DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

[RTID 0648–XR069]

Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to THwaites Offshore Research (THOR) Project in the Amundsen Sea, Antarctica

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

ACTION: Notice; proposed incidental harassment authorization; request for comments on proposed authorization and possible renewal.

SUMMARY: NMFS has received a request from the National Science Foundation (NSF) Office of Polar Programs on behalf of the University of Houston for authorization to take marine mammals incidental to the THOR project in the Amundsen Sea, Antarctica. Pursuant to the Marine Mammal Protection Act (MMPA), NMFS is requesting comments on its proposal to issue an incidental harassment authorization (IHA) to incidentally take marine mammals during the specified activities. NMFS is also requesting comments on a possible one-year renewal that could be issued under certain circumstances and if all requirements are met, as described in *Request for Public Comments* at the end of this notice. NMFS will consider public comments prior to making any final decision on the issuance of the requested MMPA authorizations and agency responses will be summarized in the final notice of our decision.

DATES: Comments and information must be received no later than January 21, 2020.

ADDRESSES: Comments should be addressed to Jolie Harrison, Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service. Physical comments should be sent to 1315 East-West Highway, Silver Spring, MD 20910 and electronic comments should be sent to *ITP.DeJoseph@noaa.gov.*

Instructions: NMFS is not responsible for comments sent by any other method, to any other address or individual, or received after the end of the comment period. Comments received electronically, including all attachments, must not exceed a 25-megabyte file size. All comments received are a part of the public record and will generally be posted online at *https://www.fisheries.noaa.gov/permit/incidental-take-authorizations-under-marine-mammal-protection-act* without change. All personal identifying information (*e.g.,* name, address) voluntarily submitted by the commenter may be publicly accessible. Do not submit confidential business information or otherwise sensitive or protected information.

FOR FURTHER INFORMATION CONTACT: Bonnie DeJoseph, 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: *https://www.fisheries.noaa.gov/permit/incidental-take-authorizations-under-marine-mammal-protection-act.* In case of problems accessing these documents, please call the contact listed above.

SUPPLEMENTARY INFORMATION:

Background

The MMPA prohibits the ''take'' of marine mammals, with certain exceptions. Sections 101(a)(5)(A) and (D) of the MMPA (16 U.S.C. 1361 *et seq.*) direct 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 and either regulations are issued or, if the taking is limited to harassment, a notice of a proposed incidental take authorization may be provided to the public for review.

Authorization for incidental takings shall be granted if NMFS finds that the taking will have a negligible impact on the species or stock(s) and will not have an unmitigable adverse impact on the availability of the species or stock(s) for taking for subsistence uses (where relevant). Further, NMFS must prescribe the permissible methods of taking and other ''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, and on the availability of the species or stocks for taking for certain subsistence uses (referred to in shorthand as ''mitigation''); and requirements pertaining to the mitigation, monitoring and reporting of the takings are set forth.

The definitions of all applicable MMPA statutory terms cited above are included in the relevant sections below.

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 review our proposed action (*i.e.,* the issuance of an incidental harassment authorization) with respect to potential impacts on the human environment.

This action is consistent with categories of activities identified in Categorical Exclusion B4 (incidental harassment authorizations with no anticipated serious injury or mortality) of the Companion Manual for NOAA Administrative Order 216–6A, which do not individually or cumulatively have the potential for significant impacts on the quality of the human environment and for which we have not identified any extraordinary circumstances that would preclude this categorical exclusion. Accordingly, NMFS has preliminarily determined that the issuance of the proposed IHA qualifies to be categorically excluded from further NEPA review.

We will review all comments submitted in response to this notice prior to concluding our NEPA process or making a final decision on the IHA request.

Summary of Request

On July 24, 2019, NMFS received a request from NSF for an IHA to take marine mammals incidental to conducting a low-energy marine geophysical survey and icebreaking as necessary in the Amundsen Sea. The application was deemed adequate and complete on November 21, 2019. NSF's request is for take of a small number of 18 species of marine mammals, by harassment. Neither NSF nor NMFS expects serious injury or mortality to result from this activity and, therefore, an IHA is appropriate. The planned activity is not expected to exceed one year.

Description of Proposed Activity

Overview

NSF plans to conduct low-energy marine seismic surveys in the Amundsen Sea during February 2019. The proposed activity will complement Thwaites Glacier and other Amundsen Sea oceanographic and geological/geophysical studies and provide reference data that can be used to initiate and evaluate the reliability of ocean models. Data obtained by the project would assist in establishing boundary conditions seaward of the Thwaites Glacier grounding line, obtaining records of external drivers of change, improving knowledge of processes leading to the collapse of Thwaites Glacier, and determining the history of past change in grounding line migration and conditions at the glacier base.

The seismic surveys would be conducted in approximately 8400 km^2 between 75.25°–73.5° S and 101.0°–108.5°W of the Amundsen Sea in water depths ranging from approximately 100 to 1000 m plus. The surveys would involve one source vessel, the Research Vessel/Icebreaker (RVIB) *Nathaniel B. Palmer* (*Palmer*). The *Palmer* would deploy up to two 45-in^3 generator injector (GI) airguns at a depth of 2–4 m with a total maximum discharge volume for the largest, two-airgun array of 3441 cm^3 maximum total volume (210 in^3) along predetermined track lines. Because of the extent of sea ice in the Amundsen Sea that typically occurs between January and February annually, icebreaking activities are expected to be required during the cruise.

Dates and Duration

The RVIB *Palmer* would likely depart from Punta Arenas, Chile, on or about January 25, 2020. Seismic surveys will begin on or about February 6, 2020 for approximately eight days. An additional two contingency days are allotted for unforeseen events such as weather, logistical issues, or mechanical issues with the research vessel and/or equipment. Weather conditions permitting, it is anticipated that seismic surveying would not exceed 240 hours of operation.

Specific Geographic Region

The proposed surveys would take place within the Amundsen Sea, between approximately between 75.25°–73.5° S and 101.0°–108.5° W. Surveys will be contained in approximately 8400 km^2 in the Amundsen Sea along representative track lines totaling approximately 1600 km, shown in Figure 1.

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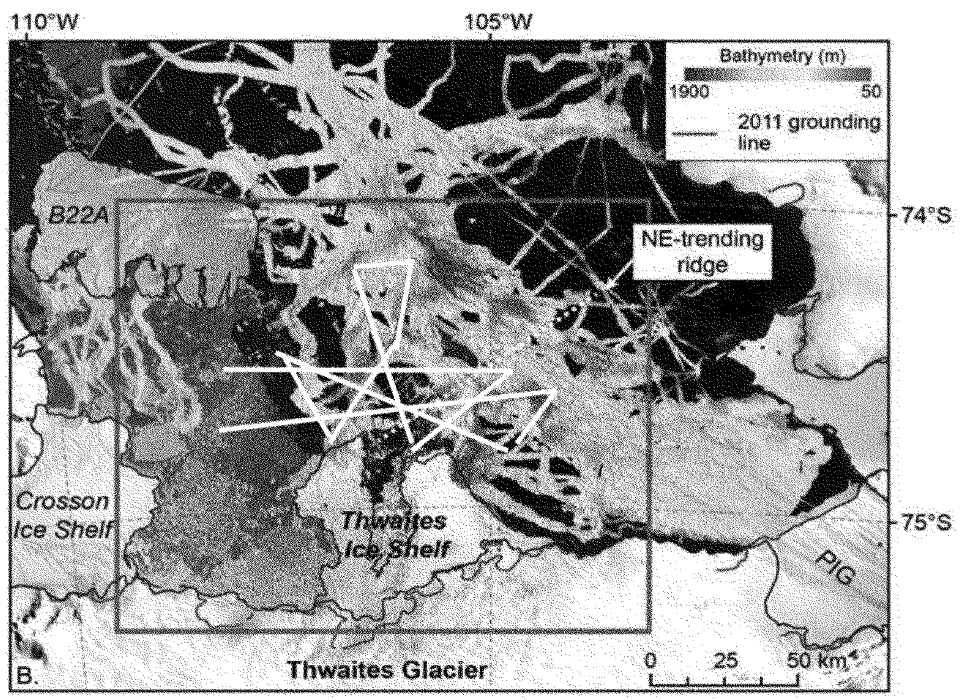
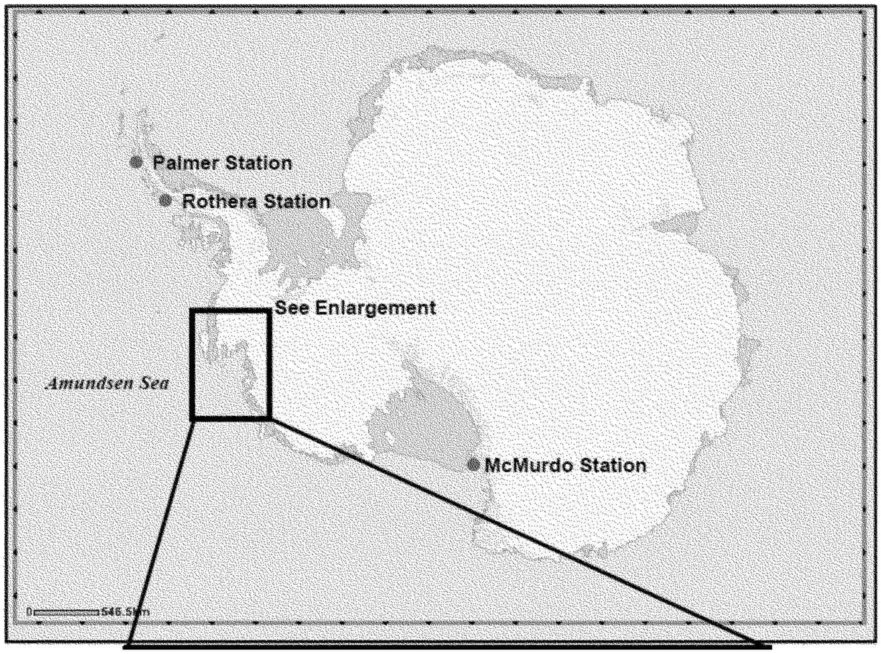
Figure 1 – Amundsen Sea Study Area





Note: Thwaites Glacier study area (red box) and approximate seismic survey lines (white line within box). Black line is generalized coastline-grounding line (from *http://www.add.scar.org/*) and purple line is 2011 grounding line from Rignot *et al*., 2014.
PIG = Pine Island Glacier.
Source: Scambos *et al*. 2017 in Global and Planetary Change.

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Detailed Description of Specific Activity

Seismic Surveys and Other Acoustic Sources

NSF proposes to conduct low-energy seismic surveys along a 1600-km track (Figure 1) using a one or two-generator injector airgun array, with a ''hot spare'', (Table 1) as a low-energy seismic source and returning acoustic signals would be collected via a hydrophone streamer (100–300 m in length). Other acoustic sources to be used include the following: acoustic doppler current profilers (ADCPs) and multi, single, and splitbeam echosounders. Data acquisition in the THOR survey area will occur in water depths that range between 100–1,000 m in 65 percent of the survey area and depths greater than 1,000 m in 35 percent of the study area (Figure 1).

The procedures to be used for the seismic surveys would be similar to those used during previous seismic surveys by NSF and would use conventional seismic methodology. The surveys would involve one source vessel, RVIB *Palmer,* which is managed by Galliano Marine Service LLC. The airgun array would be deployed at a depth of approximately 2–4 m below the surface, spaced approximately 3 m apart for the two-gun array, and between 15–40 m astern. Each airgun would be configured in the true GI or harmonic mode, with varying displacement volumes (Table 1). The total maximum discharge volume for the largest, two-airgun array would be 3441 cm3 (210 in^3; Table 1). The receiving system would consist of one hydrophone streamer, 100–300 m in length, with the vessel traveling at 8.3 km/hr (4.5 knots) to achieve high-quality seismic reflection data. As the airguns are towed along the survey lines, the hydrophone streamer would receive the returning acoustic signals and transfer the data to the on-board processing system.

TABLE 1—PROPOSED SEISMIC SURVEY ACTIVITIES IN THE AMUNDSEN SEA [1]

Configuration	Airgun array total volume (GI configuration)	Frequency between seismic shots (seconds)	Streamer length
Preferred	2 x 45/105 in^3 (300 in^3 total) (true GI mode)	5	100–300 m (328–984 ft).
Alternate 1	1 x 45/105 in^3 (150 in^3 total) (true GI mode)	5	
Alternate 2 (used for take request).	2 x 105/105 in^3 (420 in^3 total) (harmonic mode)	5	
Alternate 3	1 x 105/105 in^3 (210 in^3 total) (harmonic mode)	5	

[1] Seismic surveying operations are planned for 1600 km (994 mi) in length.

The airguns would fire compressed air at an approximate firing pressure of 140 kg/cm^2 (2000 psi). In harmonic mode, the injector volume is designed to destructively interfere with the reverberations of the generator (*i.e.,* the source component). Firing the airguns in harmonic mode maximizes resolution in the data and minimizes excess noise in the water column or in the data, caused by the reverberations (*i.e.,* bubble pulses). There would be approximately 720 shots per hour, and the relative linear distance between shots would be 12.5 m. The cumulative duration of airgun operation is anticipated to be no more than 240 hours, which includes equipment testing, ramp-up, line changes, and repeat coverage. If the preferred airgun configuration, the two-gun array in true GI mode, does not provide data to meet scientific objectives, alternate configurations would be utilized as shown in Table 1.

There could be additional seismic operations in the project area associated with equipment testing, re-acquisition due to reasons such as but not limited to equipment malfunction, data degradation during poor weather, or interruption due to shut-down or track deviation in compliance with IHA requirements. To account for these additional seismic operations, 25 percent has been added in the form of operational days, which is equivalent to adding 25 percent to the proposed line km to be surveyed. There would be approximately 720 shots per hour, and the relative linear distance between shots would be 12.5 m (41 ft). The cumulative duration of airgun operation is anticipated to be no more than 240 hours, which includes equipment testing, ramp-up, line changes, and repeat coverage.

