necessary negligible impact finding. We preliminarily find, were this alternative finalized, that the total potential marine mammal take from the projected survey activities will have a negligible impact on the Bryde's whale.

While the economic analysis accompanying this proposed rule indicates that a CPA restriction benefiting sperm whales would not be practicable, we propose to require a shutdown of the acoustic source upon any acoustic detection of sperm whales. We also propose shutdown requirements upon any detection of beaked whales or *Kogia* spp. (although these two species are rarely detected visually). If the observed animal is within the behavioral harassment zone, it would still be considered to have experienced harassment, but by immediately shutting down the acoustic source the duration and degree of disruption is minimized and the significance of the harassment event reduced as much as possible. Therefore, in consideration of the proposed mitigation, we preliminarily find that the total potential marine mammal take from the projected survey activities will have a negligible impact on the sperm whale, beaked whales, and *Kogia* spp.

The risk assessment process rates impacts as moderate or less for all other affected species. Therefore, in consideration of the proposed mitigation, we preliminarily find that the total potential marine mammal take from the projected survey activities will have a negligible impact on all other affected species, including all affected stocks of bottlenose dolphin.

In summary and as described above, the following factors primarily support our preliminary determination that the impacts resulting from this activity are not expected to adversely affect the affected species or stocks through effects on annual rates of recruitment or survival:

- No mortality is anticipated or authorized;
- Level A harassment not expected for species other than Bryde's whale and *Kogia* spp., and not expected to be a meaningful source of harm for these species;
- Risk assessment process rates impacts as moderate or less, for most species in most places and higher risk species have associated mitigation to lessen impacts;
- Known habitat for Bryde's whales protected;
- Shutdown requirements for species of concern (Bryde's whale, sperm whale, beaked whales, *Kogia* spp.); and
- Modeling resulted in daily exposures totaling 3–35 minutes, which, in most situations, is likely insufficient time to result in disruptions of behavior that raise concerns about fitness consequences.

Based on the analysis contained herein of the likely effects of the specified activity on marine mammals and their habitat, and taking into consideration the implementation of the proposed monitoring and mitigation measures, with a year-round closure in Bryde's whale habitat (Area 3; Figure 5), we preliminarily find that the total marine mammal take from the proposed activity will have a negligible impact on all affected marine mammal species or stocks.

Small Numbers

What are small numbers?

The MMPA does not define ''small numbers.'' NMFS's and the U.S. Fish and Wildlife Service's joint 1989 implementing regulations defined small numbers as a portion of a marine mammal species or stock whose taking would have a negligible impact on that species or stock. This definition was invalidated in *Natural Resources Defense Council* v. *Evans,* 279 F.Supp.2d 1129 (2003) (N.D. Cal. 2003), based on the court's determination that the regulatory definition of small numbers was improperly conflated with the regulatory definition of ''negligible impact,'' which rendered the small numbers standard superfluous. As the court observed, ''the plain language indicates that small numbers is a separate requirement from negligible impact.'' Since that time, NMFS has not applied the definition found in its regulations. Rather, consistent with Congress' pronouncement that small numbers is not a concept that can be expressed in absolute terms (House Committee on Merchant Marine and Fisheries Report No. 97–228 (September 16, 1981)), NMFS now makes its small numbers findings based on an analysis of whether the number of individuals taken annually from a specified activity is small relative to the stock or population size. The Ninth Circuit has upheld a similar approach. See *Center for Biological Diversity* v. *Salazar,* No. 10–35123, 2012 WL 3570667 (9th Cir. Aug. 21, 2012). However, we have not previously indicated what we believe the upper limit of small numbers is. Here, we provide additional information and clarification regarding our consideration of small numbers pursuant to paragraphs (A) and (D) of section 101(a)(5) of the MMPA.

To maintain an interpretation of small numbers as a proportion of a species or stock that does not conflate with negligible impact, we propose the following framework. A plain reading of ''small'' implies as corollary that there also could be ''medium'' or ''large'' numbers of animals from the species or stock taken. We therefore propose a simple approach that establishes three equal bins corresponding to small, medium, and large numbers of animals: Small is comprised of 1–33 percent, medium 34–66 percent, and large 67–100 percent of the population abundance.

NMFS's practice for making small numbers determinations is to compare the number of individuals estimated to be taken against the best available abundance estimate for that species or stock. Although NMFS's implementing regulations require applications for incidental take to include an estimate of the marine mammals to be taken, there is nothing in paragraphs (A) or (D) of section 101(a)(5) that requires NMFS to quantify or estimate numbers of marine mammals to be taken for purposes of evaluating whether the number is small.

While it can be challenging to predict the numbers of individual marine mammals that will be taken by an activity (many models calculate instances of take and are unable to account for repeated exposures of individuals), in some cases we are able to generate a reasonable estimate utilizing a combination of quantitative tools and qualitative information. When it is possible to predict with relative confidence the number of individual marine mammals of each species or stock that are likely to be taken, we recommend the small numbers determination be based directly upon whether or not these estimates exceed one third of the stock abundance. In other words, as in past practice, when the estimated number of animals is up to, but generally not greater than, one third of the species or stock abundance, NMFS will determine that the numbers of marine mammals of a species or stock are small.

When sufficient quantitative information is not available to estimate the number of individuals that might be taken (typically due to insufficient information about presence, density, or daily or seasonal movement patterns of the species in an area), we consider other factors, such as the spatial scale of the specified activity footprint as compared with the range of the affected species or stock and/or the duration of the activity in order to infer the relative proportion of the affected species or stock that might reasonably be expected to be taken by the activity. For example, an activity that is limited to a small spatial scale (*e.g.,* a coastal construction project or HRG survey) and relatively short duration might not be expected to result in take of more than a small number of a comparatively wider-ranging species. Unlike direct quantitative modeling of a number of individuals taken, this comparison may necessitate the presentation of some additional information and logical inferences to make a small numbers determination.

Another circumstance in which NMFS considers it appropriate to make a small numbers finding in the absence of a quantitative estimate is in the case of a species or stock that may potentially be taken but is either rarely encountered or only expected to be taken on rare occasions. In that circumstance, one or two assumed encounters with a group of animals (meaning a group that is traveling together or aggregated, and thus exposed to a stressor at the same approximate time) could reasonably be considered small numbers, regardless of consideration of the proportion of the stock (if known), as rare brief encounters resulting in take of one or two groups should be considered small relative to the range and distribution of any stock.

In summary, when quantitative take estimates of individual marine mammals are available or inferable through consideration of additional factors, and the number of animals taken is one third or less of the best available abundance estimate for the species or stock, NMFS would consider it to be of small numbers. When quantitative take estimates are not available, NMFS will examine other factors, such as the spatial extent of the take zone compared to the species or stock range and/or the duration of the activity to determine if the take will likely be small relative to the abundance of the affected species or stocks. Last, NMFS may appropriately find that one or two predicted group encounters will result in small numbers of take relative to the range and distribution of a species, regardless of the estimated proportion of the abundance.

How is the small numbers standard evaluated within the structure of the section 101(a)(5)(A) process?

Neither the MMPA nor NMFS's implementing regulations address whether the small numbers determination should be based upon the total annual taking for all activities occurring under incidental take regulations or to individual LOAs issued thereunder. The MMPA does not define small numbers or explain how to apply the term in either paragraph (A) or (D) of section 101(a)(5), including how to apply the term in a way that allows for consistency between those two very similar provisions. NMFS has not previously made a clear and deliberate policy choice or specifically explored applying the small numbers finding to each individual LOA under regulations that cover multiple concurrent LOA holders. Here we propose a reasonable interpretation of how to make a small numbers determination based on a permissible interpretation of the statute.

Specifically, section 101(a)(5)(A)(i)(I) explicitly states that the negligible impact determination for a specified activity must take into account the total taking over the five-year period, but the small numbers language is not tied explicitly to the same language. As the provision is structured, the small numbers language is not framed as a standard for the issuance of the authorization, but rather appears in the chapeau as a limitation on what the Secretary may allow. The regulatory vehicle for authorizing (*i.e.,* allowing) the take of marine mammals is the LOA.

Given NMFS's discretion in light of the ambiguities in the statute regarding how to apply the small numbers standard, and the clear benefits of application as described here, we have determined that the small numbers finding should be applied to the annual take authorized in each LOA. To demonstrate why this approach is preferred, we first describe below why it is beneficial to NMFS, the public, and the resource (marine mammals) to utilize section 101(a)(5)(A) for multiple activities, where possible.

- From a resource protection standpoint, it is more protective to conduct a comprehensive negligible impact analysis that considers all of the activities covered under the rule and ensures that the total combined taking from those activities will have a negligible impact on the affected marine mammal species or stocks and no unmitigable adverse impact on subsistence uses. Furthermore, mitigation and monitoring are more effective when considered across all activity and years covered under regulations.
- From an agency resource standpoint, it ultimately will save significant time and effort to cover multi-year activities under a rule instead of multiple incidental harassment authorizations (IHAs). While regulations require more analysis up front, additional public comment and internal review, and additional time to promulgate compared to a single IHA, they are effective for up to five years and can cover multiple actors within a year. The process of issuing individual LOAs under incidental take regulations utilizes the analysis, public comment, and review that was conducted for the regulations, and takes significantly less time than it takes to issue an IHA.
- From an applicant standpoint, incidental take regulations offer more regulatory certainty than IHAs (five years versus one year) and significant cost savings, both in time and environmental compliance analysis and documentation, especially for situations like here, where multiple applicants will be applying for individual LOAs under regulations. In the case of this proposed rule, the certainty afforded by the promulgation of a regulatory framework (*e.g.,* by using previously established take estimates, mitigation and monitoring requirements, and procedures for requesting and obtaining an LOA) is a significant benefit for prospective applicants.

