DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

RIN 0648–XR056

Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to a Low-Energy Geophysical Survey in the South Atlantic Ocean

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 Scripps Institute of Oceanography (SIO) for authorization to take marine mammals incidental to a low-energy marine geophysical survey in the South Atlantic Ocean. 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 October 30, 2019.

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.Egger@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. Attachments to electronic comments will be accepted in Microsoft Word or Excel or Adobe PDF file formats only. 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: Stephanie Egger, 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 such 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 such takings are set forth.

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 May 15, 2019, NMFS received a request from SIO for an IHA to take marine mammals incidental to conducting a low-energy marine geophysical survey in the Southeast Atlantic Ocean. The application was deemed adequate and complete on August 12, 2019. SIO's request is for take of a small number of 48 species of marine mammals by Level B harassment. Neither SIO 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

SIO plans to conduct low-energy marine seismic surveys in the Southeast Atlantic Ocean during November–December 2019. The seismic surveys would be conducted to understand the volcanic and tectonic development of Walvis Ridge and Rio Grande Rise in the South Atlantic Ocean. The seismic surveys would be conducted in International Waters with water depths ranging from approximately 500 to 5700 m. The surveys would involve one source vessel, R/V *Thomas G. Thompson* (*Thompson*). The *Thompson* would deploy up to two 45-in^3 GI airguns at a depth of 2–4 m with a maximum total volume of ~90 in^3 along predetermined tracklines.

Dates and Duration

The R/V *Thompson* would likely depart from Montevideo, Uruguay, on or about November 3, 2019 and would arrive in Walvis Bay, Namibia, on or about 5 December 5, 2019. If the arrival port is Cape Town instead of Walvis Bay, an additional two days would be required for transit. Seismic operations would occur for approximately 14 days. Transit to and from the project area and between surveys would occur from approximately 16 days. Equipment deployment and recovery would take approximately 3 days. Some deviation in timing could result from unforeseen events such as weather, logistical issues, or mechanical issues with the research vessel and/or equipment. Seismic activities would occur 24 hours per day during the proposed survey.

Specific Geographic Region

The majority of the survey would take place in the Southeast Atlantic Ocean between ~33.2°–21° S and 1° W–8° E (see Figure 1). A small survey area is proposed for the Southwest Atlantic Ocean between ~33.2°–34.3° S and 30.8°–31.8° W (see Figure 1). Seismic surveys would occur in five survey areas including Libra Massif in the Southwest Atlantic and Valdivia Bank, Gough, Tristan, and Central survey areas in the Southeast Atlantic; representative survey tracklines are shown in Figure 1.

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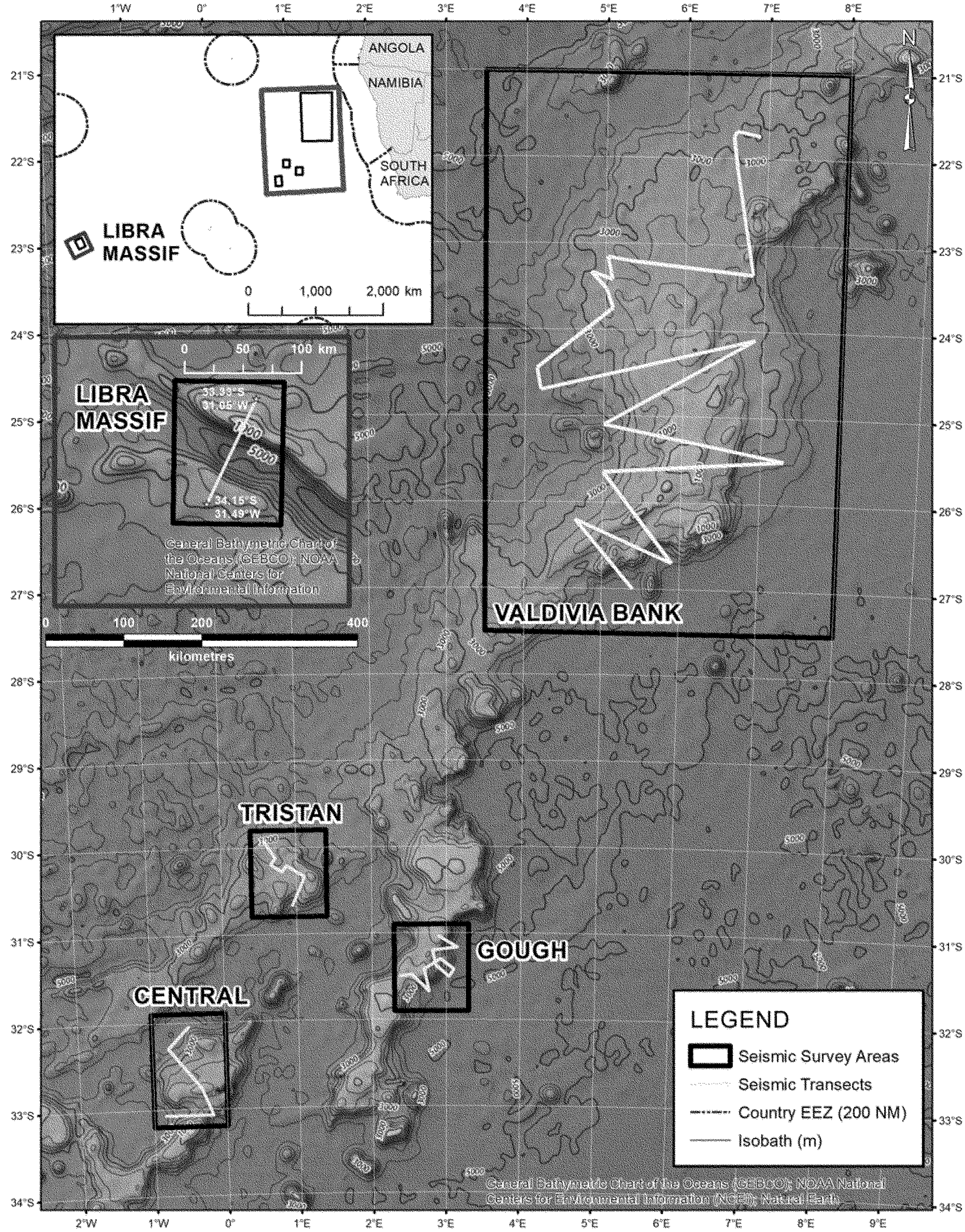

Figure 1. Location of the Proposed Surveys in the Southeast Atlantic Ocean.

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Detailed Description of Specific Activity

SIO proposes to conduct low-energy seismic surveys in five areas in the South Atlantic Ocean. Reconnaissance Surveys are planned for three survey areas (Gough, Tristan, Central) and High Quality Surveys are planned to take place along the proposed seismic transect lines in the main survey area (Valdivia Bank) and Libra Massif survey area (Figure 1). However, High-Quality Surveys may be replaced by Reconnaissance Surveys depending on weather conditions and timing (*e.g.,* 10 percent of survey effort at Valdivia Bank is expected to consist of Reconnaissance Surveys). All data acquisition in the Tristan survey area would occur in water >1,000 m deep; all other survey areas have effort in intermediate (100–1,000 m) and deep (>1,000 m) water. Most of the survey effort (97 percent) would occur in water >1,000 m deep. The proposed surveys would be in support of a potential future International Ocean Discovery Program (IODP) project and to improve our understanding of volcanic and tectonic development of oceanic ridges and to enable the selection and analysis of potential future IODP drill sites. To achieve the program's goals, the Principal Investigators propose to collect low-energy, high-resolution multi-channel seismic (MCS) profiles. The proposed cruise would consist of digital bathymetric, echosounding, and MCS surveys.

The procedures to be used for the seismic surveys would be similar to those used during previous seismic surveys by SIO and would use conventional seismic methodology. The surveys would involve one source vessel, R/V *Thompson,* which is managed by University of Washington (UW). The R/V *Thompson* would deploy up to two 45-in³ GI airguns as an energy source with a maximum total volume of ~90 in³. The receiving system would consist of one hydrophone streamer, 200 to 1,600 m in length, as described below. 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.

The airgun array would be operated in one of two different types of array modes. The first would be highest-quality survey mode to collect the highest-quality seismic reflection data. The second mode would be a reconnaissance mode, which are quicker and less impacted by adverse weather. The reconnaissance mode also allows for operations to occur in poor weather where the use of streamer longer than 400-m may not be possible safely.

The highest-quality mode is carried out using a pair of 45-in³ airguns, with airguns spaced 2 m apart at a depth of 2–4 m, with a 400, 800, or 1,600 m hydrophone streamer and with the vessel traveling at to 5 knots (5 kn) to achieve high-quality seismic reflection data. The reconnaissance mode is carried out using either one or two 45-in³ airguns, with airguns spaced 8 m apart (if 2 are being used) at a water depth of 2–4 m, with a 200 m hydrophone streamer and with the vessel traveling at 8 kn.

Seismic data would be collected first as a single profile over the rift at Libra Massif, the most southeastern edifice of Rio Grande Rise. After crossing the Atlantic, data would be collected over three seamounts (Gough, Tristan, Central) in the ''Guyot Province'' of Walvis Ridge. Approximately 24 hr of seismic profiling is proposed at each location, before moving on to the Valdivia Bank survey area, where most survey effort (75 percent) would occur.

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.

In addition to the operations of the airgun array, a hull-mounted multibeam echosounder (MBES) and a sub-bottom profiler (SBP) would also be operated from the *Thompson* continuously throughout the seismic surveys, but not during transits to and from the project area. All planned data acquisition and sampling activities would be conducted by SIO and UW with on board assistance by the scientists who have proposed the project. The vessel would be self-contained, and the crew would live aboard the vessel for the entire cruise.

The *Thompson* has a length of 83.5 m, a beam of 16 m, and a full load draft of 5.8 m. It is equipped with twin 360°-azimuth stern thrusters each powered by 3,000-hp DC motors and a water-jet bow thruster powered by a 1,100-hp DC motor. An operation speed of ~9–15 km/h (~5–8 kn) would be used during seismic acquisition. When not towing seismic survey gear, the *Thompson* cruises at 22 km/h (12 kn) and has a maximum speed of 26.9 km/h (14.5 kn). It has a normal operating range of ~24,400 km. The *Thompson* would also serve as the platform from which vessel-based protected species visual observers (PSVO) would watch for marine mammals and before and during airgun operations.

During the survey, the *Thompson* would tow two 45-in³ GI airguns and a streamer containing hydrophones. The generator chamber of each GI gun, the one responsible for introducing the sound pulse into the ocean, is 45 in³. The larger (105 in³) injector chamber injects air into the previously generated bubble to maintain its shape and does not introduce more sound into the water. The 45-in³ GI airguns would be towed 21 m behind the *Thompson,* 2 m (during 5-kn high-quality surveys) or 8 m (8-kn reconnaissance surveys) apart, side by side, at a depth of 2–4 m. High-quality surveys with the 2-m airgun separation configuration would use a streamer up to 1,600-m long, whereas the reconnaissance surveys with the 8-m airgun separation configuration would use a 200-m streamer. Seismic pulses would be emitted at intervals of 25 m for the 5-kn surveys using the 2-m GI airgun separation and at 50 m for the 8-kn surveys using the 8-m airgun separation.

TABLE 1—SPECIFICATIONS OF THE R/V THOMPSON AIRGUN ARRAY

Number of airguns	2.
Gun positions used	Two inline airguns 2- or 8-m apart.
Tow depth of energy source.	2–4 m.
Dominant frequency components.	0–188 hertz (Hz).
Air discharge volume	Approximately 90 in³.

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

Description of Marine Mammals in the Area of Specified Activities

Section 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. 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 proxy sources including International Whaling Commission population estimates (IWC 2019), the U.S. Atlantic SARs (Hayes *et al.,* 2018) for a few dolphin 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. However, as described above, the marine mammals encountered by the proposed survey are not assigned to stocks. All abundance estimate values presented in Table 2 are the most recent available at the time of publication and are available in the 2018 U.S. Atlantic SARs (*e.g.,* Hayes *et al.* 2018) available online at: *www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessments,* except where noted otherwise.