In addition to the operations of the airgun array, a hull-mounted Single Beam Echo Sounder (Knudsen 3260 CHIRP), Multibeam Sonar (Kongsberg EM122), Acoustic Doppler Current Profiler (ADCP) (Teledyne RDI VM–150), and ADCP (Ocean Surveyor OS–38), as well as EK biological echo sounder (Simrad ES200–7C, ES38B, ES–120–7C) would also be operated from the *Palmer* continuously throughout the cruise. The vessel would be self-contained, and the crew would live aboard the vessel for the entire cruise.

The *Palmer* has a length of 93.9 m, a beam of 18.3 m, and a design draft of 6.8 m. It is equipped with four Caterpillar Model 3608 diesel engines (each rated at 3300 brake horsepower [BHP] at 900 revolutions per minute [rpm]) and a water jet azimuthing bow thruster. Electrical power is provided by four Caterpillar 3512, 1050-kW diesel generators. When not towing seismic survey gear, the *Palmer* cruises at approximately 9.2 km/hr (5 knots), varying between 7.4–11.1 km/hr (4–6 knots) when GI airguns are operating, and has the maximum speed of 26.8 km/hr (14.5 knots). The *Palmer* would also serve as the platform from which vessel-based protected species visual observers (PSVO) would watch for marine mammals before and during airgun operations.

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

Icebreaking

The research activities and associated contingencies are designed to avoid areas of heavy sea ice condition since the *Palmer* is not suited to break multi-year sea ice. If the *Palmer* breaks ice during transit operations within the Amundsen Sea, seismic operations would not be conducted concurrently. It is noted that typical transit through areas of primarily open water and containing brash or pancake, ice are not considered icebreaking for the purposes of this activity.

Description of Marine Mammals in the Area of Specified Activities

Sections 3 and 4 of the application summarize available information regarding status and trends, distribution and habitat preferences, and behavior and life history, of the potentially affected species. Additional information about these species (*e.g.,* physical and behavioral descriptions) may be found on NMFS's website (*https://www.fisheries.noaa.gov/find-species*).

The populations of marine mammals considered in this document do not occur within the U.S. Exclusive Economic Zone (EEZ) and are therefore not assigned to stocks and are not assessed in NMFS' Stock Assessment Reports (SAR). As such, information on potential biological removal (PBR; 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) and on annual levels of serious injury and mortality from anthropogenic sources are not available for these marine mammal populations. Abundance estimates for marine mammals in the survey location are lacking; therefore estimates of abundance presented here are based on a variety of other sources including International Whaling Commission population estimates (IWC 2019), The International Union for Conservation of Nature's (IUCN) Red List of Threatened Species, and various literature estimates (see IHA application for further detail), as this is considered the best available information on potential abundance of marine mammals in the area.

Table 2 lists all species with expected potential for occurrence in the Amundsen Sea, Antarctica, and summarizes information related to the population, including regulatory status under the MMPA and ESA. For taxonomy, we follow Committee on Taxonomy (2018).

TABLE 2—MARINE MAMMAL SPECIES POTENTIALLY PRESENT IN THE PROJECT AREA EXPECTED TO BE AFFECTED BY THE SPECIFIED ACTIVITIES

Common name	Scientific name	Stock [1]	ESA/MMPA status; strategic (Y/N) [2]	Stock abundance	PBR
Order Cetartiodactyla—Cetacea—Superfamily Mysticeti (baleen whales)					
Family Balaenopteridae (rorquals):					
Blue whale	*Balaenoptera musculus*	N/A	E/D;Y	[3] 5,000	N/A
Fin whale	*Balaenoptera physalus*	N/A	E/D;Y	[4] 38,200	N/A
Humpback whale	*Megaptera novaeangliae*	N/A		[5] 42,000	N/A
Minke whale [6]	*Balaenoptera acutorostrata*	N/A	-	[7] 515,000	N/A
Sei whale	*Balaenoptera borealis*	N/A	E	[8] 10,000	N/A
Superfamily Odontoceti (toothed whales, dolphins, and porpoises)					
Family Physeteridae:					
Sperm whale	*Physeter macrocephalus*	N/A	E	[9] 12,069	N/A

TABLE 2—MARINE MAMMAL SPECIES POTENTIALLY PRESENT IN THE PROJECT AREA EXPECTED TO BE AFFECTED BY THE SPECIFIED ACTIVITIES—Continued

Common name	Scientific name	Stock [1]	ESA/ MMPA status; strategic (Y/N) [2]	Stock abundance	PBR
Family Ziphiidae (beaked whales):					
Arnoux's beaked whale	*Berardius arnuxii*	N/A	-	[10] 599,300	N/A
Gray's beaked whale	*Mesoplodon grayi*	N/A	-	[10] 599,300	N/A
Southern bottlenose	*Hyperoodon planifrons*	N/A	-	[11] 500,000	N/A
Family Delphinidae:					
Killer whale	*Orcinus orca*	N/A	-	[12] 25,000	N/A
Long-finned whale	*Globicephala macrorhynchus*	N/A	-	[13] 200,000	N/A
Family Hyperoodontidae:					
Layard's beaked whales	*Mesoplodon layardii*	N/A		[10] 599,300	N/A
Family Phocidae (earless seals):					
Crabeater seal	*Lobodon carcinophaga*	N/A	-	[14] 5,000,000	N/A
Leopard seal	*Hydrurga leptonyx*	N/A	-	[15] 222,000	N/A
Southern elephant seal	*Mirounga leonina*	N/A	-	[16] 750,000	N/A
Ross seal	*Ommatophoca rossii*	N/A	-	[17] 250,000	N/A
Weddell seal	*Leptonychotes weddellii*	N/A	-	[18] 750,000	N/A

N.A. = data not available.
[1] The populations of marine mammals considered in this document do not occur within the U.S. EEZ and are therefore not assigned to stocks.
[2] Endangered Species Act (ESA) status: Endangered (E), Threatened (T)/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.
[3] Perrin et al 2009, IWC 2019.
[4] Antarctic Range 5–8,000 (Cooke 2018).
[5] Aguilar & García-Vernet 2018.
[6] Partial coverage of Antarctic feeding grounds (IWC 2019).
[7] Antarctic and Dwarf Minke whales information is combined.
[8] Antarctic (Boyd 2002).
[9] Cooke 2018.
[10] Estimate for the Antarctic, south of 60° S (Whitehead 2002).
[11] All beaked whales south of the Antarctic Convergence; mostly southern bottlenose whales (Kasamatsu & Joyce 1995).
[12] Jefferson *et al.* 2008.
[13] Branch & Butterworth 2001.
[14] Antarctic (Boyd 2002).
[15] Global population 5–10 million (Bengtson & Stewart 2018).
[16] Global population is 222,000–440,000 (Rogers 2018).
[17] Total world population (Hindell *et al.,* 2016)
[18] Hückstädt 2015.

All species that could potentially occur in the proposed survey areas are included in Table 2. As described below, all 18 species temporally and spatially co-occur with the activity to the degree that take is reasonably likely to occur, and we have proposed authorizing it.

We have reviewed NSF's species descriptions, including life history information, distribution, regional distribution, diving behavior, and acoustics and hearing, for accuracy and completeness. We refer the reader to Section 4 of NSF's IHA application for a complete description of the species, and offer a brief introduction to the species here, as well as information regarding population trends and threats, and describe information regarding local occurrence.

Mysticetes

Blue Whale

The blue whale has a cosmopolitan distribution, but tends to be mostly pelagic, only occurring nearshore to feed and possibly breed (Jefferson *et al.* 2015). It is most often found in cool, productive waters where upwelling occurs (Reilly and Thayer 1990). The distribution of the species, at least during times of the year when feeding is a major activity, occurs in areas that provide large seasonal concentrations of euphausiids (Yochem and Leatherwood 1985). Seamounts and other deep ocean structures may be important habitat for blue whales (Lesage *et al.* 2016). Generally, blue whales are seasonal migrants between high latitudes in summer, where they feed, and low latitudes in winter, where they mate and give birth (Lockyer and Brown 1981).

Historically, blue whales were most abundant in the Southern Ocean. Although, the population structure of the Antarctic blue whale (*Balaenoptera musculus intermedia*) in the Southern Ocean is not well understood, there is evidence of discrete feeding stocks (Sears & Perrin 2018). Cooke (2018) explains that ''there are no complete estimates of recent or current abundance for the other regions, but plausible total numbers would be 1,000–3,000 in the North Atlantic, 3,000–5,000 in the North Pacific, and possibly 1,000–3,000 in the eastern South Pacific. The number of Pygmy Blue whales is very uncertain but may be in the range 2,000–5,000. Taken together with a range of 5,000–8,000 in the Antarctic, the global population size in 2018 is plausibly in the range 10,000–25,000 total or 5,000–15,000 mature, compared with a 1926 global population of at least 140,000 mature.'' Blue whales begin migrating north out of the Antarctic to winter breeding grounds earlier than fin and sei whales.

Fin Whale

The fin whale (*Balaenoptera physalus*) is widely distributed in all the world's oceans (Gambell 1985), although it is most abundant in temperate and cold waters (Aguilar and García-Vernet 2018). Nonetheless, its overall range and distribution is not well known (Jefferson *et al.* 2015). Fin whales most commonly occur offshore, but can also be found in coastal areas (Jefferson *et al.* 2015). Most populations migrate seasonally between temperate waters where mating and calving occur in winter, and polar waters where feeding occurs in the summer; they are known to use the shelf edge as a migration route (Evans 1987). The northern and southern fin whale populations likely do not interact owing to their alternate seasonal migration; the resulting genetic isolation has led to the recognition of two subspecies, *B. physalus quoyi* and *B. p. physalus* in the Southern and Northern hemispheres, respectively (Anguilar & García-Vernet 2018).

They likely migrate beyond 60° S during the early to mid-austral summer, arriving at southern feeding grounds after blue whales. Overall, fin whale density tends to be higher outside the continental slope than inside it. During the austral summer, the distribution of fin whales ranges from 40° S–60° S in the southern Indian and South Atlantic oceans and 50° S–65° S in the South Pacific. Aguilar and García-Vernet (2018) found abundance estimates resulted in 38,200 individuals in the Antarctic south of 307° S. The RV *Polarstern* observed 33 fin whales in the Amundsen Sea during seismic survey transects (Gohl 2010). The New Zealand stock of fin whales spends summers from 170° E–145° W. Fin whales migrate north before the end of the austral summer toward breeding grounds in and around the Fiji Sea.

Humpback Whale

Humpback whales (*Megaptera novaeangliae*) are found worldwide in all ocean basins. In winter, most humpback whales occur in the subtropical and tropical waters of the Northern and Southern Hemispheres (Muto *et al.,* 2015). These wintering grounds are used for mating, giving birth, and nursing new calves. Humpback whales were listed as endangered under the Endangered Species Conservation Act (ESCA) in June 1970. In 1973, the ESA replaced the ESCA, and humpbacks continued to be listed as endangered. NMFS recently evaluated the status of the species, and on September 8, 2016, NMFS divided the species into 14 distinct population segments (DPS), removed the previousspecies-level listing, and in its place listed four DPSs as endangered and one DPS as threatened (81 FR 62259; September 8, 2016). The remaining nine DPSs were not listed.

In the Southern Hemisphere, humpback whales migrate annually from summer foraging areas in the Antarctic to breeding grounds in tropical seas (Clapham 2018). Whales migrating southward from Brazil have been shown to traverse offshore, pelagic waters (Zerbini *et al.* 2006, 2011) en route to feeding areas along the Scotia Sea, including the waters around Shag Rocks, South Georgia and the South Sandwich Islands (Stevick *et al.* 2006; Zerbini *et al.* 2006, 2011; Engel *et al.* 2008; Engel and Martin 2009). Southern Hemisphere humpback whales share feeding grounds in the Antarctic, near 60° S and between 120° E and 110° W during the austral summer (December–March). The *Polarstern* observed 44 humpback whales in the Amundsen Sea during seismic survey transects (Gohl 2010). The IWC's (2019) best population estimate of humpback whales in the southern hemisphere (*i.e.,* partial coverage of Antarctic feeding grounds) is 42,000.

Minke Whale

The common minke whale has a cosmopolitan distribution ranging from the tropics and subtropics to the ice edge in both hemispheres (Jefferson *et al.* 2015). A smaller form of the common minke whale, known as the dwarf minke whale (*Balaenoptera acutorostrata*), occurs in the Southern Hemisphere, where its distribution overlaps with that of the Antarctic minke whale (*B. bonaerensis*) during summer (Perrin *et al.* 2018). The dwarf minke whale is generally found in shallower coastal waters and over the shelf in regions where it overlaps with *B. bonaerensis* (Perrin *et al.* 2018). The range of the dwarf minke whale is thought to extend as far south as 65° S (Jefferson *et al.* 2015) and as far north as 2° S in the Atlantic off South America, where it can be found nearly year-round. In the far south, it is seasonally sympatric with the Antarctic minke whale on the feeding grounds during austral summer and transitions off South Africa during the fall and winter. Where the dwarf minke whale is sympatric with the Antarctic minke whale, it tends to occur in shallower, more coastal waters over the continental shelf (Perrin *et al.* 2018). Because the counts did not properly differentiate between the two species, IWC's (2019) best estimate for population abundance (515,000) will be divided evenly and assigned to each for our purposes.

Sei Whale

The sei whale (*Balaenoptera borealis*) occurs in all ocean basins (Horwood 2018), predominantly inhabiting deep waters throughout their range (Acevedo *et al.* 2017a). It undertakes seasonal migrations to feed in sub-polar latitudes during summer, returning to lower latitudes during winter to calve (Horwood 2018). Recent observation records indicate that the sei whale may utilize the Vitória-Trindade Chain off Brazil as calving grounds (Heissler *et al.* 2016). In the Southern Hemisphere, sei whales typically concentrate between the Subtropical and Antarctic convergences during the summer (Horwood 2018) between 40° S and 50° S, with larger, older whales typically travelling into the northern Antarctic zone while smaller, younger individuals remain in the lower latitudes (Acevedo et al. 2017a).Population estimates are not available for the Amundsen Sea region.

Odontocetes

Sperm Whale

The sperm whale (*Physeter macrocephalus*) is widely distributed, occurring from the edge of the polar pack ice to the Equator in both hemispheres, with the sexes occupying different distributions (Whitehead 2018). In general, it is distributed over large temperate and tropical areas that have high secondary productivity and steep underwater topography, such as volcanic islands (Jaquet & Whitehead 1996). Its distribution and relative abundance can vary in response to prey availability, most notably squid (Jaquet & Gendron 2002). Females generally inhabit waters >1000 m deep at latitudes <40 ° where sea surface temperatures are <15° C; adult males move to higher latitudes as they grow older and larger in size, returning to warm-water breeding grounds according to an unknown schedule (Whitehead 2018).