A review of IHAs we have issued suggests that bundling together two or three IHAs that might be ideal subjects for a combined incidental take regulation (*e.g.,* for ongoing maintenance construction activities, or seismic surveys in the Arctic) would very often result in greater than small numbers of one or more species being taken if we were to apply the small numbers standard across all activity contemplated by the regulation in a year, thereby precluding the use of section 101(a)(5)(A) in many cases. Application of the small numbers standard across the total annual taking covered by regulations, inasmuch as potential applicants can see that the total take may exceed one third of species or stock abundance, creates an incentive for applicants to pursue individual IHAs, and will often preclude the ability to gain the benefits of regulations outlined above.

Our conclusion is that NMFS can appropriately elect to make a ''small numbers'' finding based on the estimated annual take in individual LOAs issued under the rule. This approach does not affect the negligible impact analysis, which is the biologically relevant inquiry and based on the total annual estimated taking for all activities the regulations will govern. Making the small numbers finding based on the estimated annual take in individual LOAs allows NMFS to take advantage of the associated administrative and environmental benefits of utilizing section 101(a)(5)(A) that would be precluded in many cases if small numbers were required to be applied to the total annual taking under the regulations.

Although this application of small numbers may be argued as being less protective of marine mammals, NMFS disagrees. As specifically differentiated from the negligible impact finding, the small numbers standard has little biological relevance. The negligible impact determination, which does have biological significance, is still controlling, and the total annual taking authorized across all LOAs under an incidental take regulation still could not exceed the overall amount analyzed for the negligible impact determination. Moreover, to the extent that this process is perceived as less protective than applying the small numbers standard across all activity occurring annually under the regulations (in that the small numbers standard can be met more readily under our proposed approach), that perception ignores the fact that applicants could always opt to pursue an IHA to circumvent a more restrictive approach to applying small numbers under section 101(A)(5)(A) (in cases where there is no serious injury or mortality).

How will small numbers be evaluated under this proposed GOM rule?

In this proposed rule, up-to-date species information is available, and sophisticated models have been used to estimate take in a manner that will allow for quantitative comparison of the take of individuals versus the best available abundance estimates for the species or stocks. Specifically, while the modeling effort utilized in the rule enumerates the estimated instances of takes that will occur across days as the result of the operation of certain survey types in certain areas, the modeling report also includes the evaluation of a test scenario that allows for a reasonable modification of those generalized take estimates to better estimate the number of individuals that will be taken within one survey. LOA applicants using modeling results from the rule to inform their applications will be able to reasonably estimate the number of marine mammal individuals taken by their proposed activities. LOA applications that do not use the modeling provided in the rule to estimate take for their activities will need to be independently reviewed, and applicants will be required to ensure that their estimates adequately inform the small numbers finding. Additionally, if applicants use the modeling provided by this rule to estimate take, additional public input will not be deemed necessary (unless other conditions necessitating public review exist, as described in the ''Letters of Authorization'' section); if they do not, however, NMFS will publish a notice in the **Federal Register** soliciting public comment. The estimated take of marine mammals for each species will then be compared against the best available scientific information on species or stock abundance estimate as determined by NMFS, and estimates that do not exceed one-third of that estimate will be considered small numbers.

Adaptive Management

The regulations governing the take of marine mammals incidental to geophysical survey activities would contain an adaptive management component. The comprehensive reporting requirements associated with this proposed rule (see the ''Proposed Monitoring and Reporting'' section) are designed to provide NMFS with monitoring data from the previous year to allow consideration of whether any changes are appropriate. The use of adaptive management allows NMFS to consider new information from different sources to determine (with input from the LOA-holders regarding practicability) on an annual or biennial basis if mitigation or monitoring measures should be modified (including additions or deletions). Mitigation measures could be modified if new data suggests that such modifications would have a reasonable likelihood of reducing adverse effects to marine mammal species or stocks or their habitat and if the measures are practicable. The adaptive management process and associated reporting requirements would serve as the basis for evaluating performance and compliance.

The following are some of the possible sources of applicable data to be considered through the adaptive management process: (1) Results from monitoring reports, as required by MMPA authorizations; (2) results from general marine mammal and sound research; and (3) any information which reveals that marine mammals may have been taken in a manner, extent, or number not authorized by these regulations or subsequent LOAs or that the specified activity may be having more than a negligible impact on affected stocks.

Under this proposed rule, NMFS proposes an annual adaptive management process involving BOEM, BSEE, and industry operators (including geophysical companies as well as exploration and production companies). Industry operators may elect to be represented in this process by their respective trade associations. NMFS, BOEM, and BSEE (*i.e.,* the regulatory agencies) and industry operators who have conducted or contracted for survey operations in the GOM in the prior year (or their representatives) will provide an agreed-upon description of roles and responsibilities, as well as points of contact, in advance of each year's adaptive management process. The foundation of the adaptive management process would be the annual comprehensive reports produced by LOA-holders (or their representatives), as well as the results of any relevant research activities, including research supported voluntarily by the oil and gas industry and research supported by the Federal government. Please see the ''Monitoring Contribution Through Other Research'' section below for a description of representative past research efforts. The outcome of the annual adaptive management process would be an assessment of effects to marine mammal populations in the GOM relative to NMFS's determinations under the MMPA and ESA, recommendations related to mitigation, monitoring, and reporting, and recommendations for future research (whether supported by industry or the regulatory agencies).

Data collection and reporting by individual LOA-holders would occur on an ongoing basis, per the terms of issued LOAs. In a given annual cycle, we propose that the comprehensive annual report would summarize and synthesize the LOA-specific reports received from

July 1 of one year through June 30 of the next, with report development (supported through collaboration of individual LOA-holders or by their representatives) occurring from July 1 through September 30 of a given year. Review and revision of the report, followed by a joint meeting of the parties, would occur between October 1 and December 31 of each year. Any agreed-upon modifications would occur through the process for modifications and/or adaptive management described in the proposed regulatory text following this preamble.

Monitoring Contribution Through Other Research

NMFS's MMPA implementing regulations require that applicants for incidental take authorizations describe the suggested means of coordinating research opportunities, plans, and activities relating to reducing incidental taking and evaluating its effects (50 CFR 216.104(a)(14)). Such coordination can serve as an effective supplement to the monitoring and reporting required pursuant to issued LOAs and/or incidental take regulations. We expect that relevant research efforts will inform the annual adaptive management process describe above, and that levels and types of research efforts will change from year to year in response to identified needs and evolutions in knowledge, emerging trends in the economy and available funding, and available scientific and technological resources. Here, we describe examples of relevant research efforts, which may not be predictive of any future levels and types of research efforts. Research occurring in locations other than the GOM may be relevant to understanding the effects of geophysical surveys on marine mammals or marine mammal populations or the effectiveness of mitigation.

Industry—In 2006, several exploration and production (E&P) companies and industry associations began a multi-year research program known as the E&P Sound and Marine Life Joint Industry Program (JIP). The aim of the program was to advance scientific understanding of the effects of sound generated by offshore oil and gas industry operations on living marine resources, including marine mammals. Since its inception, the JIP, the largest nongovernmental funder of research on this topic, has allocated $55 million to fund a wide range of different projects. The JIP website (*www.soundandmarinelife.org*) hosts a database of available products funded partially or fully through the JIP. As of June 2017, this database contained records for 133 JIP data products, including 41 project reports and 83 peer-reviewed publications, as well as the other notable products mentioned below. JIP policies stipulate that the research results be shared in public reports and submitted to peer-reviewed scientific journals to ensure maximum transparency and value to the wider research, stakeholder, and regulatory communities. JIP-funded projects and products are organized into six research categories: (1) Sound source characterization; (2) physical and physiological effects and hearing; (3) behavioral reactions and biologically significant effects; (4) mitigation and monitoring; (5) research tools; and (6) communication. Below, we summarize certain key studies as well as additional initiatives that are planned or underway (note that this is a small sample of studies and that not all of the initiatives described below have been funded through the JIP).