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

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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]	Abundance	PBR	Relative occurrence in project area
Order Cetartiodactyla – Cetacea – Superfamily Mysticeti (baleen whales)						
Family Balaenidae						
Southern right whale	*Eubalaena australis*	n/a	E/D;N	12,000[3] 3,300[5]	N.A.	Uncommon
Family Cetotheriidae						
Pygmy right whale	*Caperea marginata*	n/a		N.A.	N.A.	Rare
Family Balaenopteridae (rorquals)						
Blue whale	*Balaenoptera musculus*	n/a	E/D;Y	2,300 true[4] 1,500 pygmy[6]	N.A.	Rare
Fin whale	*Balaenoptera physalus*	n/a	E/D;Y	15,000[6]	N.A.	Uncommon
Sei whale	*Balaenoptera borealis*	n/a	E	10,000[6]	N.A.	Uncommon
Common minke whale	*Balaenoptera acutorostrata*	n/a	-	515,000[3,6]	N.A.	Common
Antarctic minke whale	*Balaenoptera bonaerensis*	n/a	-	515,000[3,6]	N.A.	Common
Humpback whale	*Megaptera novaeangliae*	n/a	-	42,000[3]	N.A.	Rare
Bryde's whale	*Balaenoptera edeni/brydei*	n/a	-	48,109[7]	NA	Common
Superfamily Odontoceti (toothed whales, dolphins, and porpoises)						
Family Physeteridae						
Sperm whale	*Physeter macrocephalus*	n/a	E	12,069[10]	N.A.	Uncommon
Family Kogiidae						
Pygmy sperm whale	*Kogia breviceps*	n/a	-	N.A.	N.A.	Rare
Dwarf sperm whale	*Kogia sima*	n/a	-	N.A.	N.A.	Uncommon
Family Ziphiidae (beaked whales)						
Arnoux's beaked whale	*Berardius arnuxii*	n/a	-	599,300[11]	N.A.	Uncommon
Cuvier's beaked whale	*Ziphius cavirostris*	n/a	-	599,300[11]	N.A.	Uncommon
Southern bottlenose whale	*Hyperoodon planifrons*	n/a	-	599,300[11]	N.A.	Uncommon
Shepherd's beaked whale	*Tasmacetus sheperdi*	n/a	-	N.A.	N.A.	Uncommon
Blainville's beaked whale	*Mesoplodon densirostris*	n/a	-	N.A.	N.A.	Rare
Gray's beaked whale	*Mesoplodon grayi*	n/a	-	599,300[11]	N.A.	Uncommon

Gervais' beaked whale	*Mesoplodon europaeus*	n/a	-	N.A.	N.A.	Rare
Hector's beaked whale	*Mesoplodon hectori*	n/a	-	N.A.	N.A.	Rare
True's beaked whale	*Mesoplodon mirus*	n/a	-	N.A.	N.A.	Rare
Strap-toothed beaked whale	*Mesoplodon layardii*	n/a	-	599,300[11]	N.A.	Uncommon
Andrews' beaked whale	*Mesoplodon bowdoini*	n/a	-	N.A.	N.A.	Rare
Spade-toothed beaked whale	*Mesoplodon traversii*	n/a	-	N.A.	N.A.	Rare
Family Delphinidae						
Risso's dolphin	*Grampus griseus*	n/a	-	18,250[12]	N.A.	Common
Rough-toothed dolphin	*Steno bredanensis*	n/a	-	N.A.	N.A.	Common
Common bottlenose dolphin	*Tursiops truncatus*	n/a	-	77,532[12]	N.A.	Uncommon
Pantropical spotted dolphin	*Stenella attenuata*	n/a	-	3,333[12]	N.A.	Common
Atlantic spotted dolphin	*Stenella frontalis*	n/a	-	44,715[12]	N.A.	Rare
Spinner dolphin	*Stenella longirostris*	n/a	-	N.A.	N.A.	Uncommon
Clymene dolphin	*Stenella clymene*	n/a	-	N.A.	N.A.	Rare
Striped dolphin	*Stenella coeruleoalba*	n/a	-	54,807[12]	N.A.	Uncommon
Short-beaked common dolphin	*Delphinus delphis*	n/a	-	70,184[10]	N.A.	Uncommon
Fraser's dolphin	*Lagenodelphis hosei*	n/a	-	N.A.	N.A.	Uncommon
Dusky dolphin	*Lagenorhynchus obscurus*	n/a	-	7,252[12]	N.A.	Rare
Hourglass dolphin	*Lagenorhynchus cruciger*	n/a	-	150,000[6]	N.A.	Rare
Southern right whale dolphin	*Lissodelphis peronii*	n/a	-	N.A.	N.A.	Uncommon
Killer whale	*Orcinus orca*	n/a	-	25,000[14]	N.A.	Uncommon
Short-finned pilot whale	*Globicephala macrorhynchus*	n/a	-	200,000[6]	N.A.	Uncommon
Long-finned pilot whale	*Globicephala melas*	n/a	-	200,000[6]	N.A.	Uncommon
False killer whale	*Pseudorca crassidens*	n/a	-	N.A.	N.A.	Uncommon
Pygmy killer whale	*Feresa attenuata*	n/a	-	N.A.	N.A.	Uncommon
Melon-headed whale	*Peponocephala electra*	n/a	-	N.A.	N.A.	Uncommon
Order Carnivora – Superfamily Pinnipedia						
Family Otariidae (eared seals and sea lions)						
Cape fur seal	*Arctocephalus*	n/a	-	Approximately	N.A.	Uncommon

	pusillus pusillus			2 million[16]		
Subantarctic fur seal	*Arctocephalus tropicalis*	n/a	-	400,000[15]	N.A.	Uncommon
Family Phocidae (earless seals)						
Crabeater seal	*Lobodon carcinophaga*	n/a	-	5 – 10 million[17]	N.A.	Rare
Leopard seal	*Hydrurga leptonyx*	n/a	-	222,000 – 440,000[18]	N.A.	Rare
Southern elephant seal	*Mirounga leonina*	n/a	-	750,000[19]	N.A.	Uncommon

N.A. = Data not available. NL = Not listed

[1] U.S. *Endangered Species Act* (NOAA 2019): EN = Endangered
[2] International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2019): EN = Endangered; NT = Near Threatened; VU = Vulnerable; LC = Least Concern; DD = Data Deficient
[3] Convention on International Trade in Endangered Species of Wild Fauna and Flora (UNEP-WCMC 2017): Appendix I = Threatened with extinction; Appendix II = not necessarily threatened with extinction but may become so unless trade is closely controlled
[4] Southern Hemisphere (IWC 2019)
[5] Southwest Atlantic (IWC 2019)
[6] Antarctic (Boyd 2002)
[7] Southern Hemisphere (IWC 1981)
[8] Dwarf and Antarctic minke whales combined
[9] There are 14 distinct population segments (DPSs) of humpback whales recognized under the ESA; the Brazil and Gabon/Southwest Africa DPSs are not listed (NOAA 2019)
[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 and Joyce 1995)
[12] Estimate for the western North Atlantic (Hayes *et al.* 2018)
[13] Estimate for Patagonian coast (Dans *et al.* 1997)
[14] Minimum estimate for Southern Ocean (Branch and Butterworth 2001)
[15] Global population (Hofmeyr and Bester 2018)
[16] Butterworth *et al.* (1995 *in* Kirkman and Arnould 2018)
[17] Global population (Bengtson and Stewart 2018)
[18] Global population (Rogers 2018)
[19] Total world population (Hindell *et al.* 2016)

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All species that could potentially occur in the proposed survey areas are included in Table 2. As described below, all 48 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.

Though other marine mammal species are known to occur in the Southwest Atlantic Ocean, the temporal and/or spatial occurrence of several of these species is such that take of these species is not expected to occur, and they are therefore not discussed further beyond the explanation provided here. An additional 13 species of marine mammals are known to occur in the Southwest Atlantic Ocean; however, they are unlikely to occur within the proposed project area because they are coastally-distributed (*e.g.,* Atlantic humpback dolphin, *Sousa teuszii;* Heaviside's dolphin, *Cephalorhynchus heavisidii;* Chilean dolphin, *C. eutropia;* long-beaked common dolphin, *Delphinus capensis;* Franciscana, *Pontoporia blainvillei;* Guiana dolphin, *Sotalia guianensis;* Burmeister's porpoise, *Phocoena spinipinnis;* West Indian manatee, *Trichechus manatus;* African manatee, *T. senegalensis;* South American fur seal, *Arctocephalus australis*); or (2) occur further south (spectacled porpoise, *Phocoena dioptrica;* Ross seal, *Ommatophoca rossii;* Weddell seal, *Leptonychotes weddellii*). Although a gray whale (*Eschrichtius robustus*) was sighted off Namibia in 2013 (Elwen and Gridley 2013), and the remains of a stranded Omura's whale (*Balaenoptera omurai*) were reported for Mauritania in western Africa (Jung *et al.* 2016), these species are not considered further as they typically do not occur in the Atlantic Ocean. None of these species are discussed further here.

We have reviewed SIO'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 SIO'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

Southern Right Whale

The southern right whale is circumpolar throughout the Southern Hemisphere between 20° S and 55° S (Jefferson *et al.* 2015), although it may occur further north where cold-water currents extend northwards (Best 2007). It migrates between summer foraging areas at high latitudes and winter breeding/calving areas in low latitudes (Jefferson *et al.* 2015). In the South Atlantic, known or historic breeding areas are located in the shallow coastal waters of South America, including Argentina and Brazil, as well as the Falkland Islands, Tristan de Cunha, Namibia, and South Africa (IWC 2001). Rowntree *et al.* (2013) reported that during 2009, primary calving grounds included an estimated 3,864 southern right whales off South Africa.

Although southern right whale calving/breeding areas are located in nearshore waters, feeding grounds in the Southern Ocean apparently are located mostly in highly-productive pelagic waters (Kenney 2018). Waters south of South Africa are believed to be a nursery area for southern right whales, as females and calves are seen there (Barendse and Best 2014). Right whales with calves are seen in nearshore waters of South Africa during July–November (Best 2007). Nearshore waters off western South Africa might be used as a year-round feeding area (Barendse and Best 2014). The highest sighting rates off western South Africa occur during early austral summer, and the lowest rates have been reported from autumn to mid-winter (Barendse and Best 2014). Although right whales were depleted in the early 19th century by whaling, they are now reappearing off Namibia; this likely indicates a range expansion of the stock from South Africa rather than a separate stock (Roux *et al.* 2001, 2015). Numerous sightings were made in the area from 1971 through 1999; most sightings were made from July through November, with one sighting during December (Roux *et al.* 2001). A total of 10 calves were born off Namibia between 1996 and 1999 (Roux *et al.* 2001). However, Roux *et al.* (2015) postulated that Namibian waters currently serve as mating grounds rather than a calving area. Best (2007) reported a summer feeding concentration between 30° and 40° S, including the Guyot Province of Walvis Ridge, where three proposed survey areas (Gough, Tristan, Central) are located.

Pygmy Right Whale

The distribution of the pygmy right whale is circumpolar in the Southern Hemisphere between 30° S and 55° S in oceanic and coastal environments (Kemper 2018; Jefferson *et al.* 2015). The pygmy right whale appears to be non-migratory, although there may be some movement inshore in spring and summer (Kemper 2002; Jefferson *et al.* 2015), possibly related to food availability (Kemper 2018). Foraging areas are not known, but it seems likely that pygmy right whales may feed at productive areas in higher latitudes, such as near the Subtropical Convergence (Best 2007). There may be hotspots of occurrence where mesozooplankton, such as *Nyctiphanes australis* and *Calanus tonsus,* are plentiful (Kemper *et al.* 2013).

In the South Atlantic, pygmy right whale records exist for southern Africa, Argentina, Falkland Islands, and pelagic waters (Baker 1985). Leeney *et al.* (2013) reported 12 strandings and 8 records of skeletal remains for Namibia since 1978. Most of the records are for Walvis Bay; strandings have only been reported during austral summer (November–March). The large number of juveniles suggests that the area may be a nursery ground (Leeney *et al.* 2013). Best (2007) reported records between 30° S and 40° S, including near the Central survey area. Bester and Ryan (2007) suggested that pygmy right whales occur in the Tristan da Cunha archipelago. One pygmy right whale was taken by whalers at 35° S and 8° W on 30 November 1970 (Budylenko *et al.* 1973 *in* Best *et al.* 2009). There are no OBIS records of pygmy right whales for the offshore waters of the proposed survey area, but 10 records exist off southwestern Africa (OBIS 2019). Pygmy right whales could be seen in any of the proposed project area at the time of the surveys, in particular in the Gough, Tristan, and Central survey areas.

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).

An extensive data review and analysis by Branch *et al.* (2007a) showed that blue whales are essentially absent from the central regions of major ocean basins, including the South Atlantic. Blue whales were captured by the thousands off Angola, Namibia, and South Africa between 1908 and 1967 (Branch *et al.* 2007a; Figueiredo and Weir 2014), including several catches near the proposed project area during 1958–1973 (including in November and December) and a few sightings off South Africa. However, whales were nearly extirpated in this region, and sightings are now rare (Branch *et al.* 2007a). At least four records exist for Angola; all sightings were made in 2012, with at least one sighting in July, two in August, and one in October (Figueiredo and Weir 2014). Sightings were also made off Namibia in 2014 from seismic vessels (Brownell *et al.* 2016). Waters off Namibia may serve as a possible wintering and possible breeding ground for Antarctic blue whales (Best 1998, 2007; Thomisch *et al.* 2017). Antarctic blue whale calls were detected on acoustic recorders that were deployed northwest of Walvis Ridge (just to the north of the Valdivia Bank survey area) from November 2011 through May 2013 during all months except during September and October, indicating that not all whales migrate to higher latitudes during the summer (Thomisch *et al.* 2017). Most blue whales in southeastern Africa are expected to be Antarctic blue whales; however, ~4 percent may be pygmy blue whales (Branch *et al.* 2007b, 2008). In fact, pygmy blue whale vocalizations were detected off northern Angola in October 2008; these calls were attributed to the Sri Lanka population (Cerchio *et al.* 2010). One offshore sighting of a blue whale was made at 13.4° S, 26.8° W and the other at 15.9° S, 4.6° W (Branch *et al.* 2007a; OBIS 2019). The occurrence of blue whales in the Tristan da Cunha archipelago also seems likely (Bester and Ryan 2007). There are ~1845 blue whale records for the South Atlantic in the OBIS database; however, no records occur within the proposed project area (OBIS 2019). Blue whales could be encountered during the proposed surveys, in particular in the Valdivia Bank survey area.

Fin Whale

The fin whale 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 and García-Vernet 2018).