Ainley *et al.* (2007) observed 19 sperm whales during their 1994 cetacean surveys (3,494 km) in the Amundsen and Bellingshausen seas.

Arnoux's Beaked Whale

Arnoux's beaked whale (*Berardius arnuxii*) is distributed in deep, cold, temperate, and subpolar waters of the Southern Hemisphere, occurring between 24° S and Antarctica (Thewissen 2018), as far south as the Ross Sea at approximately 78° S (Perrin *et al.* 2009). Most records exist for southeastern South America, Falkland Islands, Antarctic Peninsula, South Africa, New Zealand, and southern Australia (MacLeod *et al.* 2006; Jefferson *et al.* 2015).

Marine mammal observations conducted during seismic surveys in West Antarctica between January and April of 2010 counted 12 Arnoux's beaked whales (Gohl 2010).

Gray's Beaked Whale

Gray's beaked whale (*Mesoplodon grayi*), also known as Haast's beaked whale, the scamperdown whale, or the southern beaked whale, typically lives in the Southern Hemisphere, between 30° S–45° S. Numerous strandings have occurred off New Zealand; others have occurred off South America and the Falkland Islands. This species has been sighted in groups in the Antarctic area.

Abundance estimates are not available for the Amundsen Sea.

Southern Bottlenose Whale

The southern bottlenose whale (*Hyperoodon planifrons*) is found throughout the Southern Hemisphere from 30° S to the ice edge, with most sightings reported between ~57° S and 70° S (Jefferson *et al.* 2015; Moors-Murphy 2018). It is migratory, occurring in Antarctic waters during summer (Jefferson *et al.* 2015).

Killer Whale

Killer whales (*Orcinus orca*) have been observed in all oceans and seas of the world (Leatherwood and Dahlheim 1978). Based on sightings by whaling vessels between 1960 and 1979, killer whales are distributed throughout the South Atlantic (Budylenko 1981; Mikhalev *et al.* 1981). Although reported from tropical and offshore waters (Heyning and Dahlheim 1988), killer whales prefer the colder waters of both hemispheres, with greatest abundances found within 800 km of major continents (Mitchell 1975). Branch and Butterworth (2001) determined 25,000 as the minimum estimate for the Southern Ocean.

Long-Finned Pilot Whales

Three distinct populations or subspecies of long-finned pilot whales are recognized: Southern Hemisphere (*Globicephala melas edwardii*), North Atlantic (*Globicephala melas melas*), and an unnamed extinct form in the western North Pacific. In the Southern Hemisphere, their range extends from 19°–60° S, but they have been regularly sighted in the Antarctic Convergence Zone (47°–62° S) and in the Central and South Pacific as far south as 68° S. Their distribution is considered circumpolar, and they have been documented near the Antarctic sea ice. They have been associated with the colder Benguela and Humboldt Currents, which may extend their normal range, as well as the Falklands. In the winter and spring, they are more likely to occur in offshore oceanic waters or on the continental slope. In the summer and autumn, long-finned pilot whales generally follow their favorite foods farther inshore and on to the continental shelf. In the Southern Hemisphere, there are an estimated 200,000 long-finned pilot whales in Antarctic waters (Jefferson *et al.* 2008, Reeves *et al.* 2002, Shirihai & Jarrett 2006).

Layard's Beaked Whales

Layard's beaked whale (*Mesoplodon layardii*), also known as the strap-toothed whale due to its unusual tooth configuration, is distributed in cool temperate waters of the Southern Hemisphere between 30° S and the Antarctic Convergence. Strandings have been reported in New Zealand, Australia, southern Argentina, Tierra del Fuego, southern Chile, and the Falkland Islands. The world-wide population of all beaked whales south of the Antarctic Convergence is estimated at approximately 599,300 animals (Kasamatsu and Joyce 1995).

Crabeater Seal

Crabeater seals (*Lobodon carcinophaga*) have a circumpolar distribution off Antarctica and generally spend the entire year in the advancing and retreating pack ice; occasionally they are seen in the far southern areas of South America though this is uncommon (Bengtson and Stewart 2018). Vagrants are occasionally found as far north as Brazil (Oliveira et al. 2006). Telemetry studies show that crabeater seals are generally confined to the pack ice, but spend ~14 percent of their time in open water outside of the breeding season (reviewed in Southwell *et al.* 2012). During the breeding season crabeater seals were most likely to be present within 5° or less (~550 km) of the shelf break in the south, though non-breeding animals ranged further north. Pupping season peaks in mid- to late-October and adults are observed with their pubs as late as mid-December (Bengtson and Stewart 2018).

Twenty-four hundred crabeater seals were counted during the 2010 seismic surveys aboard the RV *Polarstein* in the Amundsen Sea (Gohl 2010).

Leopard Seal

The leopard seal (*Hydrurga leptonyx*) has a circumpolar distribution around the Antarctic continent where it is solitary and widely dispersed (Rogers 2018). Most leopard seals remain within the pack ice; however, members of this species regularly visit southern continents during the winter (Rogers 2018). Rogers (2018) estimates the global population to range from 222,000–440,000; however, densities are thought to be higher than previously thought from visual surveys alone (Southwell *et al.* 2008, Rogers *et al.* 2013).

Leopard seals are top predators, consuming everything from krill and fish to penguins and other seals (*e.g.,* Hall-Aspland & Rogers 2004; Hirukie *et al.* 1999). Pups are born during October to mid-November and weaned approximately one month later (Rogers 2018). Mating occurs in the water during December and January.

Fifteen leopard seals were observed in the Amundsen Sea during transects conducted by Gohl (2010) and company from the RV *Polarstern.*

Southern Elephant Seal

The southern elephant seal (*Mirounga leonina*) has a near circumpolar distribution in the Southern Hemisphere (Jefferson *et al.* 2015), with breeding sites located on islands throughout the subantarctic (Hindell 2018). In the South Atlantic, southern elephant seals breed at Patagonia, South Georgia, and other islands of the Scotia Arc, Falkland Islands, Bouvet Island, and Tristan da Cunha archipelago (Bester & Ryan 2007). Península Valdés, Argentina, is the sole continental South American large breeding colony, where tens of thousands of southern elephant seals congregate (Lewis *et al.* 2006). Breeding colonies are otherwise island-based, with the occasional exception of the Antarctic mainland (Hindell 2018).

When not breeding (September to October) or molting (November to April), southern elephant seals range throughout the Southern Ocean from areas north of the Antarctic Polar Front to the pack ice of the Antarctic, spending >80 percent of their time at sea each year, up to 90 percent of which is spent submerged while hunting, travelling and resting in water depths ≥200 m (Hindell 2018). Males generally feed in continental shelf waters, while females preferentially feed in ice-free Antarctic Polar Front waters or the marginal ice zone in accordance with winter ice expansion (Hindell 2018). Southern elephant seals tagged at South Georgia showed long-range movements from ~April through October into the open Southern Ocean and to the shelf of the Antarctic Peninsula (McConnell & Fedak 1996). One adult male that was sighted on Gough Island had previously been tagged at Marion Island in the Indian Ocean (Reisinger and Bester 2010). Vagrant southern elephant seals, mainly consisting of juvenile and subadult males, have been documented in Uruguay, Brazil, Argentina, Falkland Islands, and South Georgia (Lewis *et al.* 2006a; Oliveira *et al.* 2011; Mayorga *et al.* 2015).

Ross Seal

Ross seals (*Ommatophoca rossii*) are considered the rarest of all Antarctic seals; they are the least documented because they are infrequently observed. Ross seals have a circumpolar Antarctic distribution. They are pelagic through most of the year. Satellite tracking data showed individuals traveled from East Antarctica and the Amundsen Sea north to forage in lower latitudes, spending the majority of their time south of the Antarctic polar front. They reach distances of ~2000 km from the capture sites (Blix & Nordøy 2007, Arcalis-Planas *et al.* 2015); yet, they return to areas with heavy pack ice for breeding (October to December) and again at the time of molting (January to March). Vagrants have been reported at several subantarctic islands, including South Georgia Island, Heard and McDonald Islands, Kerguelen Island, South Sandwich Islands, and Falklands/Malvinas Islands. Their behavior, habitat preference, and life cycle make it difficult to estimate population size. Genetic studies, estimating the effective population size of the species, are larger (~250,000 individuals) than traditional population size surveys (Curtis *et al.* 2011). There are no estimates available for Ross seal populations in the Amundsen Sea, but four individuals were observed during transects conducted aboard the RV *Polarstern* (Gohl 2010).

Weddell Seal

The Weddell seal (*Leptonychotes weddellii*) has a circumpolar distribution around Antarctica, preferring land-fast ice habitats with access to open water. Their range is farther south than that of all other Antarctic seals. Occasionally, Weddell seals are seen at sub-Antarctic islands (Perrin *et al.* 2009).

Since they do not migrate north, adult Weddell seals live under the vast coating of sea ice during the coldest months and maintain breathing holes open by reaming them with their canine and incisor teeth, which are robust and project forward (Kooyman 1981b). They may suffer shortened lives due to damage sustained by their teeth and gums. They haul-out through cracks in the ice. Weddell seals give birth on fast ice, in late September to early November, while mating takes place in the water.

Forty Weddell seals were observed in the Amundsen Sea during seismic survey transects conducted from the RV *Polarstern* (Gohl 2010).

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 (2018) described generalized hearing ranges for these marine mammal hearing groups. Generalized hearing ranges were chosen based on the approximately 65 decibel (dB) threshold from the normalized composite audiograms, with the exception for lower limits for low-frequency cetaceans where the lower bound was deemed to be biologically implausible and the lower bound from Southall *et al.* (2007) retained. Marine mammal hearing groups and their associated hearing ranges are provided in Table 3.

TABLE 3—MARINE MAMMAL HEARING GROUPS

[NMFS, 2018]

Hearing group	Generalized hearing range *
Low-frequency (LF) cetaceans (baleen whales)	7 Hz to 35 kHz.
Mid-frequency (MF) cetaceans (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kHz.
High-frequency (HF) cetaceans (true porpoises, *Kogia,* river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* & *L. australis*).	275 Hz to 160 kHz.
Phocid pinnipeds (PW) (underwater) (true seals)	50 Hz to 86 kHz.
Otariid pinnipeds (OW) (underwater) (sea lions and fur seals)	60 Hz to 39 kHz.

* Represents the generalized hearing range for the entire group as a composite (*i.e.,* all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range chosen based on ~65 dB threshold from normalized composite audiogram, with the exception for lower limits for LF cetaceans (Southall et al. 2007) and PW pinniped (approximation).

The pinniped functional hearing group was modified from Southall *et al.* (2007) on the basis of data indicating that phocid species have consistently demonstrated an extended frequency range of hearing compared to otariids, especially in the higher frequency range (Hemilä *et al.,* 2006; Kastelein *et al.,* 2009; Reichmuth and Holt, 2013).

For more detail concerning these groups and associated frequency ranges, please see NMFS (2018) for a review of available information. Eighteen marine mammal species (13 cetacean and 5 pinniped (0 otariid and 5 phocid) species) have the reasonable potential to co-occur with the proposed survey activities. Please refer to Table 2. Of the cetacean species that may be present, six are classified as low-frequency cetaceans (*i.e.,* all mysticete species), seven are classified as mid-frequency cetaceans (*i.e.,* all delphinid and ziphiid species and the sperm whale), and none are classified as high-frequency cetaceans (*i.e.,* harbor porpoise and Kogia spp.).

Potential Effects of Specified Activities 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, 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.

Description of Active Acoustic Sound Sources

This section contains a brief technical background on sound, the characteristics of certain sound types, and on metrics used in this proposal inasmuch as the information is relevant to the specified activity and to a discussion of the potential effects of the specified activity on marine mammals found later in this document.

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 hertz (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 one 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 one m from the source (referenced to one μPa) while the received level is the SPL at the listener's position (referenced to one μPa).

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). 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.

Sound exposure level (SEL; represented as dB re 1 μPa^2-s) represents the total energy contained within a pulse and considers both intensity and duration of exposure. Peak sound pressure (also referred to as zero-to-peak sound pressure or 0–p) 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 six dB higher than peak pressure (Southall *et al.,* 2007).

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 the case for pulses produced by the airgun arrays considered here. 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.

Even in the absence of sound from the specified activity, the underwater environment is typically loud due to ambient sound. Ambient sound is defined as environmental background sound levels lacking a single source or point (Richardson *et al.,* 1995), and 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 the following (Richardson *et al.,* 1995):

• *Wind and waves:* The complex interactions between wind and water surface, including processes such as breaking waves and wave-induced bubble oscillations and cavitation, are a main source of naturally occurring ambient sound for frequencies between 200 Hz and 50 kHz (Mitson, 1995). In general, ambient sound levels tend to increase with increasing wind speed and wave height. Surf sound becomes important near shore, with measurements collected at a distance of 8.5 km from shore showing an increase of 10 dB in the 100 to 700 Hz band during heavy surf conditions;

• *Precipitation:* Sound from rain and hail impacting the water surface can become an important component of total sound at frequencies above 500 Hz, and possibly down to 100 Hz during quiet times;

• *Biological:* 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; and

• *Anthropogenic:* Sources of ambient sound related to human activity include transportation (surface vessels), dredging and construction, oil and gas drilling and production, seismic surveys, sonar, explosions, and ocean acoustic studies. 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. Sound from identifiable anthropogenic sources other than the activity of interest (*e.g.,* a passing vessel) is sometimes termed background sound, as opposed to ambient sound.

The sum of the various natural and anthropogenic sound sources at any given location and time—which comprise ''ambient'' or ''background'' sound—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 dB from day to day (Richardson *et al.,* 1995). The result is that, depending on the source type and its intensity, sound from a given activity may be a negligible addition to the local environment or could form a distinctive signal that may affect marine mammals. Details of source types are described in the following text.

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.

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 non-continuous (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 (such as those used by the U.S. Navy). The duration of such sounds, as received at a distance, can be greatly extended in a highly reverberant environment.