- Analyses of existing PSO data: The GOM is one of three regions currently being reviewed under a JIP contract, initiated in 2016, to assess the utility of existing PSO data. Visual PSO and PAM data through 2015 are being examined for quality and consistency, and assessments will be made about the data's utility in the validation of risk modeling, assessing behavioral responses, and the potential for deriving animal density and distribution information. This work will complement and reinforce similar efforts by BOEM (see below). An earlier JIP study resulted in standardizing the basic data recording formats used by vessel operators in the UK and other jurisdictions (*jncc.defra.gov.uk/page-1534*).
- Acoustic measurements and modeling: The JIP has funded measurement of the acoustic output of both single airgun sources as well as airgun arrays that help increase confidence in the source and propagation models used in the GOM. These include extensive near-field, mid-field, and far-field in-water acoustic measurements (conducted in Norwegian waters in 2007–2010) of the most commonly used single-source and two-element configurations over a range of volumes, depths, and pressures with the objective of measuring acoustic output at higher frequencies up to 50 kHz. More recently, measurements of the sound field from a fully operational airgun array in the GOM have been completed, with fully analyzed data products anticipated in 2018. Additionally, the JIP is funding work into the development of standard procedures for underwater noise measurements for activities related to offshore oil and gas exploration and production, to ensure that processing of selected acoustic metrics used to describe the characteristics of a sound signal propagating in water can be analyzed in a consistent and systematic manner, and is funding a review of available marine acoustic propagation models.
- PAMGuard: Industry has funded ongoing development and at-sea testing of this now-standard, open source real-time PAM software to improve mitigation capabilities during operations. More information and the software itself is available online at *www.pamguard.org.*
- Alternative technology: Pursuant to the terms of a settlement agreement (as amended) concerning pending litigation between the Natural Resources Defense Council *et al.* and the Department of Interior (joined by industry as intervenor-defendants) (*NRDC et al.* v. *Zinke et al.,* Civil Action No. 2:10 cv-01882 (E.D. La.)), industry has conducted a study of vibroseis technology, including construction and testing of prototypes. Development of vibroseis technology is promising in terms of reducing potential harm to marine mammals because the system outputs lower peak amplitude, and consequently less high-frequency energy, while maintaining the main bandwidth necessary for seismic data acquisition.
- Advanced dive behavior tag technology development: The JIP co-funded, with BOEM's predecessor agency (MMS) and the U.S. Navy's Office of Naval Research (ONR), initial development of advanced dive behavior tracking technology that has been used to study sperm whale diving and foraging behavior in the GOM.
- Effects of sound on marine mammal hearing: The JIP funds multiple hearing research projects specifically focused on defining the impacts of seismic sound sources on the hearing systems of various marine mammal species, *e.g.,* TTS, TTS growth, and masking in bottlenose dolphins and harbor porpoise. For example, the JIP funded research by the U.S. Navy's Marine Mammal Program that specifically examined the physiological effect of airgun sound on hearing in bottlenose dolphins by measuring TTS after exposure to multiple seismic pulses (Finneran *et al.,* 2015). New and ongoing studies are aimed at developing an understanding of the role of hearing recovery between exposures from intermittent sound sources, like airguns, in the process of TTS generation, as well as developing TTS growth functions to better refine TTS/PTS threshold relationships. The JIP has also funded research into modeling work to better estimate baleen whale hearing.
- Behavioral response study: The JIP and BOEM jointly funded a study examining how humpback whales respond to airgun sound in general and to the ramp-up procedure specifically (Behavioral Response of Australian Humpback Whales to Seismic Surveys (BRAHSS)). The experimental design progressed from using a single airgun source to a fully operational commercial array with a ramp-up procedure, and involved treatment and control groups, a pre-trial statistical power analysis, a range of exposures, and a four-stage ramp-up design. For more details of the study and results, please see Cato *et al.* (2013) and Dunlop *et al.* (2013, 2015, 2016, 2017).

BOEM—BOEM's Environmental Studies Program (ESP) develops, funds, and manages scientific research to inform policy decisions regarding OCS resource development. These environmental studies cover a broad range of disciplines, including physical oceanography, biology, protected species, and the environmental impacts of energy development. Through the ESP, BOEM is a leading contributor to the growing body of scientific knowledge about the marine and coastal environment. BOEM and its predecessor agencies have funded more than $1 billion in research since the studies program began in 1973. Technical summaries of more than 1,200 BOEM-sponsored environmental research projects and more than 3,400 research reports are publicly available online through the Environmental Studies Program Information System (ESPIS). Below, we summarize certain key studies, as well as additional initiatives that are planned or underway. For the latest information on BOEM's ongoing environmental studies work, please visit *www.boem.gov/studies.*

- Analyses of existing PSO data: MMS previously funded an analysis of GOM PSO data from 2002–2008 (Barkaszi *et al.,* 2012), and BOEM has currently contracted for additional analyses of PSO data from 2009–2015.
- Development of PAM standards: As discussed in ''Proposed Monitoring and Reporting,'' BSEE is working with Scripps Institute of Oceanography to develop standards for towed PAM systems.
- Passive acoustic monitoring: BOEM is funding a fixed PAM array for 5 years. Hydrophones will be deployed, maintained, and redeployed on a regular schedule throughout the GOM. Placement will include shelf, slope and deep water depths as well as all planning areas in order to gather a comprehensive data set representative of the entire GOM. This program is expected to establish a relative baseline for ambient noise in the GOM against which to evaluate potential future noise impacts from permitted activities as well as characterize the sound budget from other kinds of noise already occurring in the GOM (*e.g.,* shipping). In addition, acoustic recorders will be able to detect vocalizing marine mammals, providing both spatial and temporal information about cetacean species in the GOM.
- Sperm whale studies: The Sperm Whale Acoustic Monitoring Program (SWAMP) began in 2000 with joint support from MMS, ONR, and NMFS and laid the groundwork for future study by developing new methods for studying sperm whale behavior and their responses to sound. Subsequently, the Sperm Whale Seismic Study (SWSS) began in 2002 to evaluate potential effects of geophysical exploration on sperm whales in the GOM (*e.g.,* Jochens *et al.,* 2008). SWSS included support from MMS, ONR, the National Science Foundation (NSF), and a coalition of industry funders. In 2009, MMS (through an interagency agreement with NMFS) began the Sperm Whale Acoustic Prey Study (SWAPS), which studied how airgun noise may affect sperm whale prey species (*e.g.,* squid and small pelagic fish).
- GoMMAPPS: BOEM is supporting a multi-year, multi-disciplinary study of marine protected species in the GOM (Gulf of Mexico Marine Assessment Program for Protected Species (GoMMAPPS)), which is patterned after the successful Atlantic Marine Assessment Program for Protected Species (AMAPPS) that began in 2010 and has provided valuable information on the seasonal distribution and abundance of protected species in U.S. waters of the Atlantic Ocean. The overall goals are to improve our understanding of living marine resource abundance, distribution, habitat use, and behavior in the GOM to facilitate appropriate mitigation and monitoring of potential impacts from human activities, including geophysical survey activities. The study will utilize a variety of methods, depending on target species, including aerial surveys, shipboard surveys, satellite tagging and tracking, and genetic analyses. GoMMAPPS is a joint partnership of BOEM, NMFS, the U.S. Fish and Wildlife Service, and the U.S. Geological Survey. More information is available online at (*www.boem.gov/GOMMAPPS/*).
- Workshops: BOEM has funded various workshops, including a 2012 workshop focused on mitigation and monitoring associated with seismic surveys and a 2013 workshop concerning quieting technologies for reducing noise during seismic surveying (BOEM, 2014).

Impact on Availability of Affected Species for Taking for Subsistence Uses

There are no relevant subsistence uses of marine mammals implicated by these actions. Therefore, we have determined that the total taking of affected species or stocks would not have an unmitigable adverse impact on the availability of such species or stocks for taking for subsistence purposes.

Endangered Species Act (ESA)

Section 7(a)(2) of the Endangered Species Act of 1973 (16 U.S.C. 1531 *et seq.*) requires that each Federal agency insure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of designated critical habitat. To ensure ESA compliance for the promulgation of regulations and potential issuance of LOAs, NMFS consults internally whenever we propose to authorize take for ESA-listed marine mammal species. The sperm whale is listed as endangered under the ESA, and the GOM Bryde's whale has been proposed to be listed as endangered. Consultation under section 7 of the ESA will be concluded prior to issuance of any final incidental take regulations.

Letters of Authorization

Under issued incidental take regulations, industry operators would be able to apply for and obtain LOAs, as described in NMFS's MMPA implementing regulations (50 CFR 216.106). LOAs may be issued for multiple years, depending on the degree of specificity with which an operator can describe their planned survey activities. Because the specified activity described herein does not provide actual specifics of the timing, location, and survey design for activities that would be the subject of issued LOAs, such requests must include, at minimum, the information described at 50 CFR 216.104(a)(1 and 2), and should include an affirmation of intent to adhere to the mitigation, monitoring, and reporting requirements described in the regulations. The level of effort proposed by an operator would be used to develop an LOA-specific take estimate based on the results of Zeddies *et al.* (2015, 2017a). The annual estimated take, per zone and per species, would serve as a cap on the number of authorizations that could be issued. Applicants may choose to present additional information in a request for LOA, *e.g.,* independent exposure estimates, description of proposed mitigation and monitoring (if more stringent than the requirements in issued regulations). However, such additional information would be subject to NMFS review and approval as well as public review via a 30-day comment period prior to issuance. Any substantive departure from the activity and exposure estimation parameters described here and which form the basis for our preliminary determinations would be subject to public review.