In the Southern Hemisphere, fin whales are typically distributed south of 50° S in the austral summer, migrating northward to breed in the winter (Gambell 1985). Historical whaling data showed several catches for the Tristan da Cunha archipelago (Best *et al.* 2009), as well as off Namibia and southern Africa (Best 2007). Fin whales appear to be somewhat common in the Tristan da Cunha archipelago from October–December (Bester and Ryan 2007). According to Edwards *et al.* (2015), sightings have been made south of South Africa from December–February; they did not report any sightings or acoustic detections near the proposed project area. Several fin whales sightings and strandings have been reported for Namibia in the last decade (NDP unpublished data *in* Pisces Environmental Services 2017). Fin whale calls were detected on acoustic recorders that were deployed northwest of Walvis Ridge from November 2011 through May 2013 during the months of November, January, and June through August, indicating that the waters off Namibia serve as wintering grounds (Thomisch *et al.* 2017). Similarly, Best (2007) also suggested that waters off Namibia may be wintering grounds.

Sei Whale

The sei whale 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). 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). Best (2007) showed summer concentrations between 30° S and 50° S, including near the three proposed survey areas (Central, Tristan, Gough) in the Guyot Province of Walvis Ridge. Waters off northern Namibia may serve as wintering grounds (Best 2007).

A sighting of a mother and calf were made off Namibia in March 2012, and one stranding was reported in July 2013 (NDP unpublished data in Pisces Environmental Services 2017). One sighting was made during seismic surveys off the coast of northern Angola between 2004 and 2009 (Weir 2011). A group of 2–4 sei whales was seen near St. Helena during April 2011 (Clingham *et al.* 2013). Although the occurrence of sei whales is likely in the Tristan da Cunha archipelago (Bester and Ryan 2007), there have been no recent records of sei whales in the region; however, sei whale catches were made here in the 1960s (Best *et al.* 2009). Sei whales were also taken off southern Africa during the 1960s, with some catches reported just to the southeast of the proposed survey area; catches were made during the May–July northward migration as well as during the August–October southward migration (Best and Lockyer 2002). In the OBIS database, there are 40 sei whale records for the South Atlantic; the closest records were reported at 33.3° S, 8.0° W and 35.1° S, 6.4° W (OBIS 2019). Sei whales could be encountered in any of the proposed survey areas at the time of the surveys, in particular in the Gough, Tristan, and Central survey areas.

Bryde's Whale

Bryde's whale occurs in all tropical and warm temperate waters in the Pacific, Atlantic and Indian oceans, between 40° N and 40° S (Jefferson *et al.* 2015). It is one of the least known large baleen whales, and it remains uncertain how many species are represented in this complex (Kato and Perrin 2018). *B. brydei* is commonly used to refer to the larger form or ''true'' Bryde's whale and *B. edeni* to the smaller form; however, some authors apply the name B. edeni to both forms (Kato and Perrin 2018). Bryde's whale remains in warm (≤16 °C) water year-round (Kato and Perrin 2018), but analyses have shown that it prefers water <20.6 °C in the eastern tropical Atlantic (Weir *et al.* 2012). Seasonal movements have been recorded towards the Equator in winter and offshore in summer (Kato and Perrin 2018). It is frequently observed in biologically productive areas such as continental shelf breaks (Davis *et al.* 2002) and regions subjected to coastal upwelling (Gallardo *et al.* 1983; Siciliano *et al.* 2004). Central oceanic waters of the South Atlantic, including the proposed project area, are considered part of its secondary range (Jefferson *et al.* 2015).

In southern Africa, there are likely three populations of Bryde's whales—an inshore population, a pelagic population of the Southeast Atlantic stock, and the Southwest Indian Ocean stock (Best 2001). The Southeast Atlantic stock ranges from the equator to ~34° S and migrates north in the fall and south during the spring, with most animals occurring off Namibia during the austral summer (Best 2001). Numerous sightings have been made off Gabon (Weir 2011), Angola (Weir 2010, 2011), and South Africa (Findlay *et al.* 1992), including in deep slope waters. Strandings have also been reported along the Namibian coast (Pisces Environmental Services 2017). Bryde's whale was sighted in the offshore waters of the South Atlantic during a cruise from Spain to South Africa in November 2009, near 22° S, 6° W (Shirshov Institut n.d.). In the OBIS database, there are 12 records off the coast of South Africa (OBIS 2019). Bryde's whales are not expected to occur in the Libra Massif survey area. However, they could be encountered in the rest of the proposed project area, in particular the eastern portions of the Valdivia Bank survey area.

Common 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 (unnamed subspecies) of the common minke whale, known as the dwarf minke whale, 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 (Perrin *et al.* 2018).

It is known to occur off South Africa during autumn and winter (Perrin *et al.* 2018), but has not been reported for the waters off Angola or Namibia (Best 2007). It is likely to occur in the waters of the Tristan da Cunha archipelago (Bester and Ryan 2007). There are 36 records for the South Atlantic in the OBIS database, including records off South America and along the coast of Namibia and South Africa; there are no records in the proposed project area (OBIS 2019). Dwarf minke whales could be encountered in the proposed project area at the time of the surveys.

Antarctic Minke Whale

The Antarctic minke whale has a circumpolar distribution in coastal and offshore areas of the Southern Hemisphere from ~7° S to the ice edge (Jefferson *et al.* 2015). It is found between 60° S and the ice edge during the austral summer; in the austral winter, it is mainly found at mid-latitude breeding grounds, including off western South Africa and northeastern Brazil, where it is primarily oceanic, occurring beyond the shelf break (Perrin *et al.* 2018). Antarctic minke whale densities are highest near pack ice edges, although they are also found amongst pack ice (Williams *et al.* 2014), where they feed almost entirely on krill (Tamura and Konishi 2009).

In the Southeast Atlantic, Antarctic minke whales have been reported for the waters of South Africa, Namibia, and Angola (Best 2007). Antarctic minke whale calls were detected on acoustic recorders that were deployed northwest of Walvis Ridge from November 2011 through May 2013 during the months of November, December, January, and June through August, indicating that not all whales migrate to higher latitudes during the summer (Thomisch *et al.* 2017). Sightings have also been made along the coast of Namibia, in particular during summer (NPD unpublished data *in* Pisces Environmental Services 2017). Antarctic minke whales are also likely to occur in the Tristan da Cunha archipelago (Bester and Ryan 2007). Two groups totaling seven whales were sighted at 36.4° S, 8.5° W on 7 October 1988 (Best *et al.* 2009). A sighting of two whales was made off Brazil during an August–September 2010 survey from Vitória, at ~20° S, 40° W, to Trindade and Martim Vaz islands; the whales were seen in association with a group of rough-toothed dolphins near 19.1° S, 35.1° W on 21 August (Wedekin *et al.* 2014). There are five OBIS records for the South Atlantic, including along the coast of South America and South Africa; there are no records for the proposed project area (OBIS 2019). Antarctic minke whales could be encountered in the proposed project area at the time of the surveys.

Humpback Whale

Humpback whales 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 current species-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). Two of the breeding grounds are in the South Atlantic, off Brazil and West Africa (Engel and Martin 2009). Bettridge *et al.* (2015) identified humpback whales at these breeding locations as the Brazil and Gabon/Southwest Africa DPSs. There may be two breeding substocks in Gabon/Southwest Africa, including individuals in the main breeding area in the Gulf of Guinea and those animals migrating past Namibia and South Africa (Rosenbaum *et al.* 2009; Barendse *et al.* 2010a; Branch 2011; Carvalho *et al.* 2011). Migration rates are relatively high between populations within the southeastern Atlantic (Rosenbaum *et al.* 2009). However, Barendse *et al.* (2010a) reported no matches between individuals sighted in Namibia and South Africa based on a comparison of tail flukes. In addition, wintering humpbacks have also been reported on the continental shelf of northwest Africa, which may represent the northernmost humpback whales that are known to winter in the Gulf of Guinea (Van Waerebeek *et al.* 2013). Feeding areas for this stock include Bouvet Island (Rosenbaum *et al.* 2014) and waters of the Antarctic Peninsula (Barendse *et al.* 2010b).

Humpbacks have been seen on breeding grounds around São Tomé in the Gulf of Guinea from August through November; off Gabon, whales occur from late June–December (Carvalho *et al.* 2011). The west coast of South Africa might not be a 'typical' migration corridor, as humpbacks are also known to feed in the area; they are known to occur in the region during the northward migration (July–August), the southward migration (October–November), and into February (Barendse *et al.* 2010b; Carvalho *et al.* 2011; Seakamela *et al.* 2015). The highest sighting rates in the area occurred during mid-spring through summer (Barendse *et al.* 2010b). Off Namibia, the main peak of occurrence is during winter (July), with another peak during spring (September); however, this area is unlikely to be a breeding area (Elwen *et al.* 2014). Elwen *et al.* (2014) suggested that humpbacks are migrating northward past Namibia during winter and migrate closer to shore during a southward migration during spring/summer. Humpback whale calls were detected on acoustic recorders that were deployed northwest of Walvis Ridge from November 2011 through May 2013 during the months of November, December, January, and May through August, indicating that not all whales migrate to higher latitudes during the summer (Thomisch *et al.* 2017). Based on whales that were satellite-tagged in Gabon in winter 2002, migration routes southward include offshore waters along Walvis Ridge (Rosenbaum *et al.* 2014). Hundreds of sightings have been made during seismic surveys off the coast of Angola between 2004 and 2009, including in deep slope water; most sightings were reported during winter and spring (Weir 2011). Best *et al.* (1999) reported some sightings off the coast of Angola during November 1995. Humpback whale acoustic detections were made in the area from June through December 2008 (Cerchio *et al.* 2014).

Humpbacks occur occasionally around the Tristan da Cunha archipelago (Bester and Ryan 2007). Three records exist for Tristan waters, all south of 37° S (Best *et al.* 2009). Humpback whales have also been sighted off St. Helena (MacLeod and Bennett 2007; Clingham *et al.* 2013). Numerous humpbacks were detected visually and acoustically during a survey off Brazil from Vitória at ~20° S, 40° W, to Trindade and Martim Vaz islands during August–September 2010 (Wedekin *et al.* 2014). One adult humpback was seen on 31 August near Trindade Island, at 20.5° S, 29.3° W in a water depth of 150 m, but no acoustic detections were made east of 35° W (Wedekin *et al.* 2014). Numerous sightings were also made near Trindade Island during July–August 2007 and before that date (Siciliano *et al.* 2012). For the South Atlantic, the OBIS database shows over 700 records for the South Atlantic, including along the coast of South America and western Africa, and in offshore waters of the central Atlantic (OBIS 2019). The closest sightings to the proposed survey areas in the southeastern Atlantic occur near the Gough survey area at 33.8° S, 2.1° E and 32.5° S, 3.8° E (OBIS 2019). The waters of the proposed project area are considered part of the humpback's secondary range (Jefferson *et al.* 2015). However, humpback whales could be encountered at the time of the proposed surveys, in particular in the Valdivia Bank survey area.

Odontocetes

Sperm Whale

The sperm whale 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 and Whitehead 1996). Its distribution and relative abundance can vary in response to prey availability, most notably squid (Jaquet and Gendron 2002). Females generally inhabit waters >1,000 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).

Whaling data from the South Atlantic indicate that sperm whales may be migratory off South Africa, with peak abundances reported in the region during autumn and late winter/spring (Best 2007). The waters of northern Namibia and Angola were also historical whaling grounds (Best 2007; Weir 2019). Sperm whales were the most frequently sighted cetacean during seismic surveys off the coast of northern Angola between 2004 and 2009; hundreds of sightings were made off Angola and a few sightings were reported off Gabon (Weir 2011). Sperm whales have also been sighted off South Africa during surveys of the Southern Ocean (Van Waerebeek *et al.* 2010). In addition, a sighting was made at 30.1° S, 14.3° E (Clingham *et al.* 2013). Bester and Ryan (2007) reported that sperm whales might be common in the Tristan da Cunha archipelago. Catches of sperm whales in the 19th century were made in Tristan waters between October and January (Townsend 1935 *in* Best *et al.* 2009), and catches also occurred there in the 1960s (Best *et al.* 2009). One group was seen at St. Helena during July 2009 (Clingham *et al.* 2013). There are ~3,080 records of sperm whales for the South Atlantic in the OBIS database, including nearshore waters of South American and Africa and offshore waters (OBIS 2019). Most (3,069) records are from historical catch data, which include captures within the proposed project area (OBIS 2019). Sperm whales could be encountered in the proposed project area at the time of the surveys.

Pygmy and Dwarf Sperm Whales

Dwarf and pygmy sperm whales are distributed throughout tropical and temperate waters of the Atlantic, Pacific and Indian oceans, but their precise distributions are unknown because much of what we know of the species comes from strandings (McAlpine 2018). They are difficult to sight at sea, because of their dive behavior and perhaps because of their avoidance reactions to ships and behavior changes in relation to survey aircraft (Würsig *et al.* 1998). The two species are often difficult to distinguish from one another when sighted (McAlpine 2018). It has been suggested that the pygmy sperm whale is more temperate and the dwarf sperm whale more tropical, based at least partially on live sightings at sea from a large database from the eastern tropical Pacific (Wade and Gerrodette 1993; McAlpine 2018). This idea is also supported by the distribution of strandings in South American waters (Muñoz-Hincapié *et al.* 1998; Moura *et al.* 2016).