Airgun arrays produce pulsed signals with energy in a frequency range from about 10–2,000 Hz, with most energy radiated at frequencies below 200 Hz. The amplitude of the acoustic wave emitted from the source is equal in all directions (*i.e.,* omnidirectional), but airgun arrays 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 sound transmitted in horizontal directions and at higher frequencies is minimized to the extent possible.

As described above, a Kongsberg EM122 MBES and a Knudsen Chirp 3260 SBP would be operated continuously during the proposed surveys, but not during transit to and from the survey areas. Additionally a 12-kHz pinger would be used during coring, when seismic airguns, are not in operation (more information on this pinger is available in NSF–USGS (2011). Each ping emitted by the MBES consists of eight (in water >1,000 m deep) or four (<1,000 m) successive fan-shaped transmissions, each ensonifying a sector that extends 1° fore-aft. Given the movement and speed of the vessel, the intermittent and narrow downward-directed nature of the sounds emitted by the MBES would result in no more than one or two brief ping exposures of any individual marine mammal, if any exposure were to occur.

Due to the lower source levels of the Knudsen Chirp 3260 SBP relative to the *Palmer's* airgun array (maximum SL of 222 dB re 1 μPa · m for the SBP, versus a minimum of 230.9 dB re 1 μPa · m for the 2 airgun array (LGL, 2019)), sounds from the SBP are expected to be effectively subsumed by sounds from the airgun array. Thus, any marine mammal potentially exposed to sounds from the SBP would already have been exposed to sounds from the airgun array, which are expected to propagate further in the water.

The use of pingers is also highly unlikely to affect marine mammals given their intermittent nature, short-term and transitory use from a moving vessel, relatively low source levels, and brief signal durations (NSF–USGS, 2011). As such, we conclude that the likelihood of marine mammal take resulting from exposure to sound from the MBES or SBP (beyond that which is already quantified as a result of exposure to the airguns) is discountable. Additionally the characteristics of sound generated by pingers means that take of marine mammals resulting from exposure to these pingers is discountable. Therefore we do not consider noise from the MBES, SBP, or pingers further in this analysis.

Acoustic Effects

Here, we discuss the effects of active acoustic sources on marine mammals.

Potential Effects of Underwater Sound—Please refer to the information given previously regarding sound, characteristics of sound types, and metrics used in this document. 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 the more severe effects of 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.

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 dBs 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).

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 this study). The authors note that the failure to induce more significant auditory effects 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, harbor porpoise, and Yangtze finless porpoise) 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 (2016a).

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 seismic 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, b). 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, 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.,* 2006; 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.,* 2006; 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 six percent lower during exposure than control periods (Miller *et al.,* 2009). These data raise concerns that seismic 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).

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, 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 breeding activity 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 a seismic airgun survey. During the first 72 h 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 seismic 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 SEL_{cum} 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 seismic surveys (Malme *et al.,* 1984). Humpback whales showed avoidance behavior in the presence of an active seismic array during observational studies and controlled exposure experiments in western Australia (McCauley *et al.,* 2000). 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).

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 (2015) reported data from at-sea observations during 1,196 seismic 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 a seismic 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 seismic 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) 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.

Masking effects of pulsed sounds (even from large arrays of airguns) on marine mammal calls and other natural sounds are expected to be limited, although there are few specific data on this. Because of the intermittent nature and low duty cycle of seismic pulses, animals can emit and receive sounds in the relatively quiet intervals between pulses. However, in exceptional situations, reverberation occurs for much or all of the interval between pulses (*e.g.,* Simard *et al.* 2005; Clark and Gagnon 2006), which could mask calls. Situations with prolonged strong reverberation are infrequent. However, it is common for reverberation to cause some lesser degree of elevation of the background level between airgun pulses (*e.g.,* Gedamke 2011; Guerra *et al.* 2011, 2016; Klinck *et al.* 2012; Guan *et al.* 2015), and this weaker reverberation presumably reduces the detection range of calls and other natural sounds to some degree. Guerra *et al.* (2016) reported that ambient noise levels between seismic pulses were elevated as a result of reverberation at ranges of 50 km from the seismic source. Based on measurements in deep water of the Southern Ocean, Gedamke (2011) estimated that the slight elevation of background levels during intervals between pulses reduced blue and fin whale communication space by as much as 36–51 percent when a seismic survey was operating 450–2,800 km away. Based on preliminary modeling, Wittekind *et al.* (2016) reported that airgun sounds could reduce the communication range of blue and fin whales 2000 km from the seismic source. Nieukirk *et al.* (2012) and Blackwell *et al.* (2013) noted the potential for masking effects from seismic surveys on large whales.

Some baleen and toothed whales are known to continue calling in the presence of seismic pulses, and their calls usually can be heard between the pulses (*e.g.,* Nieukirk *et al.* 2012; Thode *et al.* 2012; Bröker *et al.* 2013; Sciacca *et al.* 2016). As noted above, Cerchio *et al.* (2014) suggested that the breeding display of humpback whales off Angola could be disrupted by seismic sounds, as singing activity declined with increasing received levels. In addition, some cetaceans are known to change their calling rates, shift their peak frequencies, or otherwise modify their vocal behavior in response to airgun sounds (*e.g.,* Di Iorio and Clark 2010; Castellote *et al.* 2012; Blackwell *et al.* 2013, 2015). The hearing systems of baleen whales are undoubtedly more sensitive to low-frequency sounds than are the ears of the small odontocetes that have been studied directly (*e.g.,* MacGillivray *et al.* 2014). The sounds important to small odontocetes are predominantly at much higher frequencies than are the dominant components of airgun sounds, thus limiting the potential for masking. In general, masking effects of seismic pulses are expected to be minor, given the normally intermittent nature of seismic pulses.

Ship Noise

Vessel noise from the *Palmer* could affect marine animals in the proposed survey areas. Houghton *et al.* (2015) proposed that vessel speed is the most important predictor of received noise levels, and Putland *et al.* (2017) also reported reduced sound levels with decreased vessel speed. Sounds produced by large vessels generally dominate ambient noise at frequencies from 20 to 300 Hz (Richardson *et al.* 1995). However, some energy is also produced at higher frequencies (Hermannsen *et al.* 2014); low levels of high-frequency sound from vessels has been shown to elicit responses in harbor porpoise (Dyndo *et al.* 2015). Increased levels of ship noise have been shown to affect foraging by porpoise (Teilmann *et al.* 2015; Wisniewska *et al.* 2018); Wisniewska *et al.* (2018) suggest that a decrease in foraging success could have long-term fitness consequences.

Ship noise, through masking, can reduce the effective communication distance of a marine mammal if the frequency of the sound source is close to that used by the animal, and if the sound is present for a significant fraction of time (*e.g.,* Richardson *et al.* 1995; Clark *et al.* 2009; Jensen *et al.* 2009; Gervaise *et al.* 2012; Hatch *et al.* 2012; Rice *et al.* 2014; Dunlop 2015; Erbe *et al.* 2015; Jones *et al.* 2017; Putland *et al.* 2017). In addition to the frequency and duration of the masking sound, the strength, temporal pattern, and location of the introduced sound also play a role in the extent of the masking (Branstetter *et al.* 2013, 2016; Finneran and Branstetter 2013; Sills *et al.* 2017). Branstetter *et al.* (2013) reported that time-domain metrics are also important in describing and predicting masking. In order to compensate for increased ambient noise, some cetaceans are known to increase the source levels of their calls in the presence of elevated noise levels from shipping, shift their peak frequencies, or otherwise change their vocal behavior (*e.g.,* Parks *et al.* 2011, 2012, 2016a,b; Castellote *et al.* 2012; Melcón *et al.* 2012; Azzara *et al.* 2013; Tyack and Janik 2013; Luís *et al.* 2014; Sairanen 2014; Papale *et al.* 2015; Bittencourt *et al.* 2016; Dahlheim and Castellote 2016; Gospić and Picciulin 2016; Gridley *et al.* 2016; Heiler *et al.* 2016; Martins *et al.* 2016; O'Brien *et al.* 2016; Tenessen and Parks 2016). Harp seals did not increase their call frequencies in environments with increased low-frequency sounds (Terhune and Bosker 2016). Holt *et al.* (2015) reported that changes in vocal modifications can have increased energetic costs for individual marine mammals. A negative correlation between the presence of some cetacean species and the number of vessels in an area has been demonstrated by several studies (*e.g.,* Campana *et al.* 2015; Culloch *et al.* 2016).

Baleen whales are thought to be more sensitive to sound at these low frequencies than are toothed whales (*e.g.,* MacGillivray *et al.* 2014), possibly causing localized avoidance of the proposed survey area during seismic operations. Reactions of gray and humpback whales to vessels have been studied, and there is limited information available about the reactions of right whales and rorquals (fin, blue, and minke whales). Reactions of humpback whales to boats are variable, ranging from approach to avoidance (Payne 1978; Salden 1993). Baker *et al.* (1982, 1983) and Baker and Herman (1989) found humpbacks often move away when vessels are within several kilometers. Humpbacks seem less likely to react overtly when actively feeding than when resting or engaged in other activities (Krieger and Wing 1984, 1986). Increased levels of ship noise have been shown to affect foraging by humpback whales (Blair *et al.* 2016). Fin whale sightings in the western Mediterranean were negatively correlated with the number of vessels in the area (Campana *et al.* 2015). Minke whales and gray seals have shown slight displacement in response to construction-related vessel traffic (Anderwald *et al.* 2013).

Many odontocetes show considerable tolerance of vessel traffic, although they sometimes react at long distances if confined by ice or shallow water, if previously harassed by vessels, or have had little or no recent exposure to ships (Richardson *et al.* 1995). Dolphins of many species tolerate and sometimes approach vessels (*e.g.,* Anderwald *et al.* 2013). Some dolphin species approach moving vessels to ride the bow or stern waves (Williams *et al.* 1992). Pirotta *et al.* (2015) noted that the physical presence of vessels, not just ship noise, disturbed the foraging activity of bottlenose dolphins. Sightings of striped dolphin, Risso's dolphin, sperm whale, and Cuvier's beaked whale in the western Mediterranean were negatively correlated with the number of vessels in the area (Campana *et al.* 2015).

There are few data on the behavioral reactions of beaked whales to vessel noise, though they seem to avoid approaching vessels (*e.g.,* Würsig *et al.* 1998) or dive for an extended period when approached by a vessel (*e.g.,* Kasuya 1986). Based on a single observation, Aguilar Soto *et al.* (2006) suggest foraging efficiency of Cuvier's beaked whales may be reduced by close approach of vessels.

In summary, project vessel sounds would not be at levels expected to cause anything more than possible localized and temporary behavioral changes in marine mammals, and would not be expected to result in significant negative effects on individuals or at the population level. In addition, in all oceans of the world, large vessel traffic is currently so prevalent that it is commonly considered a usual source of ambient sound (NSF–USGS 2011).

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 (*e.g.,* fin 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 one hundred percent above 15 kn.

The *Palmer* travels at a speed of either 5 kn (9.2 km/hour) or 4–6 kn (7.4–11.1 km/hr). 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 discountable. 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). 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. This strike represents the only such incident in approximately 540,000 hours of similar coastal mapping activity ($p = 1.9 \times 10^{-6}$; 95 percent CI = $0–5.5 \times 10^{-6}$; NMFS, 2013b). 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 the vessel striking a marine mammal is 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 a seismic data acquisition vessel towing gear, while not impossible, represent unlikely, unpredictable events for which there are no preventive measures. Given the required mitigation measures, the relatively slow speed of the vessel towing gear, the presence of bridge crew watching for obstacles at all times (including marine mammals), and the presence of marine mammal observers, 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, and this potential effect of the specified activity will not be discussed further in the following analysis.

Stranding—When a living or dead marine mammal swims or floats onto shore and becomes ''beached'' or incapable of returning to sea, the event is a ''stranding'' (Geraci *et al.,* 1999; Perrin and Geraci, 2002; Geraci and Lounsbury, 2005; NMFS, 2007). The legal definition for a stranding under the MMPA is that (A) a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water, is in need of apparent medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance.

Marine mammals 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. However, the cause or causes of most strandings are unknown (Geraci *et al.,* 1976; Eaton, 1979; Odell *et al.,* 1980; Best, 1982). Numerous studies suggest that the physiology, behavior, habitat relationships, age, or condition of cetaceans may cause them to strand or might pre-dispose them to strand when exposed to another phenomenon. These suggestions are consistent with the conclusions of numerous other studies that have demonstrated that combinations of dissimilar stressors commonly combine to kill an animal or dramatically reduce its fitness, even though one exposure without the other does not produce the same result (Chroussos, 2000; Creel, 2005; DeVries *et al.,* 2003; Fair and Becker, 2000; Foley *et al.,* 2001; Moberg, 2000; Relyea, 2005a; 2005b, Romero, 2004; Sih *et al.,* 2004).

Use of military tactical sonar has been implicated in a majority of investigated stranding events. 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. We have considered the potential for the proposed surveys to result in marine mammal stranding and have concluded that, based on the best available information, stranding is not expected to occur.

Effects to Prey—Marine mammal prey varies by species, season, and location and, for some, is not well documented. Fish react to sounds which are especially strong and/or intermittent low-frequency sounds. Short duration, sharp sounds can cause overt or subtle changes in fish behavior and local distribution. Hastings and Popper (2005) identified several studies that suggest fish may relocate to avoid certain areas of sound energy. Additional studies have documented effects of pulsed sound on fish, although several are based on studies in support of construction projects (*e.g.,* Scholik and Yan, 2001, 2002; Popper and Hastings, 2009). Sound pulses at received levels of 160 dB may cause subtle changes in fish behavior. SPLs of 180 dB may cause noticeable changes in behavior (Pearson *et al.,* 1992; Skalski *et al.,* 1992). SPLs of sufficient strength have been known to cause injury to fish and fish mortality. The most likely impact to fish from survey activities at the project area would be temporary avoidance of the area. 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.

Information on seismic airgun impacts to zooplankton, which represent an important prey type for mysticetes, is limited. However, McCauley *et al.* (2017) reported that experimental exposure to a pulse from a 150 $inch^3$ airgun decreased zooplankton abundance when compared with controls, as measured by sonar and net tows, and caused a two- to threefold increase in dead adult and larval zooplankton. Although no adult krill were present, the study found that all larval krill were killed after air gun passage. Impacts were observed out to the maximum 1.2 km range sampled.