Technologies continue to evolve to meet the technical, environmental, and economic challenges of oil and gas development. The use of ''new and unusual technologies'' (NUT), *i.e.,* technologies other than those described herein, would be evaluated on a case-by-case basis and may require public review. Some seemingly new technologies proposed for use by operators are often extended applications of existing technologies and interface with the environment in essentially the same way as well-known or conventional technologies. For such evaluations, we propose to follow the existing process used by BOEM, by using the following considerations:

- Has the technology or hardware been used previously or extensively in the U.S. GOM under operating conditions similar to those anticipated for the activities proposed by the operator? If so, the technology would not be considered a NUT;
- Does the technology function in a manner that potentially causes different impacts to the environment than similar equipment or procedures did in the past? If

so, the technology would be considered a NUT;

- Does the technology have a significantly different interface with the environment than similar equipment or procedures did in the past? If so, the technology would be considered a NUT; and
- Does the technology include operating characteristics that are outside established performance parameters? If so, the technology would be considered a NUT.

We would consult with BOEM as well as with NMFS's Endangered Species Act Interagency Cooperation Division regarding the level of review necessary for issuance of an LOA in which a NUT is proposed for use.

Alternative Regulatory Text

Please see Table 11 for a summary of mitigation measures with alternatives for consideration, for which alternative regulatory text is presented here.

Area Restriction

- Based on our analyses-to-date (''Proposed Mitigation'' and ''Negligible Impact Analysis and Preliminary Determination''), we evaluated a year-round restriction on airgun surveys in Area 3 (Figure 5), and our preliminary finding of negligible impact on the Gulf of Mexico stock of Bryde's whale is based on a year-round restriction in this area. Alternative regulatory text at § 217.184(e)(2) for this proposal would read: ''No use of airguns may occur within the area bounded by the 100- and 400-m isobaths, from 87.5° W to 27.5° N (buffered by 6 km).''

For our proposals of no restriction or a seasonal restriction, but with the addition of a requirement for BOEM and/or members or representatives of the oil and gas industry to ensure real-time detection of Bryde's whales across the area of potential impact including real-time communication of detections to survey operators, which would be used to initiate shutdowns to ensure that survey operations do not take place when a Bryde's whale is within 6 km of the acoustic source, the proposed regulatory text would be the following. For the three-month restriction, we are proposing using a moored listening array and thus the alternative regulatory text at § 217.184(e)(2) would read: ''No use of airguns may occur within the area bounded by the 100- and 400-m isobaths, from 87.5° W to 27.5° N (buffered by 6 km), during June through August. During September through May, LOA-holders conducting airgun surveys must monitor the area of potential impact using a moored passive listening array and may not use airguns when Bryde's whales are detected within 6 km of the acoustic source.'' For no restriction plus a requirement of real-time detection using the moored array in the area of impact alone, alternative regulatory text at § 217.184(e)(2) would read: ''In the area bounded by the 100- and 400-m isobaths, from 87.5° W to 27.5° N (buffered by 6 km), LOA-holders conducting airgun surveys must monitor a moored passive listening array and may not use airguns when a confirmed or potential Bryde's whale is detected within 6 km of the acoustic source.''

The proposal of a three-month seasonal restriction on airgun surveys in Area 3 with no additional monitoring requirement is included in the regulatory text at the end of this document, following the preamble.

As mentioned in the ''Proposed Mitigation'' section, we are interested in public comment on these proposals, including any data that may support the necessary findings regarding potential impacts to the GOM Bryde's whale for these proposals, as well as any additional alternative proposals that could vary the time period or length of seasonal closure from what NMFS has proposed.

Shutdowns

For the proposal requiring shutdown upon a confirmed acoustic detection of sperm whales within 1 km or upon a confirmed visual or acoustic detection of Bryde's whales, large whales with calf, beaked whales, or *Kogia* spp. within 1 km, the regulatory text at § 217.184(b)(6) would read: ''Buffer Zone and Exclusion Zone—The PSOs shall establish and monitor a 500-m exclusion zone and additional 500-m buffer to the exclusion zone. For all confirmed detections of baleen whales, beaked whales, and *Kogia* spp., and for confirmed acoustic detections of sperm whales, the full 1,000-m zone shall function as an exclusion zone. These zones shall be based upon radial distance from any element of the airgun array (rather than being based on the center of the array or around the vessel itself). During use of the acoustic source, occurrence of marine mammals within the buffer zone (but outside the exclusion zone) shall be communicated to the operator to prepare for the potential shutdown of the acoustic source. PSOs must monitor the 1,000-m zone for a minimum of 30 minutes prior to ramp-up (*i.e.,* pre-clearance).'' Regulatory text at § 217.184(b)(8)(ii) would read: ''Upon completion of ramp-up, if a marine mammal appears within, enters, or appears on a course to enter the exclusion zone, the acoustic source must be shut down (*i.e.,* power to the acoustic source must be immediately turned off). If a marine mammal (excluding delphinids) is detected acoustically and is determined to be within 1 km of the acoustic source, the acoustic source must be shut down.'' Regulatory text at § 217.184(b)(8)(iv) would read: ''Shutdown of the acoustic source is required upon detection (visual or acoustic) of a baleen whale, beaked whale, or *Kogia* spp. within 1 km.''

For the proposal waiving the shutdown or power-down requirement upon detection of small dolphins within a 500-m exclusion zone, regulatory text at § 217.184(b)(8)(iii) would read: ''This shutdown requirement is waived for dolphins of the following genera: *Tursiops, Stenella, Steno,* and *Lagenodelphis.* If there is uncertainty regarding identification (*i.e.,* whether the observed animal(s) belongs to the group described above), shutdown must be implemented.''

The other proposals discussed in the ''Proposed Mitigation'' section for detection of Bryde's whales, beaked whales, sperm whales, *Kogia* spp., and small dolphins are included in the regulatory text following the preamble. As mentioned in the ''Proposed Mitigation'' section, we are interested in public comment on these proposals.

Scope of the Rule

NMFS requests comment on the issuance of incidental take regulations that do not apply to BOEM's Eastern Planning Area. In the regulatory text, 217.180(b) would be replaced with the following text: ''The taking of marine mammals by oil and gas industry operators may be authorized in a Letter of Authorization (LOA) only if it occurs within the Bureau of Ocean Energy Management's Western or Central Planning Areas in the Gulf of Mexico.'' Under this alternative scope, NMFS would continue working on a programmatic approach to the authorization of take incidental to geophysical survey operations in the Eastern Planning Area, but applicants could apply for individual permits (IHAs) until that process is completed.

This revision of scope, if it occurred, would result in less impacts to affected species or stocks of marine mammals relative to what was considered in the analyses presented previously in this preamble. Based on the analysis included in the preceding sections, if no other changes are made to the scope of the rule or the required mitigation measures analyzed in the preceding sections (*i.e.,* the measures are not modified as considered above in this Alternatives for Consideration section), we preliminarily find that the total marine mammal take from the proposed activity (reflecting the revised scope considered here) will have a negligible impact on all affected marine mammal species or stocks and the mitigation measures included would effect the least practicable adverse impact on the affected species and stocks and their habitat.

Request for Information

NMFS requests interested persons to submit comments, information, and suggestions concerning the proposed rule and regulations, including the variations of the proposed rule, two economic baselines, and other information provided in the Regulatory Impact Analysis and associated appendices (*www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-oil-and-gas*) (see **ADDRESSES**). All comments will be reviewed and evaluated as we prepare the final rule. This proposed rule and referenced documents provide all environmental information relating to our proposed action for public review.

Classification

Pursuant to the procedures established to implement Executive Order 12866, the Office of Management and Budget has determined that this proposed rule is significant. Accordingly, a regulatory impact analysis (RIA) has been prepared and is available for review online at: *www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-oil-and-gas.* The RIA evaluates the potential costs and benefits of these proposed incidental take regulations, as well as a more stringent alternative, against two baselines. The baselines correspond with regulatory requirements associated with management of geophysical survey activity in the GOM prior to 2013 (pursuant to BOEM's authorities under the Outer Continental Shelf Lands Act) and conditions in place since 2013 pursuant to a settlement agreement, as amended through stipulated agreement, involving a stay of litigation (*NRDC et al.* v. *Zinke et al.,* Civil Action No. 2:10 cv–01882 (E.D. La.)). Under the settlement agreement that is in effect, industry trade groups representing operators agreed to include certain mitigation requirements for geophysical surveys in the GOM. As described previously in this preamble (''Economic Baseline''), NMFS is seeking comment on the most appropriate baseline against which to measure the costs and benefits of the proposed regulatory action.

The proposed rule would require new mitigation measures relative to the baseline and, thus, new costs for survey operators. However, the proposed rule would also alleviate the regulatory burden of implementing minimum separation distance requirements for deep penetration airgun surveys. The proposed rule also would result in indirect (but non-monetized) costs as a result of the proposed time-area restrictions. However, we do not believe that these would be significant, as described in the RIA and in the ''Proposed Mitigation'' section. Moreover, as described in the RIA, total costs related to compliance for survey activities are small compared with expenditures on other aspects of oil and gas industry operations, and direct compliance costs of the regulatory requirements are unlikely to result in materially reduced oil and gas activities in the GOM.

The proposed rule would also result in certain non-monetized benefits. The protection of marine mammals afforded by this rule (pursuant to the requirements of the MMPA) would benefit the regional economic value of marine mammals via tourism and recreation to some extent, as mitigation measures applied to geophysical survey activities in the GOM region are expected to benefit the marine mammal populations that support this economic activity in the GOM. In addition, some degree of benefits can be expected to accrue solely via ecological benefits to marine mammals and other wildlife as a result of the proposed regulatory requirements. The published literature (described in the RIA) is clear that healthy populations of marine mammals and other co-existing species benefit regional economies and provide social welfare benefits to people; however, it does not provide a basis for quantitatively valuing the cost of anticipated incremental changes in environmental disturbance and marine mammal harassment associated with the proposed rule.