Both species are known to occur in the South Atlantic, occurring as far south as northern Argentina in the west and South Africa in the east (Jefferson *et al.* 2015). There are 30 records of *Kogia* sp. for Namibia; most of these are strandings of pygmy sperm whales, but one live stranding of a dwarf sperm whale has also been reported (Elwen *et al.* 2013). Twenty-six sightings of dwarf sperm whales were made during seismic surveys off the coast Angola between 2004 and 2009 (Weir 2011). Findlay *et al.* (1992) reported numerous records of dwarf sperm whales for South Africa. *Kogia* sp. were sighted during surveys off St. Helena during August–October 2004 (Clingham *et al.* 2013). There are no records of *Kogia* sp. in the offshore waters of the proposed survey area (OBIS 2019). The only records in the OBIS database for the South Atlantic are for Africa; there are 57 records of *K. breviceps* and 22 records of *K. sima* exist for southwestern Africa (OBIS 2019). Both pygmy and dwarf sperm whales could be encountered in the proposed project area at the time of the surveys.

Arnoux's Beaked Whale

Arnoux's beaked whale is distributed in deep, cold, temperate, and subpolar waters of the Southern Hemisphere, occurring between 24° S and Antarctica (Thewissen 2018). 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). One sighting was made south of Africa at ~40° S during surveys of the Southern Ocean (Van Waerebeek *et al.* 2010). Arnoux's beaked whales likely occur in the Tristan da Cunha archipelago (Bester and Ryan 2007). There are three OBIS records for the Southeast Atlantic in South Africa and no records for the Southwest Atlantic (OBIS 2019). Based on information presented in Best (2007), it is more likely to be encountered in the southern Central, Gough, and Tristan survey areas than in the more northern survey area.

Cuvier's Beaked Whale

Cuvier's beaked whale is probably the most widespread and common of the beaked whales, although it is not found in high-latitude polar waters (Heyning 1989; Baird 2018a). It is rarely observed at sea and is known mostly from strandings; it strands more commonly than any other beaked whale (Heyning 1989). Cuvier's beaked whale is found in deep water in the open-ocean and over and near the continental slope (Gannier and Epinat 2008; Baird 2018a).

In the South Atlantic, there are stranding records for Brazil, Uruguay, Argentina, Falkland Islands, and South Africa (MacLeod *et al.* 2006; Otley *et al.* 2012; Fisch and Port 2013; Bortolotto *et al.* 2016; Riccialdelli *et al.* 2017). Sighting records exist for nearshore Brazil, South Africa, and the central South Atlantic and Southern Ocean (Findlay *et al.* 1992; MacLeod *et al.* 2006; Prado *et al.* 2016), as well as for Gabon (Weir 2007) and Angola (Best 2007; Weir 2019). UNEP/CMS (2012) reported its presence in Namibia. Bester and Ryan (2007) suggested that Cuvier's beaked whales likely occur in the Tristan da Cunha archipelago. There are 11 OBIS records for the South Atlantic, including Brazil, Namibia, and South Africa; however, there are no records within or near the proposed project area (OBIS 2019). Cuvier's beaked whale could be encountered in the proposed project area at the time of the surveys.

Southern Bottlenose Whale

The southern bottlenose whale 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 apparently migratory, occurring in Antarctic waters during summer (Jefferson *et al.* 2015). Several sighting and stranding records exist for southeastern South America, Falkland Islands, South Georgia Island, southeastern Brazil, and Argentina, and numerous sightings have been reported for the Southern Ocean (MacLeod *et al.* 2006; de Oliveira Santos and e Figueiredo 2016; Riccialdelli *et al.* 2017). Southern bottlenose whales were sighted near 45° S and south of there during surveys of the Southern Ocean (Van Waerebeek *et al.* 2010). There are eight records in the OBIS database for the South Atlantic, including one in the central South Atlantic at 37.1° S, 12.3° W, as well as Brazil, Namibia, and South Africa (OBIS 2019). Based on limited information on its distributional range (Best 2007; Jefferson *et al.* 2015), the southern bottlenose whale is more likely to occur in the southern survey areas than the Valdivia Bank survey area.

Shepherd's Beaked Whale

Based on known records, it is likely that Shepherd's beaked whale has a circumpolar distribution in the cold temperate waters of the Southern Hemisphere, between 33–50° S (Mead 2018). It is primarily known from strandings, most of which have been recorded in New Zealand and the Tristan da Cunha archipelago (Pitman *et al.* 2006; Mead 2018). The Tristan da Cunha archipelago has the second highest number of strandings (Mead 2018) and is thought to be a concentration area for Shepherd's beaked whales (Bester and Ryan 2007; Best *et al.* 2009). Pitman *et al.* (2006) and Best *et al.* (2009) reported six stranding records for Tristan da Cunha and possible sightings on the Tristan Plateau (2 sightings of 10 whales on 17 November 1985 near 37.3° S, 12.5° W) and Gough Island (one sighting of 4–5 animals). Another stranding of two whales on Tristan da Cunha occurred on 13 January 2012 (Best *et al.* 2014). Shepherd's beaked whales were sighted south of Africa during surveys of the Southern Ocean (Van Waerebeek *et al.* 2010). There are three records for the South Atlantic in the OBIS database, all southwest of South Africa (OBIS 2019). Based on limited information on its distributional range (Best 2007; Jefferson *et al.* 2015), Shepherd's beaked whale is more likely to occur in the southern survey areas than the Valdivia Bank survey area.

Blainville's Beaked Whale

Blainville's beaked whale is found in tropical and warm temperate waters of all oceans (Pitman 2018). It has the widest distribution throughout the world of all *Mesoplodon* species (Pitman 2018). In the South Atlantic, strandings have been reported for southern Brazil and South Africa (Findlay *et al.* 1992; Secchi and Zarzur 1999; MacLeod *et al.* 2006; Prado *et al.* 2016). A sighting was made during a boat survey off St. Helena in November 2007 (Clingham *et al.* 2013). There are 20 OBIS records for South Africa, but none for the offshore waters of the proposed project area (OBIS 2019). Based on limited information on its distributional range (Best 2007; Jefferson *et al.* 2015), Blainville's beaked whale could be encountered in the proposed project area.

Gray's Beaked Whale

Gray's beaked whale is thought to have a circumpolar distribution in temperate waters of the Southern Hemisphere (Pitman 2018). It primarily occurs in deep waters beyond the edge of the continental shelf (Jefferson *et al.* 2015). Some sightings have been made in very shallow water, usually of sick animals coming in to strand (Gales *et al.* 2002; Dalebout *et al.* 2004). There are numerous sighting records from Antarctic and sub-Antarctic waters (MacLeod *et al.* 2006); in summer months, Gray's beaked whales appear near the Antarctic Peninsula and along the shores of the continent (sometimes in the sea ice).

In the South Atlantic, several stranding records exist for Brazil, the southeast coast of South America, Falkland Islands, Namibia, and South Africa (Findlay *et al.* 1992; MacLeod *et al.* 2006; Otley 2012; Otley *et al.* 2012; Prado *et al.* 2016; Riccialdelli *et al.* 2017). Additionally, one sighting was reported off the southwestern tip of South Africa (MacLeod *et al.* 2006). A sighting was also made south of Arica near 45° S during surveys of the Southern Ocean (Van Waerebeek *et al.* 2010). UNEP/CMS (2012) reported their presence in Namibia. Gray's beaked whales likely occur in the Tristan da Cunha archipelago (Bester and Ryan 2007). However, there are no OBIS records for the offshore waters of the proposed project area, but there are records for Argentina and South Africa (OBIS 2019). Based on limited information on its distributional range (Best 2007; Jefferson *et al.* 2015). Gray's beaked whale is more likely to occur in the southern survey areas than the Valdivia Bank survey area.

Hector's Beaked Whale

Hector's beaked whale is thought to have a circumpolar distribution in temperate waters of the Southern Hemisphere (Pitman 2018). Like other Mesoplodonts, Hector's beaked whale likely inhabits deep waters (200–2000 m) in the open ocean or continental slopes (Pitman 2018). To date, Hector's beaked whales have only been identified from strandings and have not been observed in the wild (Pitman 2018). Based on the number of stranding records for the species, it appears to be relatively rare. Nonetheless, in the South Atlantic, strandings have been reported for southern Brazil, Argentina, Falkland Islands, and South Africa (MacLeod *et al.* 2006; Otley *et al.* 2012; Prado *et al.* 2016; Riccialdelli *et al.* 2017). However, there are no OBIS records for this species for the South Atlantic (OBIS 2019). Based on limited information on its distributional range (Best 2007; Jefferson *et al.* 2015). Hector's beaked whale is more likely to occur in the southern survey areas than the Valdivia Bank survey area.

Gervais' Beaked Whale

Although Gervais' beaked whale is generally considered to be a North Atlantic species, it likely occurs in deep waters of the temperate and tropical Atlantic Ocean in both the northern and southern hemispheres (Jefferson *et al.* 2015). Stranding records have been reported for Brazil and Ascension Island in the central South Atlantic (MacLeod *et al.* 2006). The southernmost stranding record was reported for São Paulo, Brazil, possibly expanding the known distributional range of this species southward (Santos *et al.* 2003). Although the distribution range of Gervais' beaked whale is not generally known to extend as far south as the proposed project area, this species might range as far south as Angola or northern Namibia in the South Atlantic (MacLeod *et al.* 2006; Best 2007; Jefferson *et al.* 2015). In fact, one stranding has been reported for Namibia (Bachara and Norman 2014). There are no OBIS records for the South Atlantic (OBIS 2019). Gervais' beaked whale could be encountered in the proposed project area at the time of the surveys.

True's Beaked Whale

True's beaked whale has a disjunct, antitropical distribution (Jefferson *et al.* 2015). In the Southern Hemisphere, it is known to occur in South Africa, South America, and Australia (Findlay *et al.* 1992; Souza *et al.* 2005; MacLeod and Mitchell 2006; MacLeod *et al.* 2006; Best *et al.* 2009). These areas may comprise three separate populations; the region of South Africa in the Indian Ocean is considered a key beaked whale area (MacLeod and Mitchell 2006). In the South Atlantic, True's beaked whale has stranded on Tristan da Cunha (Best *et al.* 2009). Based on stranding and sighting data, the proposed southern project area, including southern waters of Valdivia Bank survey area, is part of the possible range of True's beaked whale (MacLeod *et al.* 2006; Best 2007; Jefferson *et al.* 2015). There are 14 OBIS records for the South Atlantic, all for the off South Africa (OBIS 2019). True's beaked whale could be encountered in the proposed project area at the time of the surveys.

Strap-Toothed Beaked Whale

The strap-toothed beaked whale is thought to have a circumpolar distribution in temperate and subantarctic waters of the Southern Hemisphere, mostly between 32° and 63° S (MacLeod *et al.* 2006; Jefferson *et al.* 2015). It may undertake limited migration to warmer waters during the austral winter (Pitman 2018). Strap-toothed beaked whales are thought to migrate northward from Antarctic and subantarctic latitudes during April–September (Sekiguchi *et al.* 1995).

In the South Atlantic, stranding records have been reported for Brazil, Uruguay, Argentina, Falkland Islands, South Georgia, Namibia, and South Africa (Findlay *et al.* 1992; Pinedo *et al.* 2002; MacLeod *et al.* 2006; Otley *et al.* 2012; Prado *et al.* 2016; Riccialdelli *et al.* 2017). In addition, sightings have been reported off the southern tip of Africa, near Bouvet Island, and in the Southern Ocean (Finlay *et al.* 1992; MacLeod *et al.* 2006). One sighting was made south of Africa during surveys of the Southern Ocean (Van Waerebeek *et al.* 2010). Bester and Ryan (2007) suggested that strap-toothed beaked whales likely occur in the Tristan da Cunha archipelago (Bester and Ryan 2007). There are 38 OBIS records for the South Atlantic, including for Argentina, Namibia, and South Africa; however, there are no records in the offshore waters of the proposed project area (OBIS 2019). Based on limited information on its distributional range (Best 2007; Jefferson *et al.* 2015), strap-toothed beaked whales are more likely to occur in the southern survey areas than the Valdivia Bank survey area.

Andrew's Beaked Whale

Andrew's beaked whale has a circumpolar distribution in temperate waters of the Southern Hemisphere (Baker 2001; Pitman 2018). It is known only from stranding records between 32° S and 55° S, with more than half of the strandings occurring in New Zealand (Jefferson *et al.* 2015). In the South Atlantic, Andrew's beaked whales have also stranded in the Tristan da Cunha archipelago, Falkland Islands, Argentina, and Uruguay (Baker 2001; Laporta *et al.* 2005; MacLeod *et al.* 2006; Best *et al.* 2009; Otley *et al.* 2012; Riccialdelli *et al.* 2017). There are no OBIS records for the South Atlantic (OBIS 2019). Based on limited information on its distributional range (Best 2007; Jefferson *et al.* 2015), Andrew's beaked whale is more likely to occur in the southern survey areas than the Valdivia Bank survey area.

Spade-Toothed Beaked Whale

The spade-toothed beaked whale is the name proposed for the species formerly known as Bahamonde's beaked whale (*M. bahamondi*); genetic evidence has shown that it belongs to the species first identified by Gray in 1874 (Van Helden *et al.* 2002). The spade-toothed beaked whale is considered relatively rare and is known from only four records, three from New Zealand and one from Chile (Thompson *et al.* 2012). Although no records currently exist for the South Atlantic, the known records at similar latitudes suggest that the spade-toothed beaked whale could occur in the proposed project area.

