Request by Scripps Institution of Oceanography for an Incidental Harassment Authorization to Allow the Incidental Take of Marine Mammals during Low-Energy Marine Geophysical Surveys by R/V *Thomas G. Thompson* in the Southwest Atlantic Ocean, September–October 2019

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TABLE OF CONTENTS

Page

SUMMARY 1
I. OPERATIONS TO BE CONDUCTED 2
Overview of the Activity 2
Source Vessel Specifications 4
Airgun Description 5
Description of Operations 8
II. DATES, DURATION, AND REGION OF ACTIVITY 8
III. SPECIES AND NUMBERS OF MARINE MAMMALS IN AREA 9
IV. STATUS, DISTRIBUTION AND SEASONAL DISTRIBUTION OF AFFECTED SPECIES OR STOCKS OF MARINE MAMMALS 9
Mysticetes 9
Odontocetes 16
Pinnipeds 27
V. TYPE OF INCIDENTAL TAKE AUTHORIZATION REQUESTED 31
VI. NUMBERS OF MARINE MAMMALS THAT COULD BE TAKEN 31
VII. ANTICIPATED IMPACT ON SPECIES OR STOCKS 31
Summary of Potential Effects of Airgun Sounds 32
Tolerance 32
Masking 32
Disturbance Reactions 33
Hearing Impairment and Other Physical Effects 39
Possible Effects of Other Acoustic Sources 42
Other Possible Effects of Seismic Surveys 44
Numbers of Marine Mammals that could be "Taken by Harassment" 46
Basis for Estimating "Take by Harassment" 46
Potential Number of Marine Mammals Exposed 49
Conclusions 49
VIII. ANTICIPATED IMPACT ON SUBSISTENCE 50
IX. ANTICIPATED IMPACT ON HABITAT 50
X. ANTICIPATED IMPACT OF LOSS OR MODIFICATION OF HABITAT ON MARINE MAMMALS 51
XI. MITIGATION MEASURES 51
Planning Phase 51
Mitigation During Operations 52
Speed or Course Alteration 52

Shut-down Procedures 52
Ramp-up Procedures 53
XII. PLAN OF COOPERATION 53
XIII. MONITORING AND REPORTING PLAN 54
Vessel-based Visual Monitoring 54
PSO Data and Documentation 54
XIV. COORDINATING RESEARCH TO REDUCE AND EVALUATE INCIDENTAL TAKE 55
XV. LITERATURE CITED 56
LIST OF APPENDICES 87
APPENDIX A: DETERMINATION OF MITIGATION ZONES A-1
APPENDIX B: MARINE MAMMAL DENSITIES B-1
APPENDIX C: MARINE MAMMAL TAKE CALCULATIONS C-1
APPENDIX D: ENSONIFIED AREAS FOR MARINE MAMMAL TAKE CALCULATIONS D-1

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SUMMARY

Scripps Institution of Oceanography (SIO) plans to support a research activity that would involve low-energy seismic surveys in the Southwest Atlantic Ocean during September–October 2019. The research activity would be funded by the U.S National Science Foundation (NSF). The seismic surveys would use a pair of low-energy Generator-Injector (GI) airguns with a total discharge volume of ~90 in^3. The seismic surveys would take place within the exclusive economic zone (EEZ) of the Falkland Islands and in International Waters. SIO requests that it be issued an Incidental Harassment Authorization (IHA) allowing non-lethal takes of marine mammals incidental to the planned seismic surveys. This request is submitted pursuant to Section 101 (a)(5)(D) of the Marine Mammal Protection Act (MMPA), 16 U.S.C. § 1371(a)(5).

Numerous species of marine mammals inhabit the proposed project area in the Southwest Atlantic Ocean. Under the U.S. Endangered Species Act (ESA), several of these species are listed as ***endangered***, including the sperm, sei, fin, blue, and southern right whales. SIO is proposing a marine mammal monitoring and mitigation program to minimize the potential impacts of the proposed activity on marine mammals present during conduct of the proposed research, and to document the nature and extent of any effects.

ESA-listed sea turtle species that could occur in the project area include the ***endangered*** leatherback turtle, and the ***threatened*** loggerhead (South Atlantic Ocean Distinct Population Segment or DPS) and green (South Atlantic DPS) turtles. The ***threatened*** southern rockhopper penguin is the only ESA-listed seabird that could be encountered in the project area. In addition, the ***endangered*** Argentine angelshark, spiny angelshark, and striped smoothhound shark; and the ***threatened*** narrownose smoothhound shark could occur in the proposed project area.