In general, impacts to marine mammal prey are expected to be limited due to the relatively small temporal and spatial overlap between the proposed survey and any areas used by marine mammal prey species. The proposed use of airguns as part of an active seismic array survey would occur over a relatively short time period (~28 days) and would occur over a very small area relative to the area available as marine mammal habitat in the Southwest Atlantic Ocean. We believe any impacts to marine mammals due to adverse effects to their prey would be insignificant due to the limited spatial and temporal impact of the proposed survey. However, adverse impacts may occur to a few species of fish and to zooplankton.

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 see also the previous discussion on masking under *Acoustic Effects*), 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). For more detail on these concepts see, *e.g.,* Barber *et al.,* 2010; Pijanowski *et al.,* 2011; Francis and Barber, 2013; Lillis *et al.,* 2014.

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). Although the signals emitted by seismic airgun arrays are generally low frequency, they would also likely be of short duration and transient in any given area due to the nature of these surveys. As described previously, exploratory surveys such as this one cover a large area but would be transient rather than focused in a given location over time and therefore would not be considered chronic in any given location.

Potential Effects of Icebreaking

Icebreakers produce more noise while breaking ice than ships of comparable size due, primarily, to the sounds of propeller cavitating (Richardson *et al.,* 1995). Icebreakers commonly back and ram into heavy ice until losing momentum to make way. The highest noise levels usually occur while backing full astern in preparation to ram forward through the ice. Overall the noise generated by an icebreaker pushing ice was 10 to 15 dB greater than the noise produced by the ship underway in open water (Richardson *et al.,* 1995). In general, the Antarctic and Southern Ocean is a noisy environment. Calving and grounding icebergs as well as the break-up of ice sheets, can produce a large amount of underwater noise. Little information is available about the increased sound levels due to icebreaking.

Cetaceans—Few studies have been conducted to evaluate the potential interference of icebreaking noise with marine mammal vocalizations. Erbe and Farmer (1998) measured masked hearing thresholds of a captive beluga whale. They reported that the recording of a Canadian Coast Guard Ship (CCGS) *Henry Larsen,* ramming ice in the Beaufort Sea, masked recordings of beluga vocalizations at a noise to signal pressure ratio of 18 dB, when the noise pressure level was eight times as high as the call pressure. Erbe and Farmer (2000) also predicted when icebreaker noise would affect beluga whales through software that combined a sound propagation model and beluga whale impact threshold models. They again used the data from the recording of the *Henry Larsen* in the Beaufort Sea and predicted that masking of beluga whale vocalizations could extend between 40 and 71 km (21.6 and 38.3 nmi) near the surface. Lesage *et al.* (1999) report that beluga whales changed their call type and call frequency when exposed to boat noise. It is possible that the whales adapt to the ambient noise levels and are able to communicate despite the sound. Given the documented reaction of belugas to ships and icebreakers it is highly unlikely that beluga whales would remain in the proximity of vessels where vocalizations would be masked.

Beluga whales have been documented swimming rapidly away from ships and icebreakers in the Canadian high Arctic when a ship approaches to within 35 to 50 km (18.9 to 27 nmi), and they may travel up to 80 km (43.2 nmi) from the vessel's track (Richardson *et al.,* 1995). It is expected that belugas avoid icebreakers as soon as they detect the ships (Cosens & Dueck, 1993). However, the reactions of beluga whales to ships vary greatly and some animals may become habituated to high levels of ambient noise (Erbe & Darmber, 2000).

There is little information about the effects of icebreaking ships on baleen whales. Migrating bowhead whales appeared to avoid an area around a drill site by greater than 25 km (13.5 mi) where an icebreaker was working in the Beaufort Sea. There was intensive icebreaking daily in support of the drilling activities (Brewer *et al.,* 1993). Migrating bowheads also avoided a nearby drill site at the same time of year where little icebreaking was being conducted (LGL & Greeneridge, 1987). It is unclear as to whether the drilling activities, icebreaking operations, or the ice itself might have been the cause for the whale's diversion. Bowhead whales are not expected to occur in the proximity of the proposed action area.

Pinnipeds—Brueggeman *et al.* (1992) reported on the reactions of seals to an icebreaker during activities at two prospects in the Chukchi Sea. Reactions of seals to the icebreakers varied between the two prospects. Most (67 percent) seals did not react to the icebreaker at either prospect. Reaction at one prospect was greatest during icebreaking activity (running/maneuvering/jogging) and was 0.23 km (0.12 nmi) of the vessel and lowest for animals beyond 0.93 km (0.5 nmi). At the second prospect however, seal reaction was lowest during icebreaking activity with higher and similar levels of response during general (non-icebreaking) vessel operations and when the vessel was at anchor or drifting. The frequency of seal reaction generally declined with increasing distance from the vessel except during general vessel activity where it remained consistently high to about 0.46 km (0.25 nmi) from the vessel before declining.

Similarly, Kanik *et al.* (1980) found that ringed (*Pusa hispida*) and harp seals (*Pagophilus groenlandicus*) often dove into the water when an icebreaker was breaking ice within 1 km (0.5 nmi) of the animals. Most seals remained on the ice when the ship was breaking ice 1 to 2 km (0.5 to 1.1 nmi) away.

Sea ice is important for pinniped life functions such as resting, breeding, and molting. Icebreaking activities may damage seal breathing holes and would also reduce the haul-out area in the immediate vicinity of the ship's track. Icebreaking along a maximum of 500 km of tracklines would alter local ice conditions in the immediate vicinity of the vessel. This has the potential to temporarily lead to a reduction of suitable seal haul-out habitat. However, the dynamic sea-ice environment requires that seals be able to adapt to changes in sea, ice, and snow conditions, and they therefore create new breathing holes and lairs throughout the winter and spring (Hammill and Smith, 1989). In addition, seals often use open leads and cracks in the ice to surface and breathe (Smith and Stirling, 1975). Disturbance of the ice would occur in a very small area relative to the Southern Ocean ice-pack and no significant impact on marine mammals is anticipated by icebreaking during the proposed low-energy seismic survey.

In summary, activities associated with the proposed action are not likely to have a permanent, adverse effect on any fish habitat or populations of fish species or on the quality of acoustic habitat. Thus, any impacts to marine mammal habitat are not expected to cause significant or long-term consequences for individual marine mammals or their populations.

Estimated Take

This section provides an estimate of the number of incidental takes proposed for authorization through this IHA, which will inform both NMFS' consideration of ''small numbers'' and the negligible impact determination.

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).

Authorized takes would be by Level B harassment only, in the form of disruption of behavioral patterns for individual marine mammals resulting from exposure to the stressors of acoustic sources. Based on the nature of the activity (*i.e.,* small Level A zones) and the anticipated effectiveness of the mitigation measures (*i.e.,* visual mitigation monitoring; establishment of an exclusion zone; shutdown procedures; ramp-up procedures; and vessel strike avoidance measures)—discussed in detail below in Proposed Mitigation section, Level A harassment is neither anticipated, nor proposed to be authorized.

As described previously, no mortality is anticipated or proposed to be authorized for this activity. Below we describe how the take is estimated.

Generally speaking, we estimate take by considering: (1) Acoustic thresholds above which NMFS believes the best available science indicates marine mammals will be behaviorally harassed or incur some degree of hearing impairment; (2) the area or volume of water that will be ensonified above these levels in a day; (3) the density or occurrence of marine mammals within these ensonified areas; and, (4) and the number of days of activities. We note that while these basic factors can contribute to a basic calculation to provide an initial prediction of takes, additional information that can qualitatively inform take estimates is also sometimes available (*e.g.,* previous monitoring results or average group size). Below, we describe the factors considered here in more detail and present the proposed take estimate.

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 be behaviorally harassed (equated to Level B harassment) or to incur PTS of some degree (equated to Level A harassment).

Level B Harassment for non-explosive sources—Though significantly driven by received level, the onset of behavioral disturbance from anthropogenic noise exposure is also informed to varying degrees by other factors related to the source (*e.g.,* frequency, predictability, duty cycle), the environment (*e.g.,* bathymetry), and the receiving animals (hearing, motivation, experience, demography, behavioral context) and can be difficult to predict (Southall *et al.,* 2007, Ellison *et al.,* 2012). Based on what the available science indicates and the practical need to use a threshold based on a factor that is both predictable and measurable for most activities, NMFS uses a generalized acoustic threshold based on received level to estimate the onset of behavioral harassment. NMFS predicts that marine mammals are likely to be behaviorally harassed in a manner we consider Level B harassment when exposed to underwater anthropogenic noise above received levels of 120 dB re 1 μPa (rms) for continuous (*e.g.,* vibratory pile-driving, drilling) and above 160 dB re 1 μPa (rms) for non-explosive impulsive (*e.g.,* seismic airguns) or intermittent (*e.g.,* scientific sonar) sources.

NSF includes the use of impulsive seismic sources and continuous icebreaking, and therefore the 120 dB re 1 μPa (rms) is applicable.

Level A harassment for non-explosive sources—NMFS' Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0) (Technical Guidance, 2018) identifies dual criteria to assess auditory injury (Level A harassment) to five different marine mammal groups (based on hearing sensitivity) as a result of exposure to noise from two different types of sources (impulsive or non-impulsive). NSF's proposed activity includes the use of impulsive seismic and icebreaking sources.

These thresholds are provided in the table below. The references, analysis, and methodology used in the development of the thresholds are described in NMFS 2018 Technical Guidance, which may be accessed at *https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-acoustic-technical-guidance.*

TABLE 4—THRESHOLDS IDENTIFYING THE ONSET OF PERMANENT THRESHOLD SHIFT

Hearing group	PTS onset acoustic thresholds* (received level)	
	Impulsive	Non-impulsive
Low-Frequency (LF) Cetaceans	*Cell 1:* $L_{pk,flat}$: 219 dB; $L_{E,LF,24h}$: 183 dB	*Cell 2:* $L_{E,LF,24h}$: 199 dB.
Mid-Frequency (MF) Cetaceans	*Cell 3:* $L_{pk,flat}$: 230 dB; $L_{E,MF,24h}$: 185 dB	*Cell 4:* $L_{E,MF,24h}$: 198 dB.
High-Frequency (HF) Cetaceans	*Cell 5:* $L_{pk,flat}$: 202 dB; $L_{E,HF,24h}$: 155 dB	*Cell 6:* $L_{E,HF,24h}$: 173 dB.
Phocid Pinnipeds (PW) (Underwater)	*Cell 7:* $L_{pk,flat}$: 218 dB; $L_{E,PW,24h}$: 185 dB	*Cell 8:* $L_{E,PW,24h}$: 201 dB.
Otariid Pinnipeds (OW) (Underwater)	*Cell 9:* $L_{pk,flat}$: 232 dB; $L_{E,OW,24h}$: 203 dB	*Cell 10:* $L_{E,OW,24h}$: 219 dB.

*Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.

Note: Peak sound pressure (L_{pk}) has a reference value of 1 μPa, and cumulative sound exposure level (L_E) has a reference value of 1μPa²s. In this Table, thresholds are abbreviated to reflect American National Standards Institute standards (ANSI 2013). However, peak sound pressure is defined by ANSI as incorporating frequency weighting, which is not the intent for this Technical Guidance. Hence, the subscript "flat" is being included to indicate peak sound pressure should be flat weighted or unweighted within the generalized hearing range. The subscript associated with cumulative sound exposure level thresholds indicates the designated marine mammal auditory weighting function (LF, MF, and HF cetaceans, and PW and OW pinnipeds) and that the recommended accumulation period is 24 hours. The cumulative sound exposure level thresholds could be exceeded in a multitude of ways (*i.e.,* varying exposure levels and durations, duty cycle). When possible, it is valuable for action proponents to indicate the conditions under which these acoustic thresholds will be exceeded.

Ensonified Area

Here, we describe operational and environmental parameters of the activity that will feed into identifying the area ensonified above the acoustic thresholds, which include source levels and transmission loss coefficient.

When the NMFS Technical Guidance (2016) was published, in recognition of the fact that ensonified area/volume could be more technically challenging to predict because of the duration component in the new thresholds, we developed a User Spreadsheet that includes tools to help predict a simple isopleth that can be used in conjunction with marine mammal density or occurrence to help predict takes. We note that because of some of the assumptions included in the methods used for these tools, we anticipate that isopleths produced are typically going to be overestimates of some degree, which may result in some degree of overestimate of Level A harassment take. However, these tools offer the best way to predict appropriate isopleths when more sophisticated 3D modeling methods are not available, and NMFS continues to develop ways to quantitatively refine these tools, and will qualitatively address the output where appropriate. For mobile sources such as seismic surveys and icebreaking, the User Spreadsheet predicts the closest distance at which a stationary animal would not incur PTS if the sound source traveled by the animal in a straight line at a constant speed. Inputs used in the User Spreadsheet, and the resulting isopleths are reported below in Tables 5 and 6.

TABLE 5—SEL_{cum} METHODOLOGY

Source Velocity (meters/second)	*2.315
1/Repetition rate^ (seconds)	**5

Note:

† Methodology assumes propagation of 20 log R; Activity duration (time) independent.

^ Time between onset of successive pulses.

*4.5 kts.

**shot interval will be assume to be 5 seconds.

TABLE 6—TABLE SHOWING THE RESULTS FOR ONE SINGLE SEL SL MODELING WITHOUT AND WITH APPLYING WEIGHTING FUNCTION TO THE FIVE HEARING GROUPS

SEL_{cum} Threshold	183	185	155	185	203
Distance(m) (no weighting function)	19.8808	209.2295	209.5266	209.2295	210.1602
Modified Farfield SEL*	208.9687	209.2295	209.5266	209.2295	210.1602
Distance (m) (with weighting function)	10.1720	N/A	N/A	N/A	N/A
Adjustment (dB)	−5.82	N/A	N/A	N/A	N/A

Note: The modified farfield signature is estimated using the distance from the source array geometrical center to where the SELcum threshold is the largest. Apropagation of 20 log10 (Radial distance) is used to estimate the modified farfield SEL.

*Propagation of 20 $_{log}$ R.