Notably, the proposed rule would also afford significant benefit to the regulated industry by providing an efficient framework within which to achieve compliance with the MMPA, and the attendant regulatory certainty. In particular, cost savings may be generated by the reduced administrative effort required to obtain an LOA under the framework established by a rule compared to what would be required to obtain an incidental harassment authorization (IHA) under section 101(a)(5)(D). Absent the rule, survey operators in the GOM would likely be required to apply for an IHA. Although not monetized in the RIA, NMFS's analysis indicates that the upfront work associated with the rule (*e.g.,* analyses, modeling, process for obtaining LOA) would likely save significant time and money for operators. A conservative cost savings calculation, based on estimates of the costs for IHA applications (provided by a contractor providing such services) relative to LOA application costs and an assumption of the number of likely authorizations based on total annual survey days and survey estimates included in the RIA, ranges from $500,000 to $1.5 million annually. In terms of timing, NMFS recommends that IHA applicants contact the agency six to nine months in advance of the planned activity, whereas NMFS anticipates a timeframe of just three months for LOA applications under a rule.

We prepared an initial regulatory flexibility analysis (IRFA), as required by Section 603 of the Regulatory Flexibility Act (RFA), for this proposed rule. The IRFA describes the economic effects this proposed rule, if adopted, would have on small entities. A description of this action, why it is being considered, the objectives of, and legal basis for this proposed rule are contained in the preamble of this proposed rule. A copy of the full analysis is available online at *www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-oil-and-gas.* The MMPA provides the statutory basis for this proposed rule. No duplicative, overlapping, or conflicting Federal rules have been identified. A summary of the IRFA follows.

This proposed rule is expected to directly regulate businesses that conduct geophysical surveys in the GOM with the potential to incidentally take marine mammals. Some of these businesses may be defined as small entities. The IRFA identifies these businesses as well as potential indirect impacts to small business boat owners and operators, who would not be directly regulated by the rule, but who may be involved in the implementation of the survey activities. The IRFA found that, for ten years of relevant permit data (2006–2015), 62 U.S. based-companies applied for 284 permits for relevant surveys, in 15 different industry NAICS codes. The IRFA also found that, for the period 2012–2014, 33 U.S.-flagged vessels operated under contract to permit applicants; the parent companies and primary NAICS codes under which those vessels operated were also identified where possible.

Of the total number of relevant survey applications from 2006–2015, 12 percent (75 applications) were put forth by small entities. In total, 34 U.S.-based small businesses applied for relevant permits in the GOM between 2006–2015, representing only 12 percent of permit applications during this period.

Foreign businesses and U.S.-based large businesses applied for more permits per business than did small businesses. Companies involved in crude petroleum and natural gas extraction (NAICS 211111) and support activities for oil and gas (NAICS 213112) conducted the majority of the surveys by small companies (87 percent of companies). Historically, small entities undertook a larger percentage of HRG surveys (airgun and non-airgun) than did businesses as a whole (85 percent of surveys conducted by small businesses were HRG, compared to 57 percent of surveys by all entities). Small businesses did not undertake larger surveys (*e.g.,* 3D WAZ), according to the permit database reviewed.

Using this information, the IRFA finds that small entities would participate in approximately 33 to 57 surveys over the five years, or approximately 7 to 11 surveys annually, and that approximately 15 to 26 small companies will likely apply for relevant permits over the five years (approximately 3 to 5 small companies each year). The future distribution of small companies by industry is not known, but the historical pattern suggests that companies involved in crude petroleum and natural gas extraction (NAICS 211111) and support activities for oil and gas (213112) will conduct the majority of the surveys by small companies.

Annual median revenues for small entities who applied for relevant permits were $12.26 million. Incremental costs of the proposed rule for non-airgun surveys, which comprised most of the HRG surveys (95 percent are forecast to be non-airgun, as opposed to airgun, surveys), are anticipated to range from $5,700 to $12,300 per survey. Airgun HRG survey costs are anticipated to range from $25,800 to $37,500 per survey. Approximately four small entities are anticipated to be involved in survey activities annually over the five years. As such, impacts would not be universally experienced by all small entities, and would depend on the specific survey types the companies engaged in. Incremental impacts for HRG surveys, which historically comprised most small business surveys, are anticipated to increase costs to small entities by one percent or less of annual revenues. For those entities engaged in other types of surveys, costs could comprise a larger portion of annual revenues.

In summary, the IRFA finds: (1) In the majority of cases (88 percent), survey permit applicants are large businesses; (2) When the permit applicants are small businesses, the majority of the time (63 percent) they are oil and gas extractors (NAICS 211111); (3) Together these permits (for large businesses and small businesses with high annual revenues for which rule costs are a small fraction) account for 96 percent of the survey permits; (4) While small entities in other industries occasionally apply for permits (four percent historically), these businesses are quite small, with average annual revenues in the millions or even less. Given their size, it is unlikely that these permit applicants bear survey costs; otherwise it would be reflected in their annual revenues (*i.e.,* their revenues on average would reflect that they recover their costs). Accordingly, we expect it is most likely the survey costs are passed on to oil and gas extraction companies who commission the surveys or purchase the data; and (5) Overall, up to five small businesses (NAICS 211111) per year may experience increased costs of between 0.1 and 1.1 percent of average annual revenues.

NMFS's RIA evaluates the incremental regulatory impact of the proposed rule, as well as the incremental regulatory impact of a more stringent alternative to the mitigation, monitoring, and reporting requirements of the proposed rule. NMFS is requesting comment on the costs of these proposed incidental take regulations on small entities, with the goal of ensuring a thorough consideration and discussion at the final rule stage. We request comments on the analysis of entities affected, as well as information on regulatory alternatives that would simultaneously reduce the burden on small entities and afford appropriate protections to affected marine mammal species and stocks.

This proposed rule contains a collection-of-information requirement subject to the provisions of the Paperwork Reduction Act (PRA). Notwithstanding any other provision of law, no person is required to respond to nor shall a person be subject to a penalty for failure to comply with a collection of information subject to the requirements of the PRA unless that collection of information displays a currently valid OMB control number. These requirements have been approved by OMB under control number 0648–0151, currently under application for renewal, and include applications for regulations, subsequent LOAs, and reports. Send comments regarding any aspect of this data collection, including suggestions for reducing the burden, to NMFS and the OMB Desk Officer (see **ADDRESSES**).

List of Subjects in 50 CFR Part 217

Exports, Fish, Imports, Indians, Labeling, Marine mammals, Penalties, Reporting and recordkeeping requirements, Seafood, Transportation.

Dated: June 12, 2018.

Donna S. Wieting,

Acting Deputy Assistant Administrator for Regulatory Programs, National Marine Fisheries Service.

For reasons set forth in the preamble, 50 CFR part 217 is proposed to be amended as follows:

PART 217—REGULATIONS GOVERNING THE TAKING AND IMPORTING OF MARINE MAMMALS

■ 1. The authority citation for part 217 continues to read as follows:

Authority: 16 U.S.C. 1361 *et seq.*

■ 2. The heading of part 217 is revised to read as set forth above.

■ 3. Add Subpart S to read as follows:

Subpart S—Taking Marine Mammals Incidental to Geophysical Survey Activities in the Gulf of Mexico

Sec.

Subpart S—Taking Marine Mammals Incidental to Geophysical Survey Activities in the Gulf of Mexico

§ 217.180 Specified activity and specified geographical region.

(a) Regulations in this subpart apply only to oil and gas industry operators (LOA-holders), and those persons authorized to conduct activities on their behalf, for the taking of marine mammals that occurs in the area outlined in paragraph (b) of this section and that occurs incidental to geophysical survey activities.

(b) The taking of marine mammals by oil and gas industry operators may be authorized in a Letter of Authorization (LOA) only if it occurs within the Gulf of Mexico.

§ 217.181 Effective dates.

Regulations in this subpart are effective from [EFFECTIVE DATE OF FINAL RULE] through [DATE 5 YEARS AFTER EFFECTIVE DATE OF FINAL RULE].

§ 217.182 Permissible methods of taking.

Under LOAs issued pursuant to § 216.106 of this chapter and § 217.186, LOA-holders may incidentally, but not intentionally, take marine mammals within the area described in § 217.180(b) by Level A and Level B harassment associated with geophysical survey activities, provided the activity is in compliance with all terms, conditions, and requirements of the regulations in this subpart and the appropriate LOA.

§ 217.183 Prohibitions.

Notwithstanding takings contemplated in § 217.180 and § 217.182, and authorized by a LOA issued under § 216.106 of this chapter and § 217.186, no person in connection with the activities described in § 217.180 may:

(a) Violate, or fail to comply with, the terms, conditions, and requirements of this subpart or a LOA issued under § 216.106 of this chapter and § 217.186;

(b) Take any marine mammal not specified in such LOAs;

(c) Take any marine mammal specified in such LOAs in any manner other than as specified;

(d) Take a marine mammal specified in such LOAs if NMFS determines such taking results in more than a negligible impact on the species or stocks of such marine mammal; or

(e) Take a marine mammal specified in such LOAs if NMFS determines such taking results in an unmitigable adverse impact on the species or stock of such marine mammal for taking for subsistence uses.