Risso's Dolphin

Risso's dolphin is distributed worldwide in mid-temperate and tropical oceans (Kruse *et al.* 1999), although it shows a preference for mid-temperate waters of the shelf and slope between 30° and 45° S (Jefferson *et al.* 2014). Although it occurs from coastal to deep water (~200–1000 m depth), it shows a strong preference for mid-temperate waters of upper continental slopes and steep shelf-edge areas (Hartman 2018). In the southeastern Atlantic Ocean, there are records spanning from Gabon to South Africa (Jefferson *et al.* 2014). It appears to be relatively common off Angola; 75 sightings were made during seismic surveys off the coast of northern Angola between 2004 and 2009, including in deep slope waters (Weir 2011). Four sightings were also made off Gabon (Weir 2011). It was also sighted during surveys off southern Africa, and there are stranding records for Namibia (Findlay *et al.* 1992). There are 54 records for the South Atlantic in the OBIS database, including for Argentina, Namibia, and South Africa; however, there are no records in the proposed project area. Risso's dolphin could be encountered in the proposed survey areas at the time of the surveys.

Rough-Toothed Dolphin

The rough-toothed dolphin is distributed worldwide in tropical and subtropical waters (Jefferson *et al.* 2015). It is generally seen in deep, oceanic water, although it is known to occur in coastal waters of Brazil (Jefferson *et al.* 2015; Cardoso *et al.* 2019). In the Southeast Atlantic, rough-toothed dolphins have been sighted off Namibia (Findlay *et al.* 1992), Gabon (de Boer 2010), and Angola (Weir 2007, 2010). Eighteen sightings were made during seismic surveys off the coast of northern Angola between 2004 and 2009, including in deep slope waters; one sighting was also made off Gabon (Weir 2011). Rough-toothed dolphins have also been sighted at St. Helena (MacLeod and Bennett 2007; Clingham *et al.* 2013), near the Central survey area at 32.5° S, 2.0° W (Peters 1876 *in* Best *et al.* 2009), and near 37° S, 15° E (Scheidat *et al.* 2011). One rough-toothed dolphin sighting was made during an August–September 2010 survey off Brazil from Vitória at ~20° S, 40° W to Trindade and Martim Vaz islands; the group of 30 individuals was seen in association with two minke whales at ~19.1° S, 35.1° W on 21 August (Wedekin *et al.* 2014). For the South Atlantic, there are 42 records of rough-toothed dolphin in the OBIS database, including off Brazil, central West Africa, and South Africa (OBIS 2019). Rough-toothed dolphins could be encountered in the proposed project area during the surveys.

Common Bottlenose Dolphin

The bottlenose dolphin occurs in tropical, subtropical, and temperate waters throughout the world (Wells and Scott 2018). Although it is more commonly found in coastal and shelf waters, it can also occur in deep offshore waters (Jefferson *et al.* 2015). Jefferson *et al.* (2015) reported central pelagic waters of the South Atlantic Ocean (within the proposed project area) as secondary range for the bottlenose dolphin. In the southeastern South Atlantic, common bottlenose dolphins occur off Gabon (de Boer 2010), Angola (Weir 2007, 2010), Namibia (Findlay *et al.* 1992; Peddemors 1999), and South Africa (Findlay *et al.* 1992). Off Namibia, there is likely an inshore and an offshore ecotype (Peddemors 1999). Numerous sightings were made during seismic surveys off the coast of northern Angola between 2004 and 2009, including in deep slope waters; sightings were also made off Gabon (Weir 2011).

Three sightings of common bottlenose dolphins were made at Trindade Island during December 2009–February 2010 surveys; two sightings of 15 individuals were made during December and a single bottlenose dolphin was sighted on 23 February (Carvalho and Rossi-Santos 2011). Additionally, two sightings of common bottlenose dolphins were made during an August–September 2010 survey from Vitória at ~20° S, 40° W to Trindade and Martim Vaz islands; both groups were seen on 30 August at Trindade Island, near 20.5° S, 29.3° W (Wedekin *et al.* 2014). Common bottlenose dolphins have also been sighted near St. Helena (MacLeod and Bennett 2007; Clingham *et al.* 2013). There are 132 OBIS records for the western and eastern South Atlantic; however, there are no records in the offshore waters of the proposed project area (OBIS 2019). Common bottlenose dolphins could be encountered in the proposed project area during the surveys (Jefferson *et al.* 2015).

Pantropical Spotted Dolphin

The pantropical spotted dolphin is distributed worldwide in tropical and some subtropical waters, between ~40° N and 40° S (Jefferson *et al.* 2015). It is one of the most abundant cetaceans and is found in coastal, shelf, slope, and deep waters (Perrin 2018a). In the South Atlantic, pantropical spotted dolphins have been sighted off Brazil (Moreno *et al.* 2005), Gabon (de Boer 2010), Angola (Weir 2007, 2010), and St. Helena (MacLeod and Bennett 2007; Clingham *et al.* 2013). Four sightings were made during seismic surveys off the coast off northern Angola between 2004 and 2009, including in deep slope waters; and additional four sightings were made off Gabon (Weir 2011). Findlay *et al* (1992) reported sightings off the east coast of South Africa. In the OBIS database, there is one record for Brazil and one record for South Africa (OBIS 2019). Based on its distributional range (Best 2007; Jefferson *et al.* 2015), pantropical spotted dolphins could be encountered during the proposed surveys.

Atlantic Spotted Dolphin

The Atlantic spotted dolphin is distributed in tropical and warm temperate waters of the North Atlantic from Brazil to New England and to the coast of Africa (Jefferson *et al.* 2015). Although its distributional range appears to be just to the north of the proposed project area (Best 2007; Jefferson *et al.* 2015), Culik (2004) reported its presence in Namibia. These dolphins were one of the most frequently sighted cetaceans during seismic surveys off the coast of northern Angola between 2004 and 2009, including in deep slope waters; about 100 sightings were made off Angola and several sightings were also made off Gabon (Weir 2011). For the South Atlantic, there is one record for Brazil in the OBIS database (OBIS 2019). Atlantic spotted dolphins could be encountered in the proposed project area during the surveys.

Spinner Dolphin

The spinner dolphin is pantropical in distribution, with a range nearly identical to that of the pantropical spotted dolphin, including oceanic tropical and sub-tropical waters between 40° N and 40° S (Jefferson *et al.* 2015). Spinner dolphins are extremely gregarious, and usually form large schools in the open sea and small ones in coastal waters (Perrin and Gilpatrick 1994).

Its distributional range appears to be to the north of the proposed survey area in the South Atlantic (Best 2007; Jefferson *et al.* 2015). One group of three individuals was seen near the 1000-m isobath during seismic surveys off the coast of northern Angola between 2004 and 2009 (Weir 2011). There are two OBIS records for the South Atlantic: One sighting north of the Falkland Islands at 47.4° S, 54.2° W and another off Brazil (OBIS 2019). Based on distributional information (Best 2007; Jefferson *et al.* 2015), spinner dolphins could be encountered during the proposed surveys, most likely in the northern parts of the Valdivia Bank survey area.

Clymene Dolphin

The clymene dolphin only occurs in tropical and subtropical waters of the Atlantic Ocean (Jefferson *et al.* 2015). It inhabits areas where water depths are 700–4,500 m or deeper (Fertl *et al.* 2003). In the western Atlantic, it occurs from New Jersey to Florida, the Caribbean Sea, the Gulf of Mexico and south to Venezuela and Brazil (Würsig *et al.* 2000; Fertl *et al.* 2003).

In the eastern Atlantic, they have been sighted as far south as Angola (Weir 2006; Weir *et al.* 2014). One sighting was made during seismic surveys off the coast of northern Angola between 2004 and 2009 (Weir 2011). Currently available information indicates that only the northern-most proposed project area might overlap with its distributional range (*e.g.,* Fertl *et al.* 2003; Best 2007; Jefferson *et al.* 2015), although Weir *et al.* (2014) noted that it is unlikely that this species occurs farther south than Angola due to the cold Benguela Current there. There are no OBIS records for the South Atlantic (OBIS 2019). Based on distributional information (Best 2007; Jefferson *et al.* 2015), Clymene dolphins could be encountered in the northern parts of the Valdivia Bank survey area.

Striped Dolphin

The striped dolphin has a cosmopolitan distribution in tropical to warm temperate waters from ~50° N to 40° S (Perrin *et al.* 1994; Jefferson *et al.* 2015). It occurs primarily in pelagic waters, but has been observed approaching shore where there is deep water close to the coast (Jefferson *et al.* 2015). In the South Atlantic, it is known to occur along the coast of South America, from Brazil to Argentina, and along the west coast of Africa (Jefferson *et al.* 2015).

Sightings have been made on the west coast of South Africa (Findlay *et al.* 1992). Sixty-six sightings were made during seismic surveys off the coast of northern Angola between 2004 and 2009, including in deep slope waters (Weir 2011). There are approximately 60 OBIS records for the South Atlantic, including nearshore waters of Brazil, Uruguay, Argentina, Angola, and South Africa, and 19 records for offshore waters near 8.4° S, 24.4° W (OBIS 2019). Based on distributional information (Best 2007; Jefferson *et al.* 2015), striped dolphins could be encountered during the proposed surveys.

Short-Beaked Common Dolphin

The short-beaked common dolphin is found in tropical and warm temperate oceans around the world (Jefferson *et al.* 2015), ranging from ~60° N to ~50° S (Jefferson *et al.* 2015). It is the most abundant dolphin species in offshore areas of warm-temperate regions in the Atlantic and Pacific (Perrin 2018c).

In the South Atlantic, the short-beaked common dolphin occurs along the coasts of South America and Africa (Perrin 2018c). Although according to Jefferson *et al.* (2015) and Perrin (2018c), its occurrence in central oceanic waters of the South Atlantic is uncertain, Best (2007) reported a few records between 30–41° S, 15° W–10° E. Sightings have also been reported along the coast of Namibia (Best 2007; NDP unpublished data *in* Pisces Environmental Services 2017). Sightings have been reported off the west coast of southern Africa during summer and winter, and there are stranding records for Namibia (Findlay *et al.* 1992). About 100 sightings of *Delphinus* sp. were made during seismic surveys off the coast of northern Angola between 2004 and 2009, including in deep slope waters; sightings were also made off Gabon (Weir 2011). For the South Atlantic, there are 7 OBIS records for waters off Argentina and nearly 80 records for southwestern Africa, including Namibia and South Africa (OBIS 2019). Short-beaked common dolphins could be encountered in the proposed project area at the time of the surveys.

Fraser's Dolphin

Fraser's dolphin is a tropical oceanic species generally distributed between 30° N and 30° S that generally inhabits deeper, offshore water (Dolar 2018). Strandings in more temperate waters, such as in Uruguay, are likely extralimital (Dolar 2018). Three sightings were made during seismic surveys off the coast of northern Angola between 2004 and 2009, all in water deeper than 1000 m; one sighting was made in the Gulf of Guinea (Weir *et al.* 2008; Weir 2011). Fraser's dolphin has also been sighted off the east coast of South Africa (Findlay *et al.* 1992). There are 24 OBIS records for the South Atlantic, all along the coast of South America (OBIS 2019). Based on its distribution (Jefferson *et al.* 2015), Fraser's dolphin could be encountered during the proposed surveys, but is more likely to be seen in the northern portions of the Valdivia Bank survey area than elsewhere.

Dusky Dolphin

The dusky dolphin occurs throughout the Southern Hemisphere, primarily over continental shelves and slopes and sometimes over deep water close to continents or islands (Van Waerebeek and Würsig 2018). In the southeastern Atlantic, it occurs along the coast of Angola, Namibia, and South Africa, as well as Tristan da Cunha (Findlay *et al.* 1992; Culik 2004; Weir 2019). It appears to occur off the west coast of southern Africa year-round (Findlay *et al.* 1982). According to Jefferson *et al.* (2015), it is unlikely to occur in the deep waters of the proposed project area.

It has been observed in groups of 10 to 20 individuals preying on Cape horse mackerel off Namibia (Bernasconi *et al.* 2011), and it has been seen in mixed groups with southern right whale dolphins there (Culik 2004). It was sighted during spring surveys off west coast of South Africa during 2014 (Seakamala *et al.* 2015). It has also been reported near Gough Island; animals there likely make up a disjunct oceanic population rather than suggesting movement of individuals between South America and southern Africa (Cassens *et al.* 2005). There are ~150 OBIS records for the South Atlantic, but none occur within the proposed project area. The dusky dolphin is unlikely to be encountered in the proposed survey areas in the southeastern Atlantic, and is not expected to occur in the Libra Massif survey area.

Hourglass Dolphin

The hourglass dolphin occurs in all parts of the Southern Ocean, with most sightings between ~45° S and 60° S (Cipriano 2018a). However, some sightings have been made as far north as 33° S (Jefferson *et al.* 2015). Although it is pelagic, it is also sighted near banks and islands (Cipriano 2018a). There are approximately 45 records in the OBIS database for the Southwest Atlantic, but none within the Libra Massif survey area (OBIS 2019). Based on its known distributional range (Best 2007; Jefferson *et al.* 2015), it could occur in the southern-most portions of the proposed project area.