Figure 2 -- Results for Single Shot SEL Source Level Modeling for the Two 150 in³ Airguns with Weighting Function Calculations for SELcum Criteria

	Modified farfield SEL	209.6801	209.5954	209.8512	209.5954	210.9198
	Source Factor	1.85798E+20	1.82209E+20	1.93264E+20	1.82209E+20	2.47178E+20
RESULTANT ISOPLETHS*	*Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.					
	Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
	SEL_{cum} Threshold	183	185	155	185	203
	PTS SEL_{cum} Isopleth to threshold (meters)	31.1	0.0	0.0	0.3	0.0

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	
a	1	1.6	1.8	1	2	
b	2	2	2	2	2	
f_1	0.2	8.8	12	1.9	0.94	
f_2	19	110	140	30	25	
C	0.13	1.2	1.36	0.75	0.64	
Adjustment (dB)†	-6.09	-55.09	-64.39	-24.14	-31.05	OVERIDE Using LDEO Modeling

The proposed survey would entail the use of a 2-airgun array with a total discharge of 300 in³ at a two depth of 2–4 m. Lamont-Doherty Earth Observatory (L–DEO) model results are used to determine the 160 dB_{rms} radius for the 2-airgun array in deep water (<1,000 m) down to a maximum water depth of 2,000 m. Received sound levels were predicted by L–DEO's model (Diebold *et al.,* 2010) as a function of distance from the airguns, for the two 45 in³ airguns. This modeling approach uses ray tracing for the direct wave traveling from the array to the receiver and its associated source ghost (reflection at the air-water interface in the vicinity of the array), in a constant-velocity half-space (infinite homogenous ocean layer, unbounded by a seafloor). In addition, propagation measurements of pulses from a 36-airgun array at a tow depth of 6 m have been reported in deep water (~1,600 m), intermediate water depth on the slope (~600–1,100 m), and shallow water (~50 m) in the Gulf of Mexico in 2007–2008 (Tolstoy *et al.,* 2009; Diebold *et al.,* 2010).

For deep and intermediate water cases, the field measurements cannot be used readily to derive the Level A and Level B harassment isopleths, as at those sites the calibration hydrophone was located at a roughly constant depth of 350–550 m, which may not intersect all the SPL isopleths at their widest point from the sea surface down to the maximum relevant water depth (~2,000 m) for marine mammals. At short ranges, where the direct arrivals dominate and the effects of seafloor interactions are minimal, the data at the deep sites are suitable for comparison with modeled levels at the depth of the calibration hydrophone. At longer ranges, the comparison with the model—constructed from the maximum SPL through the entire water column at varying distances from the airgun array—is the most relevant.

In deep and intermediate water depths at short ranges, sound levels for direct arrivals recorded by the calibration hydrophone and L–DEO model results for the same array tow depth are in good alignment (see Figures 12 and 14 in Appendix H of NSF–USGS 2011). Consequently, isopleths falling within this domain can be predicted reliably by the L–DEO model, although they may be imperfectly sampled by measurements recorded at a single depth. At greater distances, the calibration data show that seafloor-reflected and sub-seafloor-refracted arrivals dominate. Although the direct arrivals become weak and/or incoherent. Aside from local topography effects, the region around the critical distance is where the observed levels rise closest to the model curve. However, the observed sound levels are found to fall almost entirely below the model curve. Thus, analysis of the Gulf of Mexico calibration measurements demonstrates that although simple, the L–DEO model is a robust tool for conservatively estimating isopleths.

The proposed surveys would acquire data with two 45-in³ guns at a tow depth of 2–4 m. For deep water (>1000 m), we use the deep-water radii obtained from L–DEO model results down to a maximum water depth of 2,000 m for the airgun array with 2-m and 8-m airgun separation. The radii for intermediate water depths (100–1,000 m) are derived from the deep-water ones by applying a correction factor (multiplication) of 1.5, such that observed levels at very near offsets fall below the corrected mitigation curve (see Figure 16 in Appendix H of NSF–USGS 2011). The shallow-water radii are obtained by scaling the empirically derived measurements from the Gulf of Mexico calibration survey to account for the differences in source volume and tow depth between the calibration survey (6,000 in³; 6-m tow depth) and the proposed survey (90 in³; 4-m tow depth); whereas the shallow water in the Gulf of Mexico may not exactly replicate the shallow water environment at the proposed survey sites, it has been shown to serve as a good and very conservative proxy (Crone *et al.,* 2014). A simple scaling factor is calculated from the ratios of the isopleths determined by the deep-water L–DEO model, which are essentially a measure of the energy radiated by the source array.

L–DEO's modeling methodology is described in greater detail in NSF's IHA application. The estimated distances to the Level B harassment isopleths for the two proposed airgun configurations in each water depth category are shown in Table 7.

TABLE 7—LEVEL B—PREDICTED DISTANCES TO THE LEVEL B THRESHOLD

[160 re 1μPa$_{rms}$ isopleths]

Source and volume (cm³)[in³]	Tow depth (m)[ft]	Water depth (m)[ft] [1]	Predicted 160 re 1μPa$_{rms}$ (m)[ft] isopleth [2]
2 x 45/105 in³ (300 in³) GI guns	3 [9.8]	100–1000 [328–3280]	979 [3211]
		>1000 [>3280]	653 [2142]
1 x 45/105 in³ (150 in³) GI guns	3 [9.8]	100–1000 [328–3280]	503 [1650]
		>1000 [>3280]	335 [1099]
2 x 105/105 in³ (420 in³) GI guns	3 [9.8]	100–1000 [328–3280]	1044 [3425]
		>1000 [>3280]	696 [2283]
1 x 105/105 in³ (210 in³) GI guns	3 [9.8]	100–1000 [328–3280]	531 [1742]
		>1000 [>3280]	354 [1161]

[1] No seismic operations would be conducted in shallow depths (0–100 m [0–328 ft]).

[2] RMS radii is based on LDEO modeling and empirical measurements. Radii for 100–1000 m (328–3280 ft) depth values = deep water values * 1.5 correction factor.

Table 8 presents the proposed exclusion zone (EZ) for each marine mammal hearing group, which are based on LDEO modeling incorporated into the companion user spreadsheet (NMFS 2018).

TABLE 8—PREDICTED DISTANCES TO THE LEVEL A THRESHOLD FOR MARINE MAMMALS

Hearing group	SEL cumulative PTS threshold (dB) [1]	SEL cumulative PTS distance (m)[ft] [1]	Peak PTS threshold (dB) [1]	Peak PTS distance (m)[ft] [1]
Low-frequency cetaceans	183	31.1 [102]	219	7.55 [24.8]
Mid-frequency cetaceans	185	0.0	230	1.58 [5.2]
Phocid pinnipeds	185	0.3 [0.98]	218	8.47 [27.8]

[1] Cumulative sound exposure level for PTS (SEL$_{cum}$PTS) or Peak (SPLflat) resulting in Level A harassment (*i.e.,* injury). Based on 2018 NMFS Acoustic Technical Guidance (NMFS 2018).

[2] Per NMFS Acoustic Technical Guidance (NMFS 2018), the larger of the dual criteria results are used for the EZ.

Predicted distances to Level A harassment isopleths, which vary based on marine mammal hearing groups, were calculated based on modeling performed by L–DEO using the NUCLEUS software program and the NMFS User Spreadsheet, described below. The updated acoustic thresholds for impulsive sounds (*e.g.,* airguns) contained in the Technical Guidance were presented as dual metric acoustic thresholds using both SEL$_{cum}$ and peak sound pressure metrics (NMFS 2016a). As dual metrics, NMFS considers onset of PTS (Level A harassment) to have occurred when either one of the two metrics is exceeded (*i.e.,* metric resulting in the largest isopleth). The SEL$_{cum}$ metric considers both level and duration of exposure, as well as auditory weighting functions by marine mammal hearing group. In recognition of the fact that the requirement to calculate Level A harassment ensonified areas could be more technically challenging to predict due to the duration component and the use of weighting functions in the new SEL$_{cum}$ thresholds, NMFS developed an optional User Spreadsheet that includes tools to help predict a simple isopleth that can be used in conjunction with marine mammal density or occurrence to facilitate the estimation of take numbers.

The SEL$_{cum}$ for the two-GI airgun array is derived from calculating the modified farfield signature. The farfield signature is often used as a theoretical representation of the source level. To compute the farfield signature, the source level is estimated at a large distance (right) below the array (*e.g.,* 9 km), and this level is back projected mathematically to a notional distance of 1 m from the array's geometrical center. However, it has been recognized that the source level from the theoretical farfield signature is never physically achieved at the source when the source is an array of multiple airguns separated in space (Tolstoy *et al.,* 2009). Near the source (at short ranges, distances <1 km), the pulses of sound pressure from each individual airgun in the source array do not stack constructively as they do for the theoretical farfield signature. The pulses from the different airguns spread out in time such that the source levels observed or modeled are the result of the summation of pulses from a few airguns, not the full array (Tolstoy *et al.,* 2009). At larger distances, away from the source array center, sound pressure of all the airguns in the array stack coherently, but not within one time sample, resulting in smaller source levels (a few dB) than the source level derived from the farfield signature. Because the farfield signature does not take into account the interactions of the two airguns that occur near the source center and is calculated as a point source (single airgun), the modified farfield signature is a more appropriate measure of the sound source level for large arrays. For this smaller array, the modified farfield changes will be correspondingly smaller as well, but this method is used for consistency across all array sizes.

NSF used the same acoustic modeling as Level B harassment with a small grid step in both the inline and depth directions to estimate the SEL$_{cum}$ and peak SPL. The propagation modeling takes into account all airgun interactions at short distances from the source including interactions between subarrays using the NUCLEUS software to estimate the notional signature and the MATLAB software to calculate the pressure signal at each mesh point of a grid. For a more complete explanation of this modeling approach, please see ''Attachment A: Modeling Data'' in NSF's IHA application.

Marine Mammal Occurrence

In this section we provide the information about the presence, density, or group dynamics of marine mammals that will inform the take calculations.

For the proposed survey area in west Antarctica, NSF provided density data for marine mammal species that might be encountered in the project area. NMFS concurred with these data and additionally included information regarding the Southern elephant seal Densities were estimated using sightings and effort during aerial- and vessel-based surveys conducted in and adjacent to the proposed project area (see NSF IHA application). The three other major sources of animal abundance included the Navy Marine Species Density Database (NMSDD) 2012, Ainley *et al.* 2007, and Gohl 2010. Data sources and density calculations are described in detail in Attachment B of NSF's IHA application. For some species, the densities derived from past surveys may not be representative of the densities that would be encountered during the proposed seismic surveys. However, the approach used is based on the best available data. Estimated densities used to inform take estimates are presented in Table 9.

TABLE 9—MARINE MAMMAL DENSITIES IN THE PROPOSED SURVEY AREA

Species	Estimated density (#/km2)
Low-frequency Cetaceans:	
Blue whale	0.0000510
Fin whale	0.0072200
Humpback whale	0.0001000
Minke whale	0.0930166
Sei whale	0.0002550
Mid-frequency Cetaceans:	
Arnoux's beaked whale	0.0062410
Killer whale	0.0014110
Southern bottlenose whale	0.0067570
Sperm whale	0.0169934
Phocids:	
Crabeater	0.00762
Leopard	0.00005
Ross	0.00001
Weddell	0.000126984
Southern Elephant	[a] 1.03

Note: See Attachment B in NSF's IHA application for density sources.
[a] Hofmeyr 2015.

Take Calculation and Estimation

Here we describe how the information provided above is brought together to produce a quantitative take estimate.

Seismic Surveys

In order to estimate the number of marine mammals predicted to be exposed to sound levels that would result in Level A harassment or Level B harassment, radial distances from the airgun array to predicted isopleths corresponding to the Level A harassment and Level B harassment thresholds are calculated, as described above. Those radial distances are then used to calculate the area(s) around the airgun array predicted to be ensonified to sound levels that exceed the Level A harassment and Level B harassment thresholds. The area estimated to be ensonified in a single day of the survey is then calculated (Table 10), based on the areas predicted to be ensonified around the array and the estimated trackline distance traveled per day. This number is then multiplied by the number of survey days. The product is then multiplied by 1.25 to account for the additional 25 percent contingency. This results in an estimate of the total area (km²) expected to be ensonified to the Level A and Level B harassment thresholds for each survey type (Table 11).

TABLE 10—AREAS (km²) TO BE ENSONIFIED TO LEVEL A AND LEVEL B HARASSMENT THRESHOLDS

% Distance at depth	Distance/day (km) [length]	Radius to Level B (km)	Distance/day * 2r [length * width = area]	πr2 (km) = [endcaps-both ends]	Distance/day * 2r + πr2 = daily ensonified area(km2) [Adding of 2 endcaps]	Number days of survey	Plus 25% buffer (days)	Total ensonified area (km²)
Level A Area:								
Low-frequency	160.00	0.03	9.95	0.00	9.96	8.00	10.00	99.55
Mid-frequency	160.00	0.00	0.51	0.00	0.51	8.00	10.00	5.06
Phocids	160.00	0.01	2.71	0.00	2.71	8.00	10.00	27.11
Level B Area:								
65% = 100-1000 m	104.00	1.04	217.15	3.42	220.57	8.00	10.00	2,205.74
35% = >1000 m	56.00	0.70	77.95	1.52	79.47	8.00	10.00	794.73
All Depths								3,000.47

The marine mammals predicted to occur within these respective areas, based on estimated densities (Table 9), are assumed to be incidentally taken. Based on the small anticipated Level A harassment isopleths and in consideration of the proposed mitigation measures (see Proposed Mitigation section below), take by Level A harassment is not expected to occur and has not been proposed to be authorized. Estimated exposures for the proposed survey are shown in Table 11.