The items required to be addressed pursuant to 50 C.F.R. § 216.104, "Submission of Requests", are set forth below. They include descriptions of the specific operations to be conducted, the marine mammals occurring in the project area, proposed measures to mitigate against any potential injurious effects on marine mammals, and a plan to monitor any behavioral effects of the operations on those marine mammals.

I. OPERATIONS TO BE CONDUCTED

A detailed description of the specific activity or class of activities that can be expected to result in incidental taking of marine mammals.

Overview of the Activity

SIO plans to conduct low-energy seismic surveys in the Southwest Atlantic Ocean from ~12 September to 29 October 2019. The surveys would take place along the margin of the Argentine Basin between ~42.75° and 49.5°S, and 55.75° and 61.1°W (Fig. 1). The seismic surveys would be conducted in the EEZ of the Falkland Islands and International Waters, with water depths ranging from ~50–5700 m. Representative survey tracklines are shown in Figure 1. Some deviation in actual tracklines and timing could be necessary for reasons such as science drivers, poor data quality, inclement weather, or mechanical issues with the research vessel and/or equipment.

The proposed project consists of an integrated program to examine the histories of important deep ocean water masses that originate in the Southern Ocean and intersect the continental margin of Argentina; it is also in support of a potential future IODP (International Ocean Discovery Program) project. To achieve the program's goals, the Principal Investigators (PIs), Drs. N. Slowey (Texas A&M University) and J. Wright (Rutgers University), propose to collect low-energy, high-resolution multi-channel seismic (MCS) profiles and sediment cores, and measure water properties.

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 *Thomas G. Thompson* (R/V *Thompson*), using the portable MCS system operated by marine technicians from SIO. R/V *Thompson* (managed by University of Washington [UW]) would deploy up to two 45-in^3 GI airguns as an energy source with a maximum total volume of ~90 in^3. The receiving system would consist of one hydrophone streamer, 200–1600 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 proposed cruise would consist of digital bathymetric, echosounding, and MCS surveys within three areas to collect data on ocean circulation and climate evolution and to enable the selection and analysis of potential future IODP drillsites (Survey Areas 1–3 in Fig. 1). The airgun array would be operated in one of two modes:

(1) To collect the highest-quality seismic reflection data, 2 GI airguns would be deployed with the ship travelling at 5 kt; and a 400, 800, or 1600 m steamer would be used to collect reflected seismic energy. The two GI airguns would be spaced 2-m apart.
(2) To collect reconnaissance seismic reflection data or when weather is too poor to safely use a ≥400 m steamer, 1 or 2 GI airguns would be deployed with the ship travelling at 8 kt and a 200-m steamer would be used to collect reflected seismic energy. If two GI airguns are deployed, they would be towed 8 m apart.

A combination of reconnaissance and highest-quality surveys would take place along the proposed seismic transect lines in Area 2. Highest-quality surveying would also occur at ~18 potential IODP drill sites (1 in Area 1, 2 in Area 3, and ~15 in Area 2). For surveys at potential drill sites, two 5 n.mi-long crossing lines of highest-quality seismic reflection data would be collected over each site. Reconnaissance surveys may also occur at numerous (~75) coring locations in Survey Area 2. The reconnaissance mode is quicker and less impacted by adverse weather conditions, while the highest-quality mode yields more resolved imagery and sediment velocity values.