Southern Right Whale Dolphin

The southern right whale dolphin is distributed between the Subtropical and Antarctic convergences in the Southern Hemisphere, generally between ~30° S and 65° S (Jefferson *et al.* 2015; Lipsky and Brownell 2018). It is sighted most often in cool, offshore waters, although it is sometimes seen near shore where coastal waters are deep (Jefferson *et al.* 2015). It is also known to occur off Namibia (Findlay *et al.* 1992; Culik 2004), where it has been seen out to the 1000-m isobath (Rose and Payne 1991); it is thought to occur in the region year-round (Rose and Payne 1991). However, Best (2007) did not report any sightings in the Valdivia Bank survey area. There are no records for the South Atlantic in the OBIS database (OBIS 2019). Bester and Ryan (2007) suggested that southern right whale dolphins might be visitors to the southern waters of the Tristan da Cunha archipelago. One was captured near Tristan da Cunha on 10 December 1847 at 37.1° S, 11.6° W (Cruickshank and Brown 1981 *in* Best *et al.* 2009). There are no records for the South Atlantic in the OBIS database (OBIS 2019). According its distribution range (Best 2007; Jefferson *et al.* 2015), southern right whale dolphins could occur in the proposed project area, although they are more likely to be encountered in the more southerly survey areas.

Killer Whale

Killer whales 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). In the southeastern Atlantic, killer whales are known to occur off Gabon (de Boer 2010; Weir 2010), Angola (Weir 2007, 2010, 2011), as well as Namibia and South Africa (Findlay *et al.* 1992; Best 2007; Elwen and Leeney 2011). Sightings of killer whale pods of 1 to >100 individuals have been made near the proposed survey areas during November and December (Budylenko 1981; Mikhalev *et al.* 1981). Eighteen sightings were made during seismic surveys off northern Angola between 2004 and 2009, including in deep slope waters; one sighting was made off Gabon (Weir 2011). The number of sightings are thought to decrease north of Cape Town, South Africa, but sightings have been made year round, including in offshore waters (up to 600 km from shore), but not within the proposed project area (Rice and Saayman 1987). Killer whales are known to prey on longline catches in the waters off South Africa (Williams *et al.* 2009). Sightings of killer whale pods of 1 to >100 individuals have been made near the Libra Massif survey area during November (Budylenko 1981; Mikhalev *et al.* 1981). A sighting was made south of the proposed survey areas at approximately 45° S, 8° W (Scheidat *et al.* 2011). There are about 55 records of killer whales for the South Atlantic in the OBIS database, including records for offshore and nearshore waters of South America, as well as South Africa (OBIS 2019); however, there are no records near the proposed survey areas.

Short-Finned and Long-Finned Pilot Whale

The short-finned pilot whale is found in tropical and warm temperate waters, and the long-finned pilot whale is distributed antitropically in cold temperate waters (Olson 2018). The ranges of the two species show little overlap (Olson 2018). Short-finned pilot whale distribution does not generally range south of 40° S (Jefferson *et al.* 2008). Short-finned pilot whales were the most frequently sighted cetacean during seismic surveys off the coast of Angola between 2004 and 2009; more than 100 sightings were off Angola including in deep slope waters and several sightings were also reported off Gabon (Weir 2011). There are records of long-finned pilot whales for South Africa and Namibia (Findlay *et al.* 1992; Best 2007). Long-finned pilot whales are considered uncommon in Tristan waters (Bester and Ryan 2007); pilot whales have stranded on the islands of the Tristan da Cunha archipelago, although it is uncertain what species they were (Best *et al.* 2009). There is a single record of short-finned pilot whales in the Southwest Atlantic Ocean, but there are >100 long-finned pilot whale records for the waters off South America, Namibia, South Africa, and the central Atlantic Ocean (OBIS 2019). Based on their distributional ranges (Best 2007; Jefferson *et al.* 2015), short-finned pilot whales are more likely to occur in the Valdivia Bank survey area, whereas long-finned pilot whales are more likely to occur in the more southern survey areas.

False Killer Whale

The false killer whale is found worldwide in tropical and temperate waters, generally between 50° N and 50° S (Odell and McClune 1999). It is widely distributed, but not abundant anywhere (Carwardine 1995).

The false killer whales occurs throughout the South Atlantic. In the southeast Atlantic Ocean, 13 sightings were made during seismic surveys off the coast of northern Angola between 2004 and 2009, all in water deeper than 1000 m (Weir 2011). Stranding records and sightings also exist for Namibia and South Africa (Findlay *et al.* 1992). They have also been recorded around St. Helena (Clingham *et al.* 2013). Predation events by killer whales or false killer whales in the Uruguayan longline fishery were recorded north of the Libra Massif survey area (Passadore *et al.* 2014, 2015). Although there are no OBIS records of false killer whales for the offshore waters of the proposed project area, there are 91 records for the South Atlantic, including offshore waters off South America and nearshore waters of Namibia and South Africa; however, there are no records near the proposed survey areas (OBIS 2019). Based on its distributional range (Best 2007; Jefferson *et al.* 2015), the false killer whale could be encountered in the proposed project areas.

Pygmy Killer Whale

The pygmy killer whale has a worldwide distribution in tropical and subtropical waters, generally not ranging south of 35° S (Jefferson *et al.* 2015). It is known to inhabit the warm waters of the Indian, Pacific, and Atlantic oceans (Jefferson *et al.* 2015). It can be found in nearshore areas where the water is deep and in offshore waters (Jefferson *et al.* 2015). In the southeast Atlantic, there are stranding records along the coast of southern Africa, including Namibia (Findlay *et al.* 1992). There is one stranding record for Brazil (Santos *et al.* 2010). There are seven OBIS records for the Southeast Atlantic Ocean, but no records for the offshore waters of the proposed survey areas (OBIS 2019). Based on its distributional range (Best 2007; Jefferson *et al.* 2015), the pygmy killer whale could be encountered in the proposed survey areas.

Melon-Headed Whale

The melon-headed whale is an oceanic species found worldwide in tropical and subtropical waters from ~40° N to 35° S (Jefferson *et al.* 2015). It occurs most often in deep offshore waters and occasionally in nearshore areas where the water is deep (Jefferson *et al.* 2015). Off the west coast of Africa, melon-headed whales have been recorded off Gabon (de Boer 2010; Weir 2011) and Angola (Weir 2007a, 2010, 2011). Four sightings were made during seismic surveys off the coast of northern Angola between 2004 and 2009, all in water deeper than 1000 m (Weir 2011). Extralimital record exists for South Africa (Peddemors 1999; Jefferson *et al.* 2015). There is one OBIS record for South Africa (OBIS 2019). Based on its distributional range (Best 2007; Jefferson *et al.* 2015), melon-headed whale could be encountered in the northern portion of the Valdivia Bank survey area.

Pinnipeds

Subantarctic Fur Seal

Subantarctic fur seals occur between 10° W and 170° E north of the Antarctic Polar Front in the Southern Ocean (Hofmeyr and Bester 2018). Breeding occurs on several islands, with Gough Island in the central South Atlantic accounting for about two thirds of pup production (Hofmeyr and Bester 2018), but adults take long foraging journeys away from these colonies. Vagrant subantarctic fur seals have been reported in South Africa (Shaughnessy and Ross 1980). The at-sea distribution of subantarctic fur seals is poorly understood, although they are often seen in the waters between Tristan da Cunha and South Africa (Bester and Ryan 2007). There are 35 OBIS records for the South Atlantic, including in nearshore and offshore waters of South Africa, and 21 records at 40.3° S, 9.9° W; however, there are no records for the proposed project area (OBIS 2019).

Cape Fur Seal

The Cape fur seal is endemic to the west coast of southern Africa, occurring from Algoa Bay, South Africa to Ilha dos Tigres, Angola (Kirkman *et al.* 2013). The population severely declined between the 17th and 19th century, due to sealing and guano collection on many of the breeding islands (Kirkman *et al.* 2007). However, the population recovered when sealing limits were imposed in the early 20th century, and the population is now estimated to number ~2 million individuals (Kirkman *et al.* 2007). There have also been two mass die-offs of Cape fur seals in Namibia that were related to poor environmental conditions and reduced prey (Roux *et al.* 2002 *in* Kirkman *et al.* 2007).

The Cape fur seal currently breeds at 40 colonies along the coast of South Africa, Namibia, and Angola, including on the mainland and nearshore islands (Kirkman *et al.* 2013). There have been several new breeding colonies established in recent years, as the population has shifted northward (Kirkman *et al.* 2013). More than half of the seal population occurs in Namibia (Wickens *et al.* 1991). High densities have been observed between 30 and 60 n.mi. from shore, with densities dropping farther offshore (Thomas and Schülein 1988). Cape fur seals typically forage over the shelf up to ~220 km offshore (Shaughnessy 1979), but they are known to travel distances up to 1970 km along the coast of South America (Oosthuizen 1991). Breeding occurs during November and December (Warneke and Shaughnessy 1985 *in* Kirkman and Arnould 2018). There are over 2000 OBIS records along the coasts of Namibia and South Africa, but no records for the offshore survey areas. As Cape fur seals typically remain over the shelf to forage and are breeding during the time of the survey, they are unlikely to be encountered in the offshore project area.

Crabeater Seal

Crabeater seals 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). There are two records of crabeater seals for South Africa in the OBIS database (OBIS 2019).

Leopard Seal

The leopard seal has a circumpolar distribution around the Antarctic continent where it is solitary and widely dispersed (Rogers 2018). Leopard seals are top predators, consuming everything from krill and fish to penguins and other seals (*e.g.,* Hall-Aspland and 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. There is one record for South Africa in the OBIS database (OBIS 2019).

Southern Elephant Seal

The southern elephant seal 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 and 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–October) or molting (November–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 and 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). For the South Atlantic, there are more than 2000 OBIS records for the nearshore and offshore waters of South America and along the coasts of Namibia and South Africa (OBIS 2019). Most of the records (1793) are for waters of the Patagonian Large Marine Ecosystem (Campagna *et al.* 2006), but none occur within the proposed project area.

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. Forty-eight marine mammal species (43 cetacean and 5 pinniped (2 otariid and 3 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, 9 are classified as low-frequency cetaceans (*i.e.,* all mysticete species), 31 are classified as mid-frequency cetaceans (*i.e.,* most delphinid and ziphiid species and the sperm whale), and 3 are classified as high-frequency cetaceans (*i.e.,* Kogia spp., hourglass dolphin).

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 by Incidental Harassment* 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 by Incidental Harassment* 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 1 microPascal (μPa)) and is a logarithmic unit that accounts for large variations in amplitude; therefore, a relatively small change in dB corresponds to large changes in sound pressure. The source level (SL) represents the SPL referenced at a distance of 1 m from the source (referenced to 1 μPa) while the received level is the SPL at the listener's position (referenced to 1 μPa).

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 6 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 EM 300 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. 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 *Thompson'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.

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. Therefore, we do not consider noise from the MBES or SBP 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 (*Description of Active Acoustic Sound Sources* section) 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 (2018).

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, l*et al*one 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 6 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 *Thompson* 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 *Thompson* travels at a speed of either 5 (9.3 km/hour) or 8 kn (14.8 km/hour) while towing seismic survey gear (LGL 2019). 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 some 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. 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.

A modeling exercise was conducted as a follow-up to the McCauley *et al.* (2017) study (as recommended by McCauley *et al.*), in order to assess the potential for impacts on ocean ecosystem dynamics and zooplankton population dynamics (Richardson *et al.,* 2017). Richardson *et al.* (2017) found that for copepods with a short life cycle in a high-energy environment, a full-scale airgun survey would impact copepod abundance up to three days following the end of the survey, suggesting that effects such as those found by McCauley *et al.* (2017) would not be expected to be detectable downstream of the survey areas, either spatially or temporally.

Notably, a recently described study produced results inconsistent with those of McCauley *et al.* (2017). Researchers conducted a field and laboratory study to assess if exposure to airgun noise affects mortality, predator escape response, or gene expression of the copepod *Calanus finmarchicus* (Fields *et al.,* 2019). Immediate mortality of copepods was significantly higher, relative to controls, at distances of 5 m or less from the airguns. Mortality one week after the airgun blast was significantly higher in the copepods placed 10 m from the airgun but was not significantly different from the controls at a distance of 20 m from the airgun. The increase in mortality, relative to controls, did not exceed 30 percent at any distance from the airgun. Moreover, the authors caution that even this higher mortality in the immediate vicinity of the airguns may be more pronounced than what would be observed in free-swimming animals due to increased flow speed of fluid inside bags containing the experimental animals. There were no sublethal effects on the escape performance or the sensory threshold needed to initiate an escape response at any of the distances from the airgun that were tested. Whereas McCauley *et al.* (2017) reported an SEL of 156 dB at a range of 509–658 m, with zooplankton mortality observed at that range, Fields *et al.* (2019) reported an SEL of 186 dB at a range of 25 m, with no reported mortality at that distance.

Regardless, if we assume a worst-case likelihood of severe impacts to zooplankton within approximately 1 km of the acoustic source, the typically wide dispersal of survey vessels and brief time to regeneration of the potentially affected zooplankton populations does not lead us to expect any meaningful follow-on effects to the prey base for odontocete predators. Given the inconsistency of the McCauley *et al.* (2017) results with prior research on impacts to zooplankton as a result of exposure to airgun noise and with the research of Fields *et al.* (2019), further validation of those findings would be necessary to assume that these impacts are likely to occur. Moreover, a single study is not sufficient to evaluate the potential impacts, and further study in additional locations must be conducted.

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 in the *Acoustic Effects* section), 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.

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, as use of the acoustic sources (*i.e.,* seismic airgun) has the potential to result in disruption of behavioral patterns for individual marine mammals. Based on the nature of the activity and the anticipated effectiveness of the mitigation measures (*i.e.,* marine mammal exclusion zones) 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 permanent 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.

SIO's proposed activity includes the use of impulsive seismic sources, and therefore the 160 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) (NMFS, 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). SIO's proposed activity includes the use of impulsive seismic 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.*

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Table 4. Thresholds identifying the onset of Permanent Threshold Shift.