TABLE 11—CALCULATED AND PROPOSED LEVEL B EXPOSURES, AND PERCENTAGE OF STOCK EXPOSED

Species	Calculated total Level B	Proposed Level B	Stock abundance regional or worldwide	Percent of population
Low-frequency cetaceans:				
Blue whale	0.15	<1	5,000	0.0
Fin whale	21.66	24	38,200	0.1

TABLE 11—CALCULATED AND PROPOSED LEVEL B EXPOSURES, AND PERCENTAGE OF STOCK EXPOSED—Continued

Species	Calculated total Level B	Proposed Level B	Stock abundance regional or worldwide	Percent of population
Humpback whale	0.30	<1	42,000	0.0
Minke whale	279.09	311	515,000	0.1
Antarctic minke whale	139.55		257,500	0.1
Common (dwarf) minke whale	139.55		257,500	0.1
Sei whale	0.77	1	10,000	0.0
Mid-frequency cetaceans:				
Arnoux's beaked whale	18.73	21	599,300	0.0
Killer whale	4.23	5	25,000	0.0
Layard's beaked whale	1.91		599,300	0.0
Long-finned pilot whale	23.58		200,000	0.0
Southern bottlenose whale	20.27	23	500,000	0.0
Sperm whale	50.99	57	12,069	0.4
Gray's beaked whale	0.84		599,300	0.0
Phocids:				
Crabeater seal	22.86	25	5,000,000	0.0
Leopard seal	0.14	<1	222,000	0.0
Ross seal	0.04	<1	250,000	0.0
Southern Elephant Seal	3,095.73		325,000	1.0
Weddell seal	0.38	<1	413,671	0.0

It should be noted that the proposed take numbers shown in Table 10 are expected to be conservative because in the calculations of estimated take, 25 percent has been added in the form of operational survey days. This is to account for the possibility of additional seismic operations associated with airgun testing and repeat coverage of any areas where initial data quality is sub-standard, and in recognition of the uncertainties in the density estimates used to estimate take as described above. However, the extent to which marine mammals would move away from the sound source is difficult to quantify and is, therefore, not accounted for in the take estimates.

Icebreaking

As the vessel passes through the ice, the ship causes the ice to part and travel alongside the hull. This ice typically returns to fill the wake as the ship passes. The effects are transitory, hours at most, and localized, constrained to a relatively narrow swath to each side of the vessel. Applying the maximum estimated amount of icebreaking expected by NSF, *i.e.,* 500 km, we calculate the ensonified area of icebreaking, including endcaps (Table 12).

TABLE 12—ENSONIFIED AREA FOR ICEBREAKING

Distance/day (km)	Radius (km)	Distance/ day * 2r [length * width = area]	πr2 (km) = [endcaps]	Distance/day * 2r + πr2 = daily ensonified area(km2) [adding of 2 endcaps]	Number days of survey	Plus 25% buffer (days)	Total ensonified area (km^2)
62.50	6.456	807.00	130.87	937.87	8.00	10.00	9,378.75

TABLE 13—LEVEL B TAKE FOR ICEBREAKING

Species	Density (#/km^2)	Daily ensonified area (km^2)	Calculated Level B	Proposed Level B	Stock abundance regional or worldwide	Percent of population
Low-frequency cetaceans:						
Blue whale	0.000051	937.87	0.05	<1	5,000	0.0
Fin whale	0.00722	937.87	6.77	4	38,200	0.018
Humpback whale	0.0001	937.87	0.09	<1	42,000	0.0
Minke whale	0.0930166	937.87	87.24	53	515,000	0.0
Antarctic minke whale	0.046508	937.87	43.62		257,500	0.0
Common (dwarf) minke whale	0.0465083	937.87	43.62		257,500	0.0
Sei whale	0.000255	937.87	0.24	<1	10,000	0.0
Mid-frequency cetaceans:						
Arnoux's beaked whale	0.006241	937.87	5.85	4	599,300	0.0
Killer whale	0.001411	937.87	1.32	<1	25,000	0.0
Layard's beaked whale	0.000638	937.87	0.60		599,300	0.0
Long-finned pilot whale	0.007859	937.87	7.37		200,000	0.0
Southern bottlenose whale	0.006757	937.87	6.34	4	500,000	0.0
Sperm whale	0.0169934	937.87	15.94	10	12,069	0.1
Gray's beaked whale	0.000281	937.87	0.26		599,300	0.0

TABLE 13—LEVEL B TAKE FOR ICEBREAKING—Continued

Species	Density (#/km²)	Daily ensonified area (km²)	Calculated Level B	Proposed Level B	Stock abundance regional or worldwide	Percent of population
Phocids:						
Crabeater seal	0.007619	937.87	7.15	4	5,000,000	0.0
Leopard seal	0.0000476	937.87	0.04	<1	222,000	0.0
Ross seal	0.0000127	937.87	0.01	<1	250,000	0.0
Southern Elephant Seal	1.03	937.87	967.65	....	325,000	0.3
Weddell seal	0.000127	937.87	0.12	<1	413,671	0.0

Proposed Mitigation

In order to issue an IHA under Section 101(a)(5)(D) of the MMPA, NMFS must set forth the permissible methods of taking pursuant to the activity, and other means of effecting the least practicable impact on the species or stock and its habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of the species or stock for taking for certain subsistence uses (latter not applicable for this action). NMFS 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 the 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)).

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

(1) The manner in which, and the degree to which, the successful implementation of the measure(s) is expected to reduce impacts to marine mammals, marine mammal species or stocks, and their habitat. This considers the nature of the potential adverse impact being mitigated (likelihood, scope, range). It further considers the likelihood that the measure will be effective if implemented (probability of accomplishing the mitigating result if implemented as planned), the likelihood of effective implementation (probability implemented as planned), and;

(2) the practicability of the measures for applicant implementation, which may consider such things as cost, impact on operations, and, in the case of a military readiness activity, personnel safety, practicality of implementation, and impact on the effectiveness of the military readiness activity.

Mitigation for Marine Mammals and Their Habitat

NSF has reviewed mitigation measures employed during seismic research surveys authorized by NMFS under previous incidental harassment authorizations, as well as recommended best practices in Richardson *et al.* (1995), Pierson *et al.* (1998), Weir and Dolman (2007), Nowacek *et al.* (2013), Wright (2014), and Wright and Cosentino (2015), and has incorporated a suite of proposed mitigation measures into their project description based on the above sources.

To reduce the potential for disturbance from acoustic stimuli associated with the activities, NSF has proposed to implement mitigation measures for marine mammals. Mitigation measures that would be adopted during the proposed surveys include (1) Vessel-based visual mitigation monitoring; (2) Establishment of a marine mammal EZ and buffer zone; (3) shutdown procedures; (4) ramp-up procedures; and (4) vessel strike avoidance measures.

Vessel-Based Visual Mitigation Monitoring

Visual monitoring requires the use of trained observers (herein referred to as visual Protected Species Observers (PSOs)) to scan the ocean surface visually for the presence of marine mammals. PSO observations would take place during all daytime airgun operations and nighttime start ups (if applicable) of the airguns. If airguns are operating throughout the night, observations would begin 30 minutes prior to sunrise. If airguns are operating after sunset, observations would continue until 30 minutes following sunset. Following a shutdown for any reason, observations would occur for at least 30 minutes prior to the planned start of airgun operations. Observations would also occur for 30 minutes after airgun operations cease for any reason. Observations would also be made during daytime periods when the *Palmer* is underway without seismic operations, such as during transits, to allow for comparison of sighting rates and behavior with and without airgun operations and between acquisition periods. Airgun operations would be suspended when marine mammals are observed within, or about to enter, the designated EZ (as described below).

During seismic operations, three visual PSOs would be based aboard the *Palmer.* PSOs would be appointed by NSF with NMFS approval. One dedicated PSO would monitor the EZ during all daytime seismic operations. PSO(s) would be on duty in shifts of duration no longer than four hours. Other vessel crew would also be instructed to assist in detecting marine mammals and in implementing mitigation requirements (if practical). Before the start of the seismic survey, the crew would be given additional instruction in detecting marine mammals and implementing mitigation requirements.

The *Palmer* is a suitable platform from which PSOs would watch for marine mammals. Standard equipment for marine mammal observers would be 7 x 50 reticule binoculars and optical range finders. At night, night-vision equipment would be available. The observers would be in communication with ship's officers on the bridge and scientists in the vessel's operations laboratory, so they can advise promptly of the need for avoidance maneuvers or seismic source shutdown.

The PSOs must 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. PSO resumes shall be provided to NMFS for approval. At least one PSO must have a minimum of 90 days at-sea experience working as a PSO during a seismic survey. One ''experienced'' visual PSO will be designated as the lead for the entire protected species observation team. The lead will serve as primary point of contact for the vessel operator.

Exclusion Zone and Buffer Zone

An EZ is a defined area within which occurrence of a marine mammal triggers mitigation action intended to reduce the potential for certain outcomes, *e.g.,* auditory injury, disruption of critical behaviors. The PSOs would establish a minimum EZ with a 100 m radius for the airgun array. The 100-m EZ would be based on radial distance from any element of the airgun array (rather than being based on the center of the array or around the vessel itself). With certain exceptions (described below), if a marine mammal appears within, enters, or appears on a course to enter this zone, the acoustic source would be shut down (see Shutdown Procedures below).

The 100-m radial distance of the standard EZ is precautionary in the sense that it would be expected to contain sound exceeding injury criteria for all marine mammal hearing groups (Table 5) while also providing a consistent, reasonably observable zone within which PSOs would typically be able to conduct effective observational effort. In this case, the 100-m radial distance would also be expected to contain sound that would exceed the Level A harassment threshold based on sound exposure level (SEL_{cum}) criteria for all marine mammal hearing groups (Table 5). In the 2011 Programmatic Environmental Impact Statement for marine scientific research funded by the National Science Foundation or the U.S. Geological Survey (NSF–USGS 2011), Alternative B (the Preferred Alternative) conservatively applied a 100-m EZ for all low-energy acoustic sources in water depths >100 m, with low-energy acoustic sources defined as any towed acoustic source with a single or a pair of clustered airguns with individual volumes of ≤250 in³. Thus the 100-m EZ proposed for this survey is consistent with the PEIS.

Our intent in prescribing a standard EZ distance is to (1) encompass zones 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 for PSOs, who need to monitor and implement the EZ; and (4) define a distance within which detection probabilities are reasonably high for most species under typical conditions.

PSOs will also establish and monitor a 200-m buffer zone. During use of the acoustic source, occurrence of marine mammals within the buffer zone (but outside the EZ) will be communicated to the operator to prepare for potential shutdown of the acoustic source. The buffer zone is discussed further under *Ramp-up Procedures* below.

An extended EZ of 500 m would be enforced for all beaked whales and Southern right whales. This is a precautionary measure as right whales are not expected in the survey area. NSF would also enforce a 500-m EZ for aggregations of six or more large whales (*i.e.,* sperm whale or any baleen whale) or a large whale with a calf (calf defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult).

Shutdown Procedures

If a marine mammal is detected outside the EZ but is likely to enter the EZ, the airguns would be shut down before the animal is within the EZ. Likewise, if a marine mammal is already within the EZ when first detected, the airguns would be shut down immediately.

Following a shutdown, airgun activity would not resume until the marine mammal has cleared the 100-m EZ. The animal would be considered to have cleared the 100-m EZ if the following conditions have been met:

- It is visually observed to have departed the 100-m EZ;
- it has not been seen within the 100-m EZ for 15 minutes in the case of small odontocetes and pinnipeds; or
- it has not been seen within the 100-m EZ for 30 minutes in the case of mysticetes and large odontocetes, including sperm, pygmy sperm, and beaked whales.

Shutdown of the acoustic source would also be required upon observation of a species for which authorization has not been granted, or a species for which authorization has been granted but the authorized number of takes are met, observed approaching or within the Level A or Level B harassment zones.

Ramp-Up Procedures

Ramp-up of an acoustic source is intended to provide a gradual increase in sound levels following a shutdown, enabling animals to move away from the source if the signal is sufficiently aversive prior to its reaching full intensity. Ramp-up would be required after the array is shut down for any reason for longer than 15 minutes. Ramp-up would begin with the activation of one 45 in³ airgun, with the second 45 in³ airgun activated after 5 minutes.

Two PSOs would be required to monitor during ramp-up. During ramp up, the PSOs would monitor the EZ, and if marine mammals were observed within the EZ or buffer zone, a shutdown would be implemented as though the full array were operational. If airguns have been shut down due to PSO detection of a marine mammal within or approaching the 100 m EZ, ramp-up would not be initiated until all marine mammals have cleared the EZ, during the day or night. Criteria for clearing the EZ would be as described above.

Thirty minutes of pre-clearance observation are required prior to ramp-up for any shutdown of longer than 30 minutes (*i.e.,* if the array were shut down during transit from one line to another). This 30-minute pre-clearance period may occur during any vessel activity (*i.e.,* transit). If a marine mammal were observed within or approaching the 100 m EZ during this pre-clearance period, ramp-up would not be initiated until all marine mammals cleared the EZ. Criteria for clearing the EZ would be as described above. If the airgun array has been shut down for reasons other than mitigation (*e.g.,* mechanical difficulty) for a period of less than 30 minutes, it may be activated again without ramp-up if PSOs have maintained constant visual observation and no detections of any marine mammal have occurred within the EZ or buffer zone. Ramp-up would be planned to occur during periods of good visibility when possible. However, ramp-up would be allowed at night and during poor visibility if the 100 m EZ and 200 m buffer zone have been monitored by visual PSOs for 30 minutes prior to ramp-up.

The operator would be required to 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. The operator must provide information to PSOs documenting that appropriate procedures were followed. Following deactivation of the array for reasons other than mitigation, the operator would be required to communicate the near-term operational plan to the lead PSO with justification for any planned nighttime ramp-up.

Vessel Strike Avoidance Measures

Vessel strike avoidance measures are intended to minimize the potential for collisions with marine mammals. 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: Vessel operator and crew would maintain a vigilant watch for all marine mammals and slow down or stop the vessel or alter course to avoid striking any marine mammal. A visual observer aboard the vessel would monitor a vessel strike avoidance zone around the vessel according to the parameters stated below. Visual observers monitoring the vessel strike avoidance zone would be either third-party observers or crew members, but crew members responsible for these duties would be provided sufficient training to distinguish marine mammals from other phenomena. Vessel strike avoidance measures would be followed during surveys and while in transit.

The vessel would maintain a minimum separation distance of 100 m from large whales (*i.e.,* baleen whales and sperm whales). If a large whale is within 100 m of the vessel, the vessel would reduce speed and shift the engine to neutral, and would not engage the engines until the whale has moved outside of the vessel's path and the minimum separation distance has been established. If the vessel is stationary, the vessel would not engage engines until the whale(s) has moved out of the vessel's path and beyond 100 m. If an animal is encountered during transit, the vessel would attempt to remain parallel to the animal's course, avoiding excessive speed or abrupt changes in course. Vessel speeds would be reduced to 10 kts or less when mother/calf pairs, pods, or large assemblages of cetaceans are observed near the vessel.