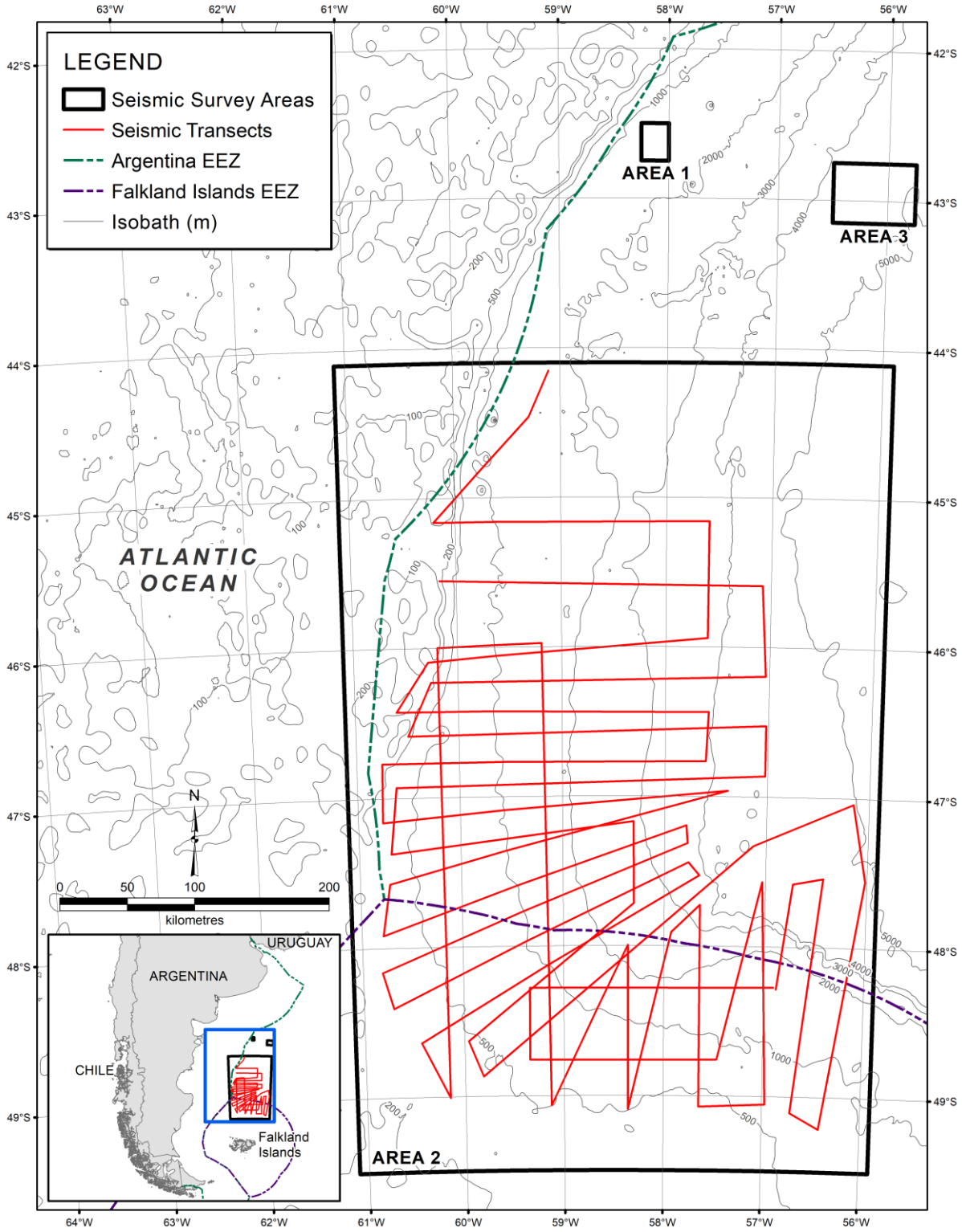

FIGURE 1. Location of the proposed low-energy seismic surveys in the Southwest Atlantic Ocean, September–October 2019.

Area 2 includes the continental slope of the southern Argentine margin, which is the primary (and largest) survey area for the project and is where most MCS data would be collected. Although representative lines are depicted in Figure 1, the line locations are preliminary and would be refined in light of information from seismic or other geological/oceanographic data obtained during the study. The survey design must be flexible for several reasons, including: (1) a large area must be surveyed during the available ship time; and (2) at present, little existing digital MCS data are available from the southern Argentine margin. Therefore, it must be possible to revise the survey plan during the cruise to focus on the areas where initially collected seismic data indicates geological and oceanographic features that result in the most appropriate sediment deposits for addressing the scientific objectives of this project and future IODP drilling. (3) Adverse weather conditions (high winds and waves) are known to occur in the area, which may preclude the use of a ≥400 m steamer.

At the three proposed Survey Areas, ~7500 km of seismic data would be collected. All data acquisition in Areas 1 and 3 would occur in water >1000 m deep. Area 2 ranges in depth from 50–5700 m; most of the survey effort (60%) would occur in water >1000 m deep; <1% would occur in shallow water <100 m deep. 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. In our calculations [see § VII], 25% has been added in the form of operational days for those additional operations.

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 R/V *Thompson* continuously throughout the seismic surveys, but not during transits to and from the project area. MBES and SBP data are essential for selecting core sites and for interpreting geological and oceanographic processes that affect the southern Argentine margin. A 12-kHz pinger would be used during coring to track the depth. 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.