	PTS Onset Acoustic Thresholds* (Received Level)	
Hearing Group	**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.

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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.

The proposed survey would entail the use of a 2-airgun array with a total discharge of 90 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, comparisons at short ranges between sound levels for direct arrivals recorded by the calibration hydrophone and model results for the same array tow depth are in good agreement (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, whereas 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-in^3 guns at a tow depth of 2–4 m. For deep water (>1,000 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).

L–DEO's modeling methodology is described in greater detail in SIO'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 5.

TABLE 5—PREDICTED RADIAL DISTANCES FROM R/V *Thompson* SEISMIC SOURCE TO ISOPLETHS CORRESPONDING TO LEVEL B HARASSMENT THRESHOLD

Airgun configuration	Water depth (m)	Predicted distances (m) to 160 dB received sound level
Two 45 in^3 guns, 2-m separation	>1,000 (deep)	[a] 539
	100–1,000 (intermediate)	[b] 809
Two 45 in^3 guns, 8-m separation	>1,000 (deep)	[a] 578
	100–1,000 (intermediate)	[b] 867

[a] Distance based on L–DEO model results.
[b] Distance based on L–DEO model results with a 1.5 x correction factor between deep and intermediate water depths.
[c] Distance based on empirically derived measurements in the Gulf of Mexico with scaling applied to account for differences in tow depth.

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 2018). 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 2–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 we use this method for consistency across all array sizes.

SIO 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 *Appendix A: Determination of Mitigation Zones* in SIO's IHA application.

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Table 6. Modeled Source Levels (dB) for R/V *Thompson* 90 in³ Airgun Arrays.

Functional Hearing Group	8-kn survey with 8-m airgun separation: Peak SPL_{flat}	8-kn survey with 8-m airgun separation: SEL_{cum}	5-kn survey with 2-m airgun separation: Peak SPL_{flat}	5-kn survey with 2-m airgun separation: SEL_{cum}
Low frequency cetaceans ($L_{pk,flat}$: 219 dB; $L_{E,LF,24h}$: 183 dB)	228.8	207	232.8	206.7
Mid frequency cetaceans ($L_{pk,flat}$: 230 dB; $L_{E,MF,24h}$: 185 dB)	N/A[1]	206.7	229.8	206.9
High frequency cetaceans ($L_{pk,flat}$: 202 dB; $L_{E,HF,24h}$: 155 dB)	233	207.6	232.9	207.2
Phocid Pinnipeds (Underwater) ($L_{pk,flat}$: 218 dB; $L_{E,HF,24h}$: 185 dB)	230	206.7	232.8	206.9
Otariid Pinnipeds (Underwater) ($L_{pk,flat}$: 232 dB; $L_{E,HF,24h}$: 203 dB)	N/A[1]	203	225.6	207.4

[1] N/A indicates source level not applicable or not available. There are no values for the 2 x 45 cu.in at 4m depth with an 8m separation for the MF cetaceans and Otariids (maximum peak value is 221dB so less than 230 or 232dB). Therefore, we cannot provide any radial distance or modified peak farfield values for these two hearing groups.

In order to more realistically incorporate the Technical Guidance's weighting functions over the seismic array's full acoustic band, unweighted spectrum data for the *Thompson's* airgun array (modeled in 1 Hz bands) was used to make adjustments (dB) to the unweighted spectrum levels, by frequency, according to the weighting functions for each relevant marine mammal hearing group. These adjusted/weighted spectrum levels were then converted to pressures (μPa) in order to integrate them over the entire broadband spectrum, resulting in broadband weighted source levels by hearing group that could be directly incorporated within the User Spreadsheet (*i.e.,* to override the Spreadsheet's more simple weighting factor adjustment). Using the User Spreadsheet's ''safe distance'' methodology for mobile sources (described by Sivle *et al.,* 2014) with the hearing group-specific weighted source levels, and inputs assuming spherical spreading propagation and source velocities and shot intervals provided in SIO's IHA application, potential radial distances to auditory injury zones were calculated for SEL_{cum} thresholds, for both array configurations.

Inputs to the User Spreadsheet in the form of estimated SLs are shown in Table 6. User Spreadsheets used by SIO to estimate distances to Level A harassment isopleths for the two potential airgun array configurations are shown in Tables A–4 and A–5 in *Appendix A* of SIO's IHA application. Outputs from the User Spreadsheet in the form of estimated distances to Level A harassment isopleths are shown in Table 7. As described above, NMFS considers onset of PTS (Level A harassment) to have occurred when either one of the dual metrics (SEL_{cum} or Peak SPL_{flat}) is exceeded (*i.e.,* metric resulting in the largest isopleth).

Table 7. Modeled Radial Distances to Isopleths Corresponding to Level A Harassment Thresholds.

Functional Hearing Group (Level A harassment thresholds)	8-kn survey with 8-m airgun separation: Peak SPL_{flat}	8-kn survey with 8-m airgun separation: SEL_{cum}	5-kn survey with 2-m airgun separation: Peak SPL_{flat}	5-kn survey with 2-m airgun separation: SEL_{cum}
Low frequency cetaceans ($L_{pk,flat}$: 219 dB; $L_{E,LF,24h}$: 183 dB)	3.08	2.4	4.89	6.5
Mid frequency cetaceans ($L_{pk,flat}$: 230 dB; $L_{E,MF,24h}$: 185 dB)	0	0	0.98	0
High frequency cetaceans ($L_{pk,flat}$: 202 dB; $L_{E,HF,24h}$: 155 dB)	34.84	0	34.62	0
Phocid Pinnipeds (Underwater) ($L_{pk,flat}$: 218 dB; $L_{E,HF,24h}$: 185 dB)	4.02	0	5.51	0.1
Otariid Pinnipeds (Underwater) ($L_{pk,flat}$: 232 dB; $L_{E,HF,24h}$: 203 dB)	0	0	0.48	0

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Note that because of some of the assumptions included in the methods used, isopleths produced may be overestimates to some degree, which will ultimately result in some degree of overestimate of take by Level A harassment. 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 the proposed seismic survey, 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.

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.

SIO determined that the preferred source of density data for marine mammal species that might be encountered in the proposed survey areas in the South Atlantic Ocean was Di Tullio *et al.* (2016). The rationale for using these data was that these surveys were conducted offshore along the continental slope at the same latitudes as the proposed seismic surveys and so come from a similar season, water depth category, and climatic region in the southern Atlantic Ocean. When data for species expected to occur in the proposed seismic survey areas were not available in Di Tullio *et al.* (2016), data from White *et al.* (2002) was used as calculated in LGL/NSF (2019) because they came from an area which was slightly south of the proposed project area but well north of the AECOM/NSF (2014) study area. An exception was made for the southern right whale, for which densities from AECOM/NSF (2014) were higher and thus more conservative. Next data came from AECOM/NSF (2014); although they come from an area south of the proposed project area, they were the next best data available for those species. For species not included in these sources stated above, data came from from de Boer (2010), Garaffo *et al.* (2011), NOAA–SWFSC LOA (2013 in AECOM/NSF 2014), Wedekin *et al.* (2014), Bradford *et al.* (2017), and Mannocci *et al.* (2017). When densities were not directly available from the above studies, they were estimated using sightings and effort reported in those sources. Densities calculated from de Boer (2010) come from LGL/NSF (2016); densities from White *et al.* (2002), Garaffo *et al.* (2011), and Wedekin *et al.* (2014) are from LGL/NSF (2019). Data sources and density calculations are described in detail in Appendix B of SIO'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 8.

TABLE 8—MARINE MAMMAL DENSITIES IN THE PROPOSED SURVEY AREA

Species	Estimated density (#/km²) [a]
LF Cetaceans	
Southern right whale	*0.007965*
Pygmy right whale	N.A.
Blue whale	*0.000051*
Fin whale	*0.000356*
Sei whale	*0.000086*
Bryde's whale	0.000439
Common (dwarf) minke whale	0.077896
Antarctic minke whale	0.077896
Humpback whale	0.000310
MF Cetaceans	
Sperm whale	*0.005975*
Arnoux's beaked whale	0.011379
Cuvier's beaked whale	0.000548
Southern bottlenose whale	0.007906
Shepherd's beaked whale	0.009269
Blainville's beaked whale	0.000053
Gray's beaked whale	0.001885
Hector's beaked whale	0.000212
Gervais' beaked whale	0.001323
True's beaked whale	0.000053
Strap-toothed beaked whale	0.000582
Andrew's beaked whale	0.000159
Spade-toothed beaked whale	0.000053
Risso's dolphin	0.010657
Rough-toothed dolphin	0.005954
Common bottlenose dolphin	0.040308
Pantropical spotted dolphin	0.003767
Atlantic spotted dolphin	0.213721
Spinner dolphin	0.040720
Clymene dolphin	0.006800
Striped dolphin	0.004089
Short-beaked common dolphin	0.717166
Fraser's dolphin	0.021040
Dusky dolphin	0.012867
Southern right whale dolphin	0.006827
Killer whale	0.000266
Short-finned pilot whale	0.002085
Long-finned pilot whale	0.021379
False killer whale	0.000882
Pygmy killer whale	0.000321
Melon-headed whale	0.003540
HF Cetaceans	
Pygmy sperm whale	0.003418
Dwarf sperm whale	0.002582
Hourglass dolphin	0.011122
Otariids	
Subantarctic fur seal	0.00274
Cape fur seal	N.A.
Phocids	
Crabeater seal	0.00649
Leopard seal	0.00162
Southern elephant seal	0.00155

N.A. indicates density estimate is not available.
Species in italics are listed under the ESA as endangered.
[a] See Appendix B in SIO's IHA application for density sources.

Take Calculation and Estimation

Here we describe how the information provided above is brought together to produce a quantitative take estimate. 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 9), 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 9).

TABLE 9—AREAS (KM²) TO BE ENSONIFIED TO LEVEL A AND LEVEL B HARASSMENT THRESHOLDS

Survey type	Criteria	Relevant isopleth (m)	Daily ensonified area (km²)	Total survey days	25 percent increase	Total ensonified area (km²)
5-kn survey	Level B Harassment (160 dB)					
	Intermediate water	809	14.67	10	1.25	183.34
	Deep water	539	231.31	10	1.25	2891.42
	Level A Harassment					
	LF cetacean	6.5	2.89	10	1.25	36.125
	MF cetacean	1	0.44	10	1.25	5.55
	HF cetacean	34.6	15.37	10	1.25	192.13
	Phocids	5.5	2.44	10	1.25	30.53
	Otariids	0.5	0.22	10	1.25	2.77
8-kn survey	Level B Harassment (160 dB)					
	Intermediate water	867	25.95	4	1.25	129.75
	Deep water	578	395.88	4	1.25	1979.38
	Level A Harassment					
	LF cetacean	3.1	2.21	4	1.25	11.04
	MF cetacean	0	0	4	1.25	0
	HF cetacean	34.8	24.78	4	1.25	124
	Phocids	4	2.85	4	1.25	14.24
	Otariids	0	0	4	1.25	0

The total ensonified areas (km²) for each criteria presented in Table 9 were summed to determine the total ensonified area for all survey activities (Table 10).

TABLE 10—TOTAL ENSONIFIED AREAS (km²) FOR ALL SURVEYS

Criteria	Total ensonified area (km^2) for all surveys
160 dB Level B (all depths)	5183.89
160 dB Level B (intermediate water)	313.09
160 dB Level B (deep water)	4870.80
LF cetacean Level A	47.11
MF cetacean Level A	5.55
HF cetacean Level A	316.04
Phocids Level A	44.77
Otariids Level A	2.77

The marine mammals predicted to occur within these respective areas, based on estimated densities (Table 8), are assumed to be incidentally taken. While some takes by Level A harassment have been estimated, based on the nature of the activity and in consideration of the proposed mitigation measures (see Proposed Mitigation section below), Level A take is not expected to occur and has not been proposed to be authorized. Estimated exposures for the proposed survey are shown in Table 11.

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Table 11. Calculated and Proposed Level A and Level B Exposures, and Percentage of Population Exposed.

Species	Calculated Take[1]		Proposed Take[4]	Percent of Population[5]
	Level B Harassment[2]	Level A Harassment[3]	Level B Harassment only	
LF Cetaceans				
Southern right whale	*41*	*0*	*41*	*1.3*
Pygmy right whale	N.A.	N.A.	2[5]	N.A.
Blue whale	*0*	*0*	*3*[6]	*<0.1*
Fin whale	*2*	*0*	*4*[6]	*<0.1*
Sei whale	*0*	*0*	*3*[6]	*<0.1*
Bryde's whale	2	0	20[5]	<0.1
Common (dwarf) minke whale	400	4	400	0.1
Antarctic minke whale	400	4	400	0.1
Humpback whale	2	0	20[5]	0
MF Cetaceans				
Sperm whale	*31*	*0*	*31*	*0.3*
Arnoux's beaked whale	59	0	59	<0.1
Cuvier's beaked whale	3	0	3	<0.1
Southern bottlenose whale	41	0	41	<0.1
Shepherd's beaked whale	48	0	48	N.A.
Blainville's beaked whale	0	0	7[6]	N.A.
Gray's beaked whale	10	0	10	<0.1
Hector's beaked whale	1	0	2[6]	N.A.
Gervais' beaked whale	7	0	7	N.A.
True's beaked whale	0	0	2[6]	N.A.
Strap-toothed beaked whale	3	0	3	<0.1
Andrew's beaked whale	1	0	2[6]	N.A.
Spade-toothed beaked whale	0	0	2[6]	N.A.
Risso's dolphin	55	0	78[6]	0.3
Rough-toothed dolphin	31	0	55[6]	N.A.
Common bottlenose dolphin	209	0	209	0.3
Pantropical spotted dolphin	20	0	104[6]	0.6
Atlantic spotted dolphin	1108	0	1108	2.5
Spinner dolphin	211	0	315[6]	N.A.
Clymene dolphin	35	0	35	N.A.
Striped dolphin	21	0	110[5]	<0.1
Short-beaked common dolphin	3714	4	3714	5.3
Fraser's dolphin	109	0	283[6]	N.A.
Dusky dolphin	67	0	67	0.9
Southern right whale dolphin	35	0	35	N.A.
Killer whale	1	0	5[6]	<0.1
Short-finned pilot whale	11	0	41[6]	<0.1
Long-finned pilot whale	111	0	111	0.1
False killer whale	5	0	19[6]	N.A.
Pygmy killer whale	2	0	26[6]	N.A.
Melon-headed whale	18	0	170[6]	N.A.