§ 217.184 Mitigation requirements.

When conducting the activities identified in § 217.180, the mitigation measures contained in any LOA issued under § 216.106 of this chapter and § 217.186 must be implemented. These mitigation measures shall include but are not limited to:

(a) General conditions:

(1) A copy of any issued LOA must be in the possession of the LOA-holder, the vessel operator and other relevant personnel, the lead protected species observer (PSO), and any other relevant designees of the LOA-holder operating under the authority of the LOA.

(2) The LOA-holder shall ensure that the vessel operator and other relevant vessel personnel are briefed on all responsibilities, communication procedures, marine mammal monitoring protocol, operational procedures, and LOA requirements prior to the start of survey activity, and when relevant new personnel join the survey operations. The LOA-holder shall instruct relevant vessel personnel with regard to the authority of the protected species monitoring team, and shall ensure that relevant vessel personnel and protected species monitoring team participate in a joint onboard briefing led by the vessel operator and lead PSO to ensure that responsibilities, communication procedures, marine mammal monitoring protocol, operational procedures, and LOA requirements are clearly understood. This briefing must be repeated when relevant new personnel join the survey operations.

(b) Deep penetration airgun surveys:

(1) Deep penetration airgun surveys are defined as surveys using airgun arrays with total volume greater than 400 in^3.

(2) The LOA-holder must use independent, dedicated, trained PSOs, meaning that the PSOs must be employed by a third-party observer provider, may have no tasks other than to conduct observational effort, record observational data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and mitigation requirements (including brief alerts regarding maritime hazards), and must have successfully completed an approved PSO training course. NMFS will maintain a list of approved PSOs and, for PSOs not on the list, NMFS must review and approve PSO resumes accompanied by a relevant training course information packet that includes the name and qualifications (*i.e.,* experience, training completed, and educational background) of the instructor(s), the course outline or syllabus, and course reference material as well as a document stating the PSO's successful completion of the course. NMFS shall have one week to approve PSOs from the time that the necessary information is submitted, after which PSOs meeting the minimum requirements shall automatically be considered approved.

(3) At least one visual PSO and two acoustic PSOs must have a minimum of 90 days at-sea experience working in those roles, respectively, during a deep penetration seismic survey, with no more than eighteen months elapsed since the conclusion of the at-sea experience. One visual PSO with such experience shall be designated as the lead for the entire protected species observation team. The lead shall coordinate duty schedules and roles for the PSO team and serve as primary point of contact for the vessel operator. To the maximum extent practicable, the lead PSO shall devise the duty schedule such that experienced PSOs are on duty with those PSOs with appropriate training but who have not yet gained relevant experience.

(4) Visual observation:

(i) During survey operations (*e.g.,* any day on which use of the acoustic source is planned to occur, and whenever the acoustic source is in the water, whether activated or not), a minimum of two PSOs must be on duty and conducting visual observations at all times during daylight hours (*i.e.,* from 30 minutes prior to sunrise through 30 minutes following sunset) and 30 minutes prior to and during nighttime ramp-ups of the airgun array.

(ii) Visual monitoring must begin not less than 30 minutes prior to ramp-up and must continue until one hour after use of the acoustic source ceases or until 30 minutes past sunset.

(iii) Visual PSOs shall coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts, and shall conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.

(iv) Visual PSOs shall immediately communicate all observations to acoustic PSOs, including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination.

(v) Visual PSOs may be on watch for a maximum of two consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period.

(vi) Any observations of marine mammals by crew members aboard any vessel associated with the survey shall be relayed to the PSO team.

(vii) During good conditions (*e.g.,* daylight hours; Beaufort sea state (BSS) 3 or less), visual PSOs shall conduct observations when the acoustic source is not operating for comparison of sighting rates and behavior with and without use of the acoustic source and between acquisition periods, to the maximum extent practicable.

(5) Acoustic observation:

(i) All surveys must use a towed passive acoustic monitoring (PAM) system at all times when operating in waters deeper than 100 m, which must be monitored beginning at least 30 minutes prior to ramp-up and at all times during use of the acoustic source.

(ii) Acoustic PSOs shall immediately communicate all detections to visual PSOs, when visual PSOs are on duty, including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination.

(iii) Acoustic PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least two hours between watches and may conduct a maximum of 12 hours of observation per 24-hour period.

(iv) Survey activity may continue for brief periods of time when the PAM system malfunctions or is damaged. Activity may continue for 30 minutes without PAM while the PAM operator diagnoses the issue. If the diagnosis indicates that the PAM system must be repaired to solve the problem, operations may continue for an additional two hours without acoustic monitoring under the following conditions:

(A) Daylight hours and sea state is less than or equal to BSS 4;

(B) No marine mammals (excluding delphinids) detected solely by PAM in the exclusion zone in the previous two hours;

(C) NMFS is notified via email as soon as practicable with the time and location in which operations began without an active PAM system; and

(D) Operations with an active acoustic source, but without an operating PAM system, do not exceed a cumulative total of four hours in any 24-hour period.

(6) Exclusion Zone and Buffer Zone—The PSOs shall establish and monitor a 500-m exclusion zone and additional 500-m buffer zone. These zones shall be based upon radial distance from any element of the airgun array (rather than being based on the center of the array or around the vessel itself). During use of the acoustic source, occurrence of marine mammals within the buffer zone (but outside the exclusion zone) shall be communicated to the operator to prepare for the potential shutdown of the acoustic source. PSOs must monitor the 1,000-m zone for a minimum of 30 minutes prior to ramp-up (*i.e.,* pre-clearance).

(7) Ramp-up—A ramp-up procedure, involving a step-wise increase in the number of airguns firing and total array volume until all operational airguns are activated and the full volume is achieved, is required at all times as part of the activation of the acoustic source. Ramp-up may not be initiated if any marine mammal is within the designated exclusion zone or buffer zone. If a marine mammal is observed within these zones during the pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting the 1,000-m zone or until an additional time period has elapsed with no further sightings (*i.e.,* 15 minutes for small odontocetes and 30 minutes for all other species). PSOs shall monitor the exclusion zone during ramp-up, and ramp-up must cease and the source shut down upon observation of marine mammals within the zones. Ramp-up may occur at times of poor visibility if appropriate acoustic monitoring has occurred with no detections in the 30 minutes prior to beginning ramp-up. Acoustic source activation may only occur at times of poor visibility where operational planning cannot reasonably avoid such circumstances. The operator must notify a designated PSO of the planned start of ramp-up as agreed-upon with the lead PSO; the notification time should not be less than 60 minutes prior to the planned ramp-up. A designated PSO must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the PSO to proceed. Ramp-up shall begin by activating a single airgun of the smallest volume in the array and shall continue in stages by doubling the number of active elements at the commencement of each stage, with each stage of approximately the same duration. Duration should not be less than 20 minutes. The operator must provide information to the PSO documenting that appropriate procedures were followed. Ramp-ups shall be scheduled so as to minimize the time spent with source activated prior to reaching the designated run-in.

(8) Shutdown requirements:

(i) Any PSO on duty has the authority to delay the start of survey operations or to call for shutdown of the acoustic source pursuant to the requirements of this subpart. When shutdown is called for by a PSO, the acoustic source must be immediately deactivated and any dispute resolved only following deactivation. The operator must establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the acoustic source to ensure that shutdown commands are conveyed swiftly while allowing PSOs to maintain watch. When there is certainty regarding the need for mitigation action on the basis of either visual or acoustic detection alone, the relevant PSO(s) must call for such action immediately. When there is uncertainty regarding the nature of the observation, all on duty PSOs must agree upon the mitigation action. When only the acoustic PSO is on duty and there is uncertainty regarding the need for mitigation action on the basis of a detection, the PSO may request that the acoustic source be shut down as a precaution.

(ii) Upon completion of ramp-up, if a marine mammal appears within, enters, or is clearly on a course to enter the exclusion zone, the acoustic source must be shut down (*i.e.,* power to the acoustic source must be immediately turned off). If a marine mammal (excluding delphinids) is detected acoustically, the acoustic source must be shut down.

(iii) This shutdown requirement is waived for dolphins of the following genera: *Tursiops, Stenella, Steno,* and *Lagenodelphis.* Instead of shutdown, the acoustic source must be powered down to the smallest single element of the array if a dolphin of the indicated genera appears within or enters the 500-m exclusion zone, or is acoustically detected and localized within the zone. Power-down conditions shall be maintained until the animal(s) is observed exiting the exclusion zone or for 15 minutes beyond the last observation of the animal, following which full-power operations may be resumed without ramp-up.

(iv) Shutdown of the acoustic source is required upon detection (visual or acoustic) of a baleen whale, beaked whale, or *Kogia* spp. at any distance.

(v) Shutdown of the acoustic source is required upon observation of a whale (*i.e.,* sperm whale or any baleen whale) with calf at any distance, with ''calf'' defined as an animal less than two-thirds the body size of an adult observed to be in close association with the calf.