Source Vessel Specifications

R/V *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 3000-hp DC motors and a water-jet bow thruster powered by a 1100-hp DC motor. The motors are driven by three 2250-hp, 1500kW main propulsion generators. An operation speed of ~9–15 km/h (~5–8 kt) would be used during seismic acquisition. When not towing seismic survey gear, R/V *Thompson* cruises at 22 km/h (12 kt) and has a maximum speed of 26.9 km/h (14.5 kt). It has a normal operating range of ~24,400 km. R/V *Thompson* would also serve as the platform from which vessel-based protected species visual observers (PSVO) would watch for marine mammals and sea turtles before and during airgun operations.

Other details of R/V *Thompson* include the following:

Owner:	U.S. Navy
Operator:	University of Washington
Flag:	United States of America
Launch Date:	8 July 1991
Gross Tonnage:	3250 LT
Compressors for Airguns:	3 x Stark Industries D-100, 100 SCFM at 2000 psi
Accommodation Capacity:	60 including 36 scientists

Airgun Description

R/V *Thompson* would tow two 45-in^3 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 in^3. The larger (105 in^3) injector chamber injects air into the previously generated bubble to maintain its shape and does not introduce more sound into the water. The 45-in^3 GI airguns would be towed 21 m behind R/V *Thompson*, 2 m (during 5-kt high-quality surveys) or 8 m (8-kt 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 1600-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-kt surveys using the 2-m GI airgun separation and at 50 m for the 8 kt surveys using the 8-m airgun separation.

GI Airgun Specifications

Energy Source	Two GI guns of 45 in^3
Gun positions used	Two inline airguns 2- or 8-m apart
Towing depth of energy source	2–4 m
Source output (2-m gun separation)*	0-peak is 3.5 bar-m (230.9 dB re 1 μPa·m); peak-peak 6.9 bar-m (236.7 dB re 1 μPa·m)
Source output (8-m gun separation)*	0-peak is 3.7 bar-m (231.4 dB re 1 μPa·m); peak-peak is 7.4 bar-m (237.4 dB re 1 μPa·m)
Air discharge volume	Approx. 90 in^3
Dominant frequency components	0–188 Hz
Gun volumes at each position (in^3)	45, 45

*Source output downward based on a conservative tow depth of 4 m.

As the airguns are towed along the survey lines, the towed hydrophone array in the streamer would receive the reflected signals and transfer the data to the on-board processing system. The turning rate of the vessel with gear deployed would be much higher (~20º) when a short streamer is towed compared with a turning rate of ~5º when a longer streamer (1600 m) is towed. Thus, the maneuverability of the vessel would be limited during operations.

The source levels can be derived from the modeled farfield source signature, which is estimated using the PGS Nucleus software. The nominal downward-directed source levels indicated above do not represent actual sound levels that can be measured at any location in the water. Rather, they represent the level that would be found 1 m from a hypothetical point source emitting the same total amount of sound as is emitted by the combined GI airguns. The actual received level at any location in the water near the GI airguns would not exceed the source level of the strongest individual source. Actual levels experienced by any organism more than 1 m from either GI airgun would be significantly lower.

A further consideration is that the rms[1] (root mean square) received levels that are used as impact criteria for marine mammals are not directly comparable to the peak (p or 0–p) or peak to peak (p–p) values normally used to characterize source levels of airgun arrays. The measurement units used to describe airgun sources, peak or peak-to-peak decibels, are always higher than the rms decibels referred to in biological

[1] The rms (root mean square) pressure is an average over the pulse duration.

literature. A measured received sound pressure level (SPL) of 160 dB re 1 μPa_{rms} in the far field would typically correspond to ~170 dB re 1 μPa_{p} or 176–178 dB re 1 $\mu Pa_{p\text{-}p}$, as measured for the same pulse received at the same location (Greene 1997; McCauley et al. 1998, 2000). The precise difference between rms and peak or peak-to-peak values depends on the frequency content and duration of the pulse, among other factors. However, the rms level is always lower than the peak or peak-to-peak level for an airgun-type source.

Mitigation zones for the proposed seismic surveys were not derived from the farfield signature but calculated based on modeling by Lamont-Doherty Earth Observatory (L-DEO) for both the exclusion zones (EZ) for Level A takes and safety zones (160 dB re 1μPa_{rms}) for Level B takes. The background information and methodology for this are provided in Appendix A and briefly summarized here.