HF Cetaceans				
Pygmy sperm whale	17	1	17	N.A.
Dwarf sperm whale	12	1	12	N.A.
Hourglass dolphin	54	4	54	<0.1
Otariids				
Subantarctic fur seal	14	0	14	<0.1
Cape fur seal	N.A.	N.A.	20[7]	N.A.
Phocids				
Crabeater seal	34	0	34	<0.1
Leopard seal	8	0	8	<0.1
Southern elephant seal	8	0	8	<0.1

Species in italics are listed under the ESA as endangered. N.A. (-) is not available

1 Take using NMFS daily method for calculating ensonified area: estimated density multiplied by the daily ensonified area to levels ≥160 dB re 1 μPa_{rms} on one selected day multiplied by the number of survey days, times 1.25 (see Appendix C); daily ensonified area = full 160-dB area minus ensonified area for the appropriate PTS threshold.

2 Level B harassment takes, based on the 160-dB criterion, excluding exposures to sound levels equivalent to PTS thresholds.

3 Level A harassment takes if there were no mitigation measures.

4 Proposed take authorization is Level B harassment calculated takes, unless otherwise indicated.

5 Proposed take authorization (Level B harassment only) increased to maximum group size from Jefferson *et al.* (2015).

6 Proposed take authorization (Level B harassment only) increased to mean group size from Weir (2001), Bradford *et al.* (2017), or Di Tullio *et al.* (2016), whichever is larger.

7 Proposoed take authorization (Level B harassment only) increased to 20 individuals, as no densities available.

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It should be noted that the proposed take numbers shown in Table 11 are expected to be conservative for several reasons. First, in the calculations of estimated take, 25 percent has been added in the form of operational survey days 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. Additionally, marine mammals would be expected to move away from a loud sound source that represents an aversive stimulus, such as an airgun array, potentially reducing the likelihood of takes by Level A harassment. 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.

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 such activity, and other means of effecting the least practicable impact on such species or stock and its habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of such species or stock for taking for certain subsistence uses (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 such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks and their habitat (50 CFR 216.104(a)(11)).

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.

SIO 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, SIO 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 exclusion zone (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 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 *Thompson* 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 *Thompson.* PSOs would be appointed by SIO 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 4 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 *Thompson* 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 PSOs 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 7) 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 7). 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 in^3. 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, *Kogia* species, and Southern right whales. SIO would also enforce a 500-m EZ for aggregations of six or more large whales (*i.e.,* sperm whale or any baleen whale) that does not appear to be traveling (*e.g.,* feeding, socializing, etc.) 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 min in the case of small odontocetes and pinnipeds; or
- it has not been seen within the 100-m EZ for 30 min in the case of mysticetes and large odontocetes (including sperm whale beaked whales), and also pygmy sperm, dwarf sperm and beaked whales.

This shutdown requirement would be in place for all marine mammals, with the exception of small delphinoids under certain circumstances. As defined here, the small delphinoid group is intended to encompass those members of the Family Delphinidae most likely to voluntarily approach the source vessel for purposes of interacting with the vessel and/or airgun array (*e.g.,* bow riding). This exception to the shutdown requirement would apply solely to specific genera of small dolphins—*Delphinus, Lagenodelphis,* *Lagenorhynchus, Lissodelphis, Stenella, Steno,* and *Tursiops*—and would only apply if the animals were traveling, including approaching the vessel. If, for example, an animal or group of animals is stationary for some reason (*e.g.,* feeding) and the source vessel approaches the animals, the shutdown requirement applies. An animal with sufficient incentive to remain in an area rather than avoid an otherwise aversive stimulus could either incur auditory injury or disruption of important behavior. If there is uncertainty regarding identification (*i.e.,* whether the observed animal(s) belongs to the group described above) or whether the animals are traveling, the shutdown would be implemented.

We include this small delphinoid exception because shutdown requirements for small delphinoids under all circumstances represent practicability concerns without likely commensurate benefits for the animals in question. Small delphinoids are generally the most commonly observed marine mammals in the specific geographic region and would typically be the only marine mammals likely to intentionally approach the vessel. As described above, auditory injury is extremely unlikely to occur for mid-frequency cetaceans (*e.g.,* delphinids), as this group is relatively insensitive to sound produced at the predominant frequencies in an airgun pulse while also having a relatively high threshold for the onset of auditory injury (*i.e.,* permanent threshold shift).

A large body of anecdotal evidence indicates that small delphinoids commonly approach vessels and/or towed arrays during active sound production for purposes of bow riding, with no apparent effect observed in those delphinoids (*e.g.,* Barkaszi *et al.,* 2012). The potential for increased shutdowns resulting from such a measure would require the *Thompson* to revisit the missed track line to reacquire data, resulting in an overall increase in the total sound energy input to the marine environment and an increase in the total duration over which the survey is active in a given area. Although other mid-frequency hearing specialists (*e.g.,* large delphinoids) are no more likely to incur auditory injury than are small delphinoids, they are much less likely to approach vessels. Therefore, retaining a power-down/shutdown requirement for large delphinoids would not have similar impacts in terms of either practicability for the applicant or corollary increase in sound energy output and time on the water. We do anticipate some benefit for a shutdown requirement for large delphinoids in that it simplifies somewhat the total range of decision-making for PSOs and may preclude any potential for physiological effects other than to the auditory system as well as some more severe behavioral reactions for any such animals in close proximity to the source vessel.

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 in^3 airgun, with the second 45 in^3 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. The vessel would maintain a minimum separation distance of 50 m from all other marine mammals (with the exception of delphinids of the genera *Delphinus, Lagenodelphis, Lagenorhynchus, Lissodelphis, Stenella, Steno,* and *Tursiops* that approach the vessel, as described above). 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 kn 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, 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); and
- Mitigation and monitoring effectiveness.

SIO 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. SIO'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 *Thompson.* PSOs would be appointed by SIO 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 4 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.,* 7x50 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 SIO'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* section, neither stranding nor vessel strike are 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 *Thompson'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 short-term 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). 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).

Potential impacts to marine mammal habitat were discussed previously in this document (see *Potential Effects of the Specified Activity on Marine Mammals and their Habitat*). Marine mammal habitat may be impacted by elevated sound levels, but these impacts would be temporary. 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 described above, marine mammals in the survey area are not assigned to NMFS stocks. For purposes of the small numbers analysis 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, most cases 0.1 percent or less that would be affected by SIO's proposed survey (less than 5.3 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 mammals 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 (14 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: Fin, sei, blue, sperm, and southern right 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 SIO'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 SIO's proposed seismic survey would result in only short-term (temporary and short in duration) effects of Level B harassment to individuals exposed. 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 is anticipated or authorized;
- No take by Level A harassment is anticipated or authorized;
- The anticipated impacts of the proposed activity on marine mammals would primarily be temporary behavioral changes due to avoidance of the area around the survey vessel. The relatively short duration of the proposed survey (14 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 5.3 percent for all species) for the species for which abundance estimates are available. No known current worldwide or regional population estimates are available for 16 species under NMFS jurisdiction that could be incidentally taken as a result of the proposed survey: The pygmy right whale, pygmy sperm whale, dwarf sperm whale, Shepherd's beaked whale, Blainville's beaked whale, Hector's beaked whale, Gervais' beaked whale, True's beaked whale, Andrew's beaked whale, spade-toothed beaked whale, rough-toothed dolphin, spinner dolphin, Clymene dolphin, Fraser's dolphin, southern right whale dolphin, false killer whale, pygmy killer whale, and Melon-headed whale and Cape fur seal.

NMFS has reviewed the geographic distributions and habitat preferences of these species in determining whether the numbers of takes authorized herein are likely to represent small numbers. Pygmy right whales have a circumglobal distribution and occur throughout coastal and oceanic waters in the Southern Hemisphere (between 30 to 55° S) (Jefferson *et al.* 2015; Kemper 2018). Pygmy and dwarf sperm whales occur in deep waters on the outer continental shelf and slope in tropical to temperate waters of the Atlantic, Indian, and Pacific Oceans, but their precise distributions are unknown because much of what we know of the species comes from strandings (McAlpine 2018). Based on stranding records and the known habitat preferences of beaked whales in general, Shepherd's beaked whales are assumed to have a circumpolar distribution in deep, cold temperate waters of the Southern Ocean (Pitman *et al.,* 2006; Mead 2018). Blainville's beaked whale is the most widely distributed beaked *Mesoplodon* species with sightings and stranding records throughout the North and South Atlantic Ocean (MacLeod *et al.,* 2006; Pitman 2018). Hector's beaked whales are found in cold temperate waters throughout the southern hemisphere between 35° S and 55° S (Zerbini and Secchi 2001; Pitman 2018). True's beaked whale has a disjunct, antitropical distribution (Jefferson *et al.* 2015). In the Southern Hemisphere, it is known to occur in South Africa, South

America, and Australia (Findlay *et al.* 1992; Souza *et al.* 2005; MacLeod and Mitchell 2006; MacLeod *et al.* 2006; Best *et al.* 2009). Andrew's beaked whales have a circumpolar distribution north of the Antarctic Convergence to 32° S (MacLeod *et al.,* 2006; Pitman 2018). Andrew's beaked whale is known only from stranding records between 32° S and 55° S, with more than half of the strandings occurring in New Zealand (Jefferson *et al.* 2015). Gervais' beaked whale is generally considered to be a North Atlantic species, it likely occurs in deep waters of the temperate and tropical Atlantic Ocean in both the northern and southern hemispheres (Jefferson *et al.* 2015). The southernmost stranding record was reported for São Paulo, Brazil, possibly expanding the known distributional range of this species southward (Santos *et al.* 2003), but the distribution range of Gervais' beaked whale is not generally known to extend as far south as the proposed project area. The spade-toothed beaked whale is considered relatively rare and is known from only four records, three from New Zealand and one from Chile (Thompson *et al.* 2012). The rough-toothed dolphin is distributed worldwide in tropical and subtropical waters (Jefferson *et al.* 2015). Rough-toothed dolphins are generally seen in deep, oceanic water, although it is known to occur in coastal waters of Brazil (Jefferson *et al.,* 2015; Cardoso *et al.,* 2019). The Clymene dolphin only occurs in tropical and subtropical waters of the Atlantic Ocean (Jefferson *et al.,* 2015). Clymeme dolphins inhabits areas where water depths are 700–4500 m or deeper (Fertl *et al.,* 2003). Fraser's dolphins are distributed in tropical oceanic waters worldwide, between 30° N and 30° S and generally inhabits deeper, offshore water (Moreno *et al.,* 2003, Dolar 2018). The southern right whale dolphin is distributed between the Subtropical and Antarctic convergences in the Southern Hemisphere, generally between ~30° S and 65° S (Jefferson *et al.,* 2015; Lipsky and Brownell 2018). The false killer whale is found worldwide in tropical and temperate waters, generally between 50° N and 50° S (Odell and McClune 1999). It is widely distributed, but not abundant anywhere (Carwardine 1995). The false killer whale generally inhabits deep, offshore waters, but sometimes is found over the continental shelf and occasionally moves into very shallow water (Jefferson *et al.* 2015; Baird 2018b). The pygmy killer whale has a worldwide distribution in tropical and subtropical waters, generally not ranging south of 35° S (Jefferson *et al.* 2015). The melon-headed whale is an oceanic species found worldwide in tropical and subtropical waters from ~40° N to 35° S (Jefferson *et al.* 2015). The Cape fur seal currently breeds at 40 colonies along the coast of South Africa, Namibia, and Angola, including on the mainland and nearshore islands (Kirkman *et al.* 2013). There have been several new breeding colonies established in recent years, as the population has shifted northward (Kirkman *et al.* 2013). More than half of the seal population occurs in Namibia (Wickens *et al.* 1991). High densities have been observed between 30 and 60 nm from shore, with densities dropping farther offshore (Thomas and Schülein 1988).

Based on the broad spatial distributions and habitat preferences of these species relative to the areas where SIO's proposed survey will occur, NMFS preliminarily concludes that the proposed take of these species likely represent small numbers relative to the affected species' overall population sizes, though we are unable to quantify the take numbers as a percentage of population.

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 size of the affected species or stocks.

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 preliminarily 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 fin, sei, blue, sperm, and southern right 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 SIO for conducting a marine geophysical survey in the southwest Atlantic Ocean in November and December 2019, 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 survey. We also request comment on the potential for 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 our final decision on the request for MMPA authorization.

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); and

(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: September 24, 2019.

Donna S. Wieting,

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

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