(vi) Upon implementation of shutdown, the source may be reactivated after the animal(s) has been observed exiting the exclusion zone or following a 30-minute clearance period with no further observation of the animal(s). Where there is no relevant zone (*e.g.,* shutdown due to observation of a baleen whale), a 30-minute clearance period must be observed following the last observation of the animal(s).

(vii) If the acoustic source is shut down for reasons other than mitigation (*e.g.,* mechanical difficulty) for brief periods (*i.e.,* less than 30 minutes), it may be activated again without ramp-up if PSOs have maintained constant visual and acoustic observation and no visual detections of any marine mammal have occurred within the exclusion zone and no acoustic detections (excluding delphinids) have occurred. For any longer shutdown, pre-clearance watch and ramp-up are required. For any shutdown at night or in periods of poor visibility (*e.g.,* BSS 4 or greater), ramp-up is required but if the shutdown period was brief and constant observation maintained, pre-clearance watch is not required.

(9) Miscellaneous protocols:

(i) The acoustic source must be deactivated when not acquiring data or preparing to acquire data, except as necessary for testing. Unnecessary use of the acoustic source shall be avoided. Notified operational capacity (not including redundant backup airguns) must not be exceeded during the survey, except where unavoidable for source testing and calibration purposes. All occasions where activated source volume exceeds notified operational capacity must be noticed to the PSO(s) on duty and fully documented. The lead PSO must be granted access to relevant instrumentation documenting acoustic source power and/or operational volume.

(ii) Testing of the acoustic source involving all elements requires normal mitigation protocols (*e.g.,* ramp-up). Testing limited to individual source elements or strings does not require ramp-up but does require pre-clearance.

(c) Shallow penetration surveys:

(1) Shallow penetration surveys are defined as surveys using airgun arrays with total volume equal to or less than 400 in^3 or boomers.

(2) LOA-holders shall follow the requirements defined for deep penetration airgun surveys at § 217.184(b), with the following exceptions:

(i) Use of a towed PAM system is not required except to begin use of the airgun(s) at night in waters deeper than 100 m. Use of a PAM system is required for nighttime start-up, with monitoring by a trained and experienced acoustic PSO during a 30-minute pre-clearance period and during the ramp-up period (if applicable). The required acoustic PSO may be a crew member.

(ii) Ramp-up is not required for shallow penetration surveys using only a single airgun or boomer.

(iii) The exclusion zone shall be established at a distance of 200 m, with an additional 200-m buffer monitored during pre-clearance.

(iv) No shutdown or power-down action is required upon detection of the dolphin genera described at § 217.184(b)(8)(iii) for surveys using a single airgun or boomer.

(v) Shutdowns are not required for observations beyond the exclusion zone under any circumstance.

(d) Non-airgun surveys:

(1) Non-airgun surveys are defined as surveys using an acoustic source other than an airgun(s) or boomer that operates at frequencies less than 200 kHz (*i.e.,* side-scan sonar, multibeam echosounder, or subbottom profiler).

(2) LOA-holders conducting non-airgun surveys shall follow the requirements defined for shallow penetration surveys at § 217.184(c), with the following exceptions:

(i) Use of a towed PAM system is not required under any circumstances;

(ii) Ramp-up is not required under any circumstances;

(iii) Non-airgun surveys shall employ a minimum of one trained and experienced independent visual PSO during all daylight operations (as described at § 217.184(b)) when operating in waters deeper than 200 m. In waters shallower than 200 m, non-airgun surveys shall employ one trained visual PSO, who may be a crew member, to monitor the exclusion zone and buffer during the pre-clearance period; and

(iv) No shutdown or power-down action is required upon detection of the dolphin genera described at § 217.184(b)(8)(iii).

(e) Restriction areas:

(1) From February 1 through May 31, no use of airguns may occur shoreward of the 20-m isobath (buffered by 13 km).

(2) No use of airguns may occur within the area bounded by the 100- and 400-m isobaths, from 87.5° W to 27.5° N (buffered by 6 km), during June through August.

(3) No use of airguns may occur within the area bounded by the 200- and 2,000-m isobaths from the northern border of BOEM's Howell Hook leasing area to 81.5° W (buffered by 9 km).

(f) To avoid the risk of entanglement, LOA-holders conducting surveys using ocean-bottom nodes or similar gear must:

(1) Use negatively buoyant coated wire-core tether cable;

(2) Retrieve all lines immediately following completion of the survey;

(3) Attach acoustic pingers directly to the coated tether cable; acoustic releases should not be used; and

(4) Employ a third-party PSO aboard the node retrieval vessel in order to document any unexpected marine mammal entanglement.

(g) To avoid the risk of vessel strike, LOA-holders must adhere to the following requirements:

(1) Vessel operators and crews must maintain a vigilant watch for all marine mammals and slow down or stop their vessel or alter course, as appropriate and regardless of vessel size, to avoid striking any marine mammal. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel, which shall be defined according to the parameters stated in this subsection, to ensure the potential for strike is minimized. Visual observers monitoring the vessel strike avoidance zone can be either third-party observers or crew members, but crew members responsible for these duties must be provided sufficient training to distinguish marine mammals from other phenomena and broadly to identify a marine mammal as a baleen whale, sperm whale, or other marine mammal;

(2) All vessels, regardless of size, must observe a 10 kn speed restriction within the restriction area described previously at § 217.184(e)(2);

(3) Vessel speeds must also be reduced to 10 kn or less when mother/calf pairs, pods, or large assemblages of cetaceans are observed near a vessel;

(4) All vessels must maintain a minimum separation distance of 500 yd (457 m) from baleen whales;

(5) All vessels must maintain a minimum separation distance of 100 yd (91 m) from sperm whales;

(6) All vessels must attempt to maintain a minimum separation distance of 50 yd (46 m) from all other marine mammals, with an exception made for those animals that approach the vessel;

(7) When cetaceans are sighted while a vessel is underway, vessels shall attempt to remain parallel to the animal's course, and shall avoid excessive speed or abrupt changes in direction until the animal has left the area; and

(8) If cetaceans are sighted in a vessel's path or in close proximity to a moving vessel, the vessel shall reduce speed and shift the engine to neutral, not engaging the engines until animals are clear of the area. This does not apply to any vessel towing gear.

§ 217.185 Requirements for monitoring and reporting.

(a) LOA-holders must provide bigeye binoculars (*e.g.,* 25 x 150; 2.7 view angle; individual ocular focus; height control) of appropriate quality (*i.e.,* Fujinon or equivalent) solely for PSO use. These shall be pedestal-mounted on the deck at the most appropriate vantage point that provides for optimal sea surface observation, PSO safety, and safe operation of the vessel. The operator must also provide a night-vision device suited for the marine environment for use during nighttime ramp-up pre-clearance, at the discretion of the PSOs. At minimum, the device should feature automatic brightness and gain control, bright light protection, infrared illumination, and optics suited for low-light situations.

(b) PSOs must also be equipped with reticle binoculars (*e.g.,* 7 x 50) of appropriate quality (*i.e.,* Fujinon or equivalent), GPS, a digital single-lens reflex camera of appropriate quality (*i.e.,* Canon or equivalent), a compass, and any other tools necessary to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals.

(c) PSO qualifications:

(1) PSOs must successfully complete relevant training, including completion of all required coursework and passing (80 percent or greater) a written and/or oral examination developed for the training program.

(2) PSOs must have successfully attained a bachelor's degree from an accredited college or university with a major in one of the natural sciences and a minimum of 30 semester hours or equivalent in the biological sciences and at least one undergraduate course in math or statistics. The educational requirements may be waived by NMFS if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver shall be submitted to NMFS and must include written justification. Requests shall be granted or denied (with justification) by NMFS within one week of receipt of submitted information. Alternate experience that may be considered includes, but is not limited to:

(i) Secondary education and/or experience comparable to PSO duties;

(ii) Previous work experience conducting academic, commercial, or government-sponsored marine mammal surveys; or

(iii) Previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.

(d) Data collection—PSOs must use standardized data forms, whether hard copy or electronic. PSOs shall record detailed information about any implementation of mitigation requirements, including the distance of animals to the acoustic source and description of specific actions that ensued, the behavior of the animal(s), any observed changes in behavior before and after implementation of mitigation, and if shutdown was implemented, the length of time before any subsequent ramp-up of the acoustic source to resume survey. If required mitigation was not implemented, PSOs should record a description of the circumstances. We require that, at a minimum, the following information be recorded:

(1) Vessel names (source vessel and other vessels associated with survey) and call signs;

(2) PSO names and affiliations;

(3) Dates of departures and returns to port with port name;

(4) Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort;

(5) Vessel location (latitude/longitude) when survey effort begins and ends; vessel location at beginning and end of visual PSO duty shifts;

(6) Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change;

(7) Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions change significantly), including wind speed and direction, Beaufort sea state, Beaufort wind force, swell height, weather conditions, cloud cover, sun glare, and overall visibility to the horizon;

(8) Factors that may be contributing to impaired observations during each PSO shift change or as needed as environmental conditions change (*e.g.,* vessel traffic, equipment malfunctions);

(9) Survey activity information, such as acoustic source power output while in operation, number and volume of airguns operating in the array, tow depth of the array, and any other notes of significance (*i.e.,* pre-ramp-up survey, ramp-up, shutdown, testing, shooting, ramp-up completion, end of operations, streamers, etc.); and

(10) If a marine mammal is sighted, the following information should be recorded:

(i) Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);

(ii) PSO who sighted the animal;

(iii) Time of sighting;

(iv) Vessel location at time of sighting;

(v) Water depth;

(vi) Direction of vessel's travel (compass direction);

(vii) Direction of animal's travel relative to the vessel;

(viii) Pace of the animal;

(ix) Estimated distance to the animal and its heading relative to vessel at initial sighting;

(x) Identification of the animal (*e.g.,* genus/species, lowest possible taxonomic level, or unidentified), also note the composition of the group if there is a mix of species;

(xi) Estimated number of animals (high/low/best);

(xii) Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);

(xiii) Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or markings, shape and size of dorsal fin, shape of head, and blow characteristics);

(xiv) Detailed behavior observations (*e.g.,* number of blows, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior);

(xv) Animal's closest point of approach (CPA) and/or closest distance from the center point of the acoustic source;

(xvi) Platform activity at time of sighting (*e.g.,* deploying, recovering, testing, shooting, data acquisition, other); and

(xvii) Description of any actions implemented in response to the sighting (*e.g.,* delays, shutdown, ramp-up, speed or course alteration, etc.); time and location of the action should also be recorded.