The proposed surveys would acquire data with the 2-GI airgun array at a tow depth of ~2–4 m. L-DEO model results are used to determine the 160-dB_{rms} radius for the 2-GI airgun array in deep water (>1000 m) down to a maximum water depth of 2000 m. The radii for intermediate water depths (100–1000 m) are derived from the deep-water ones by applying a correction factor of 1.5. The shallow-water radii are obtained by scaling empirically-derived measurements from the 2007–2008 Gulf of Mexico calibration survey (Tolstoy et al. 2009; Diebold et al. 2010) to account for the differences in tow depth between the calibration survey (6 m) and the proposed surveys (~2–4 m). Whereas the shallow water in the Gulf of Mexico may not exactly replicate the shallow water environment at the proposed survey sites, it has been shown to serve as a good and very conservative proxy (Crone et al. 2014). A simple scaling factor is calculated from the ratios of the isopleths determined by the deep-water L-DEO model, which are essentially a measure of the energy radiated by the source array.

Table 1 shows the distances at which the 160- and 175-dB re 1μPa_{rms} sound levels are expected to be received for the two different airgun configurations at a 4-m tow depth. The 160-dB level is the behavioral disturbance criterion that is used to estimate anticipated Level B takes for marine mammals; a 175-dB level is used by NMFS, as well as the U.S. Navy (USN 2017), to determine behavioral disturbance for sea turtles.

The thresholds for permanent threshold shift (PTS) onset or Level A Harassment (injury) for marine mammals for impulsive sounds use dual metrics of cumulative sound exposure level (SEL_{cum} over 24 hours) and peak sound pressure levels (SPL_{flat}). Different thresholds are provided for the various hearing groups, including low-frequency (LF) cetaceans (e.g., baleen whales), mid-frequency (MF) cetaceans (e.g., most delphinids), high-frequency (HF) cetaceans (e.g., porpoise and *Kogia* spp.), phocids underwater (PW), and otariids underwater (OW). As required by the *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NMFS 2016a, 2018a), the largest distance of the dual criteria (SEL_{cum} or Peak SPL_{flat}) was used to calculate takes and Level A threshold distances (Table 2).

This document has been prepared in accordance with the current National Oceanic and Atmospheric Administration (NOAA) acoustic practices, and the monitoring and mitigation procedures are based on best practices noted by Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al. (2013a), Wright (2014), Wright and Cosentino (2015), and Acosta et al. (2017). At the time of preparation of this document, how the technical guidance would be implemented operationally, along with other potential monitoring and mitigation measures, remains somewhat uncertain. For other recent low-energy seismic surveys supported by SIO, NMFS required protected species observers (PSOs) to establish and monitor a 100-m EZ and a 200-m buffer zone beyond the EZ.

TABLE 1. Level B. Predicted distances to the 160 dB re 1 μPa$_{rms}$ and 175-dB sound levels that could be received from two 45-in^3 GI guns (at a tow depth of 4 m) that would be used during the seismic surveys in the Southwest Atlantic Ocean during September−October 2019 (model results provided by L-DEO). The 160-dB criterion applies to all marine mammals; the 175-dB criterion applies to sea turtles.

Airgun Configuration	**Water Depth (m)**	**Predicted Distances (m) to Various Received Sound Levels**	
		160 dB re 1 μPa$_{rms}$	**175 dB re 1 μPa$_{rms}$**
Two 45-in^3 GI guns / 2-m gun separation	>1000	539[1]	95[1]
	100-1000	809[2]	142[2]
	<100	1295[3]	210[3]
Two 45-in^3 GI guns / 8-m gun separation	>1000	578[1]	103[1]
	100-1000	867[2]	155[2]
	<100	1400[3]	227[3]

[1] Distance is based on L-DEO model results.
[2] Distance is based on L-DEO model results with a 1.5 × correction factor between deep and intermediate water depths.
[3] Distance is based on empirically derived measurements in the Gulf of Mexico with scaling applied to account for differences in tow depth.

TABLE 2. Level A threshold distances for different marine mammal hearing groups. As required by NMFS (2016a, 2018a), the largest distance (in bold) of the dual criteria (SEL$_{cum}$ or Peak SPL$_{flat}$) was used to calculate takes and Level A threshold distances.

	Level A Threshold Distances (m) for Various Hearing Groups				
	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
Highest-quality seismic Two 45-in^3 GI guns/2-m separation; towed at 5 kt					
PTS SEL$_{cum}$	**6.5**	0	0	0.1	0
PTS Peak	4.9	**1.0**	**34.6**	**5.5**	**0.5**
Reconnaissance seismic Two 45-in^3 GI guns/8-m separation; towed at 8 kt					
PTS SEL$_{cum}$	2.4	0	0	0	0
PTS Peak	**3.1**	0	**34.8**	**4.0**	0

Description of Operations

Seismic Surveys

The proposed surveys would involve one source vessel, R/V *Thompson*. R/V *Thompson* would tow a pair of 45-in^3 GI airguns and a streamer up to 1600-m in length containing hydrophones along predetermined lines. As the GI 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 proposed cruise would consist of digital bathymetric, echosounding, and MCS surveys within three areas to collect data on ocean circulation and climate evolution and to enable the selection and analysis of potential future IODP drillsites. At the three proposed Survey Areas, ~7500 km of seismic data would be collected. All data acquisition in Areas 1 and 3 would occur in water >1000 m deep. Area 2 ranges in depth from 50–5700 m; most of the survey effort (60%) would occur in water >1000 m deep; <1% would occur in shallow water <100 m deep.

Piston Core, Gravity Core, and Multicore Description and Deployment

The piston corer to be used consists of (1) a piston core with a 10-cm diameter steel barrel up to ~18 m long with a 2300-kg weight and (2) a trigger core with a 10-cm diameter PVC plastic barrel 3 m long with a 230-kg weight, which are lowered concurrently into the ocean floor with 1.4-cm diameter steel cables. The gravity corer consists of a 6-m long core pipe that takes a core sample ~10 cm in diameter, a head weight ~45 cm in diameter, and a stabilizing fin. It is lowered to the ocean floor with 1.4-cm diameter steel cable at 100 m/min speed. The multicorer consists of a 2.75-m tall steel-tube frame and eight plastic sample tubes that are each 70-cm long and 10-cm in diameter (total weight ~460 kg). It is lowered to the ocean floor with 1.4-cm diameter steel cable at 45 m/min speed.

Multibeam Echosounder, Sub-bottom Profiler, and Pinger

Along with the airgun operations, two additional acoustical data acquisition systems would be operated during the seismic survey, but not during transits. The ocean floor would be mapped with the Kongsberg EM300 MBES and a Knudsen 3260 SBP. In addition, a 12-kHz pinger with a 1-sec repetition rate would be used during coring. These sources, or similar, are described in § 2.2.3.1 of the PEIS.

II. Dates, Duration, and Region of Activity

The date(s) and duration of such activity and the specific geographical region where it will occur.

The proposed surveys would take place within the EEZ of the Falkland Islands and in International Waters of the Southwest Atlantic Ocean, between ~42.75° and 49.5°S, and 55.75° and 61.1°W (Fig. 1). All data acquisition in Survey Areas 1 and 3 would occur in water >1000 m deep. Area 2 ranges in depth from 50–5700 m. R/V *Thompson* would likely depart from Montevideo, Uruguay, on or about 12 September 2019 and would return to Montevideo on or about 29 October 2019. Some deviation in timing could result from unforeseen events such as weather or logistical issues. Seismic operations would occur for ~28 days. Ten days are allotted to collecting cores and measuring water properties/collecting water samples and 5 contingency days have been allotted for adverse weather conditions. Transits from Montevideo to and from the project area would take ~2.5 days each, for a total of 5 transit days.

III. Species and Numbers of Marine Mammals in Area

The species and numbers of marine mammals likely to be found within the activity area

Fifty marine mammal species could occur or have been documented to occur in or near the project area in the Southwest Atlantic Ocean, including 8 mysticetes (baleen whales), 34 odontocetes (toothed whales), and 8 pinnipeds (seals) (Table 3). To avoid redundancy, we have included the required information about the species and (insofar as it is known) numbers of these species in § IV, below.

An additional 11 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., Franciscana, *Pontoporia blainvillei*; Guiana dolphin, *Sotalia guianensis*; Chilean dolphin, *Cephalorhynchus eutropia*; Burmeister's porpoise, *Phocoena spinipinnis*); or their distributional range is farther south (Ross seal, *Ommatophoca rossii*; Weddell seal, *Leptonychotes weddellii*) or north (Bryde's whale, *Balaenoptera edeni*; Gervais' beaked whale, *Mesoplodon europaeus*; melon-headed whale, *Peponocephala electra*; pygmy killer whale, *Feresa attenuata*; long-beaked common dolphin, *Delphinus capensis*) of the proposed project area. None of these 11 species are discussed further here.

IV. Status, Distribution and Seasonal Distribution of