Based on our evaluation of the applicant's proposed measures, as well as other measures considered by NMFS, NMFS has preliminarily determined that the proposed mitigation measures provide the means effecting the least practicable impact on the affected species or stocks and their habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance.

Proposed Monitoring and Reporting

In order to issue an IHA for an activity, Section 101(a)(5)(D) of the MMPA states that NMFS must set forth requirements pertaining to the monitoring and reporting of such taking. The MMPA implementing regulations at 50 CFR 216.104 (a)(13) indicate that requests for authorizations must include the suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species and of the level of taking or impacts on populations of marine mammals that are expected to be present in the proposed action area. Effective reporting is critical both to compliance as well as ensuring that the most value is obtained from the required monitoring.

Monitoring and reporting requirements prescribed by NMFS should contribute to improved understanding of one or more of the following:

- Occurrence of marine mammal species or stocks in the area in which take is anticipated (*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 other important physical components of marine mammal habitat).
- Mitigation and monitoring effectiveness.

NSF described marine mammal monitoring and reporting plan within their IHA application. Monitoring that is designed specifically to facilitate mitigation measures, such as monitoring of the EZ to inform potential shutdowns of the airgun array, are described above and are not repeated here. NSF's monitoring and reporting plan includes the following measures:

Vessel-Based Visual Monitoring

As described above, PSO observations would take place during daytime airgun operations and nighttime start-ups (if applicable) of the airguns. During seismic operations, three visual PSOs would be based aboard the *Palmer.* PSOs would be appointed by NSF with NMFS approval. The PSOs must have successfully completed relevant training, including completion of all required coursework and passing a written and/or oral examination developed for the training program, and 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 if the PSO has acquired the relevant skills through alternate training, including (1) secondary education and/or experience comparable to PSO duties; (2) previous work experience conducting academic, commercial, or government-sponsored marine mammal surveys; or (3) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.

During the majority of seismic operations, one PSO would monitor for marine mammals around the seismic vessel. PSOs would be on duty in shifts of duration no longer than four hours. Other crew would also be instructed to assist in detecting marine mammals and in implementing mitigation requirements (if practical). During daytime, PSOs would scan the area around the vessel systematically with reticle binoculars (*e.g.,* 7×50 Fujinon) and with the naked eye. At night, PSOs would be equipped with night-vision equipment.

PSOs would record data to estimate the numbers of marine mammals exposed to various received sound levels and to document apparent disturbance reactions or lack thereof. Data would be used to estimate numbers of animals potentially 'taken' by harassment (as defined in the MMPA). They would also provide information needed to order a shutdown of the airguns when a marine mammal is within or near the EZ. When a sighting is made, the following information about the sighting would be recorded:

(1) Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airguns or vessel (*e.g.,* none, avoidance, approach, paralleling, etc.), and behavioral pace; and

(2) Time, location, heading, speed, activity of the vessel, sea state, visibility, and sun glare.

All observations and shutdowns would be recorded in a standardized format. Data would be entered into an electronic database. The accuracy of the data entry would be verified by computerized data validity checks as the data are entered and by subsequent manual checking of the database. These procedures would allow initial summaries of data to be prepared during and shortly after the field program and would facilitate transfer of the data to statistical, graphical, and other programs for further processing and archiving. The time, location, heading, speed, activity of the vessel, sea state, visibility, and sun glare would also be recorded at the start and end of each observation watch, and during a watch whenever there is a change in one or more of the variables.

Results from the vessel-based observations would provide:

(1) The basis for real-time mitigation (*e.g.,* airgun shutdown);

(2) Information needed to estimate the number of marine mammals potentially taken by harassment, which must be reported to NMFS;

(3) Data on the occurrence, distribution, and activities of marine mammals in the area where the seismic study is conducted;

(4) Information to compare the distance and distribution of marine mammals relative to the source vessel at times with and without seismic activity; and

(5) Data on the behavior and movement patterns of marine mammals seen at times with and without seismic activity.

Reporting

A draft report would be submitted to NMFS within 90 days after the end of the survey. The report would describe the operations that were conducted and sightings of marine mammals near the operations. The report would provide full documentation of methods, results, and interpretation pertaining to all monitoring and would summarize the dates and locations of seismic operations, and all marine mammal sightings (dates, times, locations, activities, associated seismic survey activities). The report would also include estimates of the number and nature of exposures that occurred above the harassment threshold based on PSO observations, including an estimate of those that were not detected in consideration of both the characteristics and behaviors of the species of marine mammals that affect detectability, as well as the environmental factors that affect detectability.

The draft report shall also include geo-referenced time-stamped vessel tracklines for all time periods during 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. 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 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.

Negligible Impact Analysis and 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'' through harassment, NMFS considers other factors, such as 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).

To avoid repetition, our analysis applies to all the species listed in Table 2, given that NMFS expects the anticipated effects of the proposed seismic survey to be similar in nature. Where there are meaningful differences between species or stocks, or groups of species, in anticipated individual responses to activities, impact of expected take on the population due to differences in population status, or impacts on habitat, NMFS has identified species-specific factors to inform the analysis.

NMFS does not anticipate that serious injury or mortality would occur as a result of NSF's proposed seismic survey, even in the absence of proposed mitigation. Thus, the proposed authorization does not authorize any mortality. As discussed in the *Potential Effects of Specified Activities on Marine Mammals and their Habitat* section, non-auditory physical effects, stranding, and vessel strike are not expected to occur.

No takes by Level A harassment are proposed to be authorized. The 100-m exclusion zone encompasses the Level A harassment isopleths for all marine mammal hearing groups, and is expected to prevent animals from being exposed to sound levels that would cause PTS. Also, as described above, we expect that marine mammals would be likely to move away from a sound source that represents an aversive stimulus, especially at levels that would be expected to result in PTS, given sufficient notice of the *Palmer's* approach due to the vessel's relatively low speed when conducting seismic surveys. We expect that any instances of take would be in the form of short-term Level B behavioral harassment in the form of temporary avoidance of the area or decreased foraging (if such activity were occurring), reactions that are considered to be of low severity and with no lasting biological consequences (*e.g.,* Southall *et al.,* 2007).

Potential impacts to marine mammal habitat were discussed previously in this document (see Potential Effects of Specified Activities on Marine Mammals and their Habitat). Marine mammal habitat may be impacted by elevated sound levels, but these impacts would be temporary. Feeding behavior is not likely to be significantly impacted, as marine mammals appear to be less likely to exhibit behavioral reactions or avoidance responses while engaged in feeding activities (Richardson *et al.,* 1995). Prey species are mobile and are broadly distributed throughout the project area; therefore, marine mammals that may be temporarily displaced during survey activities are expected to be able to resume foraging once they have moved away from areas with disturbing levels of underwater noise. Because of the temporary nature of the disturbance, the availability of similar habitat and resources in the surrounding area, and the lack of important or unique marine mammal habitat, the impacts to marine mammals and the food sources that they utilize are not expected to cause significant or long-term consequences for individual marine mammals or their populations. In addition, there are no feeding, mating or calving areas known to be biologically important to marine mammals within the proposed project area.

As explained above in the *Marine Mammal* section, marine mammals in the survey area are not assigned to NMFS stocks. For purposes of the small numbers analysis (discussed in the next section), we rely on the best available information on the abundance estimates for the species of marine mammals that could be taken. The activity is expected to impact a very small percentage of all marine mammal populations that would be affected by NSF's proposed survey (less than two percent each for all marine mammal populations where abundance estimates exist). Additionally, the acoustic ''footprint'' of the proposed survey would be very small relative to the ranges of all marine mammal species that would potentially be affected. Sound levels would increase in the marine environment in a relatively small area surrounding the vessel compared to the range of the marine mammals within the proposed survey area. The seismic array would be active 24 hours per day throughout the duration of the proposed survey. However, the very brief overall duration of the proposed survey (eight days) would further limit potential impacts that may occur as a result of the proposed activity.

The proposed mitigation measures are expected to reduce the number and/or severity of takes by allowing for detection of marine mammals in the vicinity of the vessel by visual and acoustic observers, and by minimizing the severity of any potential exposures via shutdowns of the airgun array. Based on previous monitoring reports for substantially similar activities that have been previously authorized by NMFS, we expect that the proposed mitigation will be effective in preventing at least some extent of potential PTS in marine mammals that may otherwise occur in the absence of the proposed mitigation.

Of the marine mammal species under our jurisdiction that are likely to occur in the project area, the following species are listed as endangered under the ESA: Blue, fin, humpback, sei, and sperm whales. We are proposing to authorize very small numbers of takes for these species (Table 11), relative to their population sizes (again, for species where population abundance estimates exist), therefore we do not expect population-level impacts to any of these species. The other marine mammal species that may be taken by harassment during NSF's seismic survey are not listed as threatened or endangered under the ESA. There is no designated critical habitat for any ESA-listed marine mammals within the project area; of the non-listed marine mammals for which we propose to authorize take, none are considered ''depleted'' or ''strategic'' by NMFS under the MMPA.

NMFS concludes that exposures to marine mammal species due to NSF's proposed seismic survey would result in only short-term (temporary and short in duration) effects to individuals exposed, or some small degree of PTS to a very small number of individuals. Marine mammals may temporarily avoid the immediate area, but are not expected to permanently abandon the area. Major shifts in habitat use, distribution, or foraging success are not expected. NMFS does not anticipate the proposed take estimates to impact annual rates of recruitment or survival.

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 species or stock through effects on annual rates of recruitment or survival:

- No mortality, serious injury and Level A harassment is anticipated or authorized;
- The anticipated impacts of the proposed activity on marine mammals would primarily be temporary behavioral changes of small percentages of the affected species due to avoidance of the area around the survey vessel. The relatively short duration of the proposed survey (eight days) would further limit the potential impacts of any temporary behavioral changes that would occur;
- The availability of alternate areas of similar habitat value for marine mammals to temporarily vacate the survey area during the proposed survey to avoid exposure to sounds from the activity;
- The proposed project area does not contain areas of significance for feeding, mating or calving;
- The potential adverse effects on fish or invertebrate species that serve as prey species for marine mammals from the proposed survey would be temporary and spatially limited; and
- The proposed mitigation measures, including visual and acoustic monitoring and shutdowns, are expected to minimize potential impacts to marine mammals.

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, NMFS preliminarily finds 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

As noted above, only small numbers of incidental take may be authorized under Sections 101(a)(5)(A) and (D) of the MMPA for specified activities other than military readiness activities. The MMPA does not define small numbers and so, in practice, where estimated numbers are available, NMFS compares the number of individuals taken to the most appropriate estimation of abundance of the relevant species or stock in our determination of whether an authorization is limited to small numbers of marine mammals. Additionally, other qualitative factors may be considered in the analysis, such as the temporal or spatial scale of the activities.

The numbers of marine mammals that we authorize to be taken would be considered small relative to the relevant populations (less than two percent for all species) for the species for which abundance estimates are available.

Based on the analysis contained herein of the proposed activity (including the proposed mitigation and monitoring measures) and the anticipated take of marine mammals, NMFS preliminarily finds that small numbers of marine mammals will be taken relative to the population sizes of the affected species.

Unmitigable Adverse Impact Analysis and Determination

There are no relevant subsistence uses of the affected marine mammal stocks or species implicated by this action. Therefore, NMFS has 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 (ESA: 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 issuance of IHAs, NMFS consults internally, in this case with the ESA Interagency Cooperation Division, whenever we propose to authorize take for endangered or threatened species.

NMFS is proposing to authorize take of blue, fin, humpback, sei, and sperm whales, which are listed under the ESA. The Permit and Conservation Division has requested initiation of Section 7 consultation with the Interagency Cooperation Division for the issuance of this IHA. NMFS will conclude the ESA consultation prior to reaching a determination regarding the proposed issuance of the authorization.

Proposed Authorization

As a result of these preliminary determinations, NMFS proposes to issue an IHA to NSF for conducting seismic surveys, other acoustic sources, and icebreaking in the Amundsen Sea from on or about February 6–14, 2020, provided the previously mentioned mitigation, monitoring, and reporting requirements are incorporated. A draft of the proposed IHA can be found at *https://www.fisheries.noaa.gov/permit/incidental-take-authorizations-under-marine-mammal-protection-act.*

Request for Public Comments

We request comment on our analyses, the proposed authorization, and any other aspect of this Notice of Proposed IHA for the proposed low-energy marine geophysical survey and icebreaking activity in the Amundsen Sea. We also request at this time comment on the potential renewal of this proposed IHA as described in the paragraph below. Please include with your comments any supporting data or literature citations to help inform decisions on the request for this IHA or a subsequent Renewal.

On a case-by-case basis, NMFS may issue a one-year IHA renewal with an additional 15 days for public comments when (1) another year of identical or nearly identical activities as described in the Specified Activities section of this notice is planned or (2) the activities as described in the Specified Activities section of this notice would not be completed by the time the IHA expires and a Renewal would allow for completion of the activities beyond that described in the Dates and Duration section of this notice, provided all of the following conditions are met:

- A request for renewal is received no later than 60 days prior to expiration of the current IHA.
- The request for renewal must include the following:

(1) An explanation that the activities to be conducted under the requested Renewal are identical to the activities analyzed under the initial IHA, are a subset of the activities, or include changes so minor (*e.g.,* reduction in pile size) that the changes do not affect the previous analyses, mitigation and monitoring requirements, or take estimates (with the exception of reducing the type or amount of take because only a subset of the initially analyzed activities remain to be completed under the Renewal).

(2) A preliminary monitoring report showing the results of the required monitoring to date and an explanation showing that the monitoring results do not indicate impacts of a scale or nature not previously analyzed or authorized.

- Upon review of the request for Renewal, the status of the affected species or stocks, and any other pertinent information, NMFS determines that there are no more than minor changes in the activities, the mitigation and monitoring measures will remain the same and appropriate, and the findings in the initial IHA remain valid.

Dated: December 13, 2019.

Donna S. Wieting,

Director, Office of Protected Resources, National Marine Fisheries Service.

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