(11) If a marine mammal is detected while using the PAM system, the following information should be recorded:

(i) An acoustic encounter identification number, and whether the detection was linked with a visual sighting;

(ii) Time when first and last heard;

(iii) Types and nature of sounds heard (*e.g.,* clicks, whistles, creaks, burst pulses, continuous, sporadic, strength of signal, etc.); and

(iv) Any additional information recorded such as water depth of the hydrophone array, bearing of the animal to the vessel (if determinable), species or taxonomic group (if determinable), spectrogram screenshot, and any other notable information.

(e) LOA-holders shall provide to NMFS within 90 days of survey conclusion geo-referenced time-stamped vessel tracklines for all time periods in which airguns were operating. Tracklines should include points recording any change in airgun status (*e.g.,* when the airguns began operating, when they were turned off, or when they changed from full array to single gun or vice versa). GIS files shall be provided in ESRI shapefile format and include the UTC date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates shall be referenced to the WGS84 geographic coordinate system.

(f) Reporting:

(1) Annual reporting: LOA-holders shall submit an annual summary report to NMFS on all activities and monitoring results within 90 days of the completion of the survey or expiration of the LOA, whichever comes sooner. The report must describe all activities conducted and sightings of marine mammals near the activities, must provide full documentation of methods, results, and interpretation pertaining to all monitoring, and must summarize the dates and locations of survey operations and all marine mammal sightings (dates, times, locations, activities, associated survey activities). Geospatial data regarding locations where the acoustic source was used, provided to NMFS under subparagraph § 217.185(e), must

be provided as an ESRI shapefile with all necessary files and appropriate metadata. The report must summarize the data collected as required under § 217.185(d). In addition to the report, all raw observational data shall be made available to NMFS. The draft report must be accompanied by a certification from the lead PSO as to the accuracy of the report, and the lead PSO may submit directly to NMFS a statement concerning implementation and effectiveness of the required mitigation and monitoring. A final report must be submitted within 30 days following resolution of any comments on the draft report.

(2) Comprehensive reporting: LOA-holders shall contribute to the compilation and analysis of data for inclusion in an annual synthesis report addressing all data collected and reported through annual reporting in each calendar year. The synthesis period shall include all annual reports deemed to be final by NMFS from July 1 of one year through June 30 of the subsequent year. The report must be submitted to NMFS by October 1 of each year.

(g) Reporting of injured or dead marine mammals:

(1) In the unanticipated event that the activity defined in § 217.180 clearly causes the take of a marine mammal in a prohibited manner, the LOA-holder shall immediately cease such activity and report the incident to the Office of Protected Resources (OPR), NMFS, and to the Southeast Regional Stranding Coordinator, NMFS. Activities shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS will work with the LOA-holder to determine what measures are necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. The LOA-holder may not resume their activities until notified by NMFS. The report must include the following information:

(i) Time, date, and location (latitude/longitude) of the incident;

(ii) Name and type of vessel involved;

(iii) Vessel's speed during and leading up to the incident;

(iv) Description of the incident;

(v) Status of all sound source use in the 24 hours preceding the incident;

(vi) Water depth;

(vii) Environmental conditions (*e.g.,* wind speed and direction, Beaufort sea state, cloud cover, visibility);

(viii) Description of all marine mammal observations in the 24 hours preceding the incident;

(ix) Species identification or description of the animal(s) involved;

(x) Fate of the animal(s); and

(xii) Photographs or video footage of the animal(s).

(2) In the event that the LOA-holder discovers an injured or dead marine mammal and determines that the cause of the injury or death is unknown and the death is relatively recent (*e.g.,* in less than a moderate state of decomposition), the LOA-holder shall immediately report the incident to OPR and the Southeast Regional Stranding Coordinator, NMFS. The report must include the information identified in paragraph (f)(1) of this section. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with the LOA-holder to determine whether additional mitigation measures or modifications to the activities are appropriate.

(3) In the event that the LOA-holder discovers an injured or dead marine mammal and determines that the injury or death is not associated with or related to the activities defined in § 217.180 (*e.g.,* previously wounded animal, carcass with moderate to advanced decomposition, scavenger damage), the LOA-holder shall report the incident to OPR and the Southeast Regional Stranding Coordinator, NMFS, within 24 hours of the discovery. The LOA-holder shall provide photographs or video footage or other documentation of the stranded animal sighting to NMFS.

§ 217.186 Letters of Authorization (LOA).

(a) To incidentally take marine mammals pursuant to these regulations, prospective LOA-holders must apply for and obtain a LOA.

(b) A LOA, unless suspended or revoked, may be effective for a period not to exceed the expiration date of these regulations.

(c) In the event of projected changes to the activity or to mitigation and monitoring measures required by a LOA, the LOA-holder must apply for and obtain a modification of the LOA as described in § 217.187.

(d) The LOA shall set forth:

(1) Permissible methods of incidental taking;

(2) Means of effecting the least practicable adverse impact (*i.e.,* mitigation) on the species or stock and its habitat; and

(3) Requirements for monitoring and reporting.

(e) Issuance of the LOA shall be based on a determination that the level of taking will be consistent with the findings made for the total taking allowable under these regulations and a determination that the amount of take authorized under the LOA is of no more than small numbers.

(f) For LOA issuance, where either:

(1) The conclusions put forth in an application (*e.g.,* take estimates) are based on analytical methods that differ substantively from those used in the development of the rule; or

(2) The proposed activity or anticipated impacts vary substantively in scope or nature from those analyzed in the preamble to the rule, NMFS may publish a notice of proposed LOA in the **Federal Register**, including the associated analysis of the differences, and solicit public comment before making a decision regarding issuance of the LOA.

(g) Notice of issuance or denial of a LOA shall be published in the **Federal Register** within thirty days of a determination.

§ 217.187 Renewals and modifications of Letters of Authorization.

(a) A LOA issued under § 216.106 of this chapter and § 217.186 for the activity identified in § 217.180 shall be modified upon request by the applicant, provided that:

(1) The proposed specified activity and mitigation, monitoring, and reporting measures, as well as the anticipated impacts, are the same as those described and analyzed for these regulations (excluding changes made pursuant to the adaptive management provision in paragraph (c)(1) of this section); and

(2) NMFS determines that the mitigation, monitoring, and reporting measures required by the previous LOA under these regulations were implemented.

(b) For LOA modification requests by the applicant that include changes to the activity or the mitigation, monitoring, or reporting (excluding changes made pursuant to the adaptive management provision in paragraph (c)(1) of this section) that result in more than a minor change in the total estimated number of takes (or distribution by species or years), NMFS may publish a notice of proposed LOA in the **Federal Register**, including the associated analysis of the change, and solicit public comment before issuing the LOA.

(c) A LOA issued under § 216.106 of this chapter and § 217.186 for the activity identified in § 217.180 may be modified by NMFS under the following circumstances:

(1) Adaptive Management—NMFS may modify (including augment) the existing mitigation, monitoring, or reporting measures (after consulting with the LOA-holder regarding the practicability of the modifications) if doing so is practicable and creates a

reasonable likelihood of more effectively accomplishing the goals of the mitigation and monitoring set forth in the preamble for these regulations;

(i) Possible sources of data that could contribute to the decision to modify the mitigation, monitoring, or reporting measures in a LOA:

(A) Results from monitoring from previous years;

(B) Results from other marine mammal and/or sound research or studies; and

(C) Any information that reveals marine mammals may have been taken in a manner, extent or number not authorized by these regulations or subsequent LOAs.

(ii) If, through adaptive management, the modifications to the mitigation, monitoring, or reporting measures are substantial, NMFS will publish a notice of proposed LOA in the **Federal Register** and solicit public comment.

(2) Emergencies—If NMFS determines that an emergency exists that poses a significant risk to the well-being of the species or stocks of marine mammals specified in a LOA issued pursuant to § 216.106 of this chapter and § 217.186, a LOA may be modified without prior notice or opportunity for public comment. Notice would be published in the **Federal Register** within thirty days of the action.

§ 217.188 [Reserved]

§ 217.189 [Reserved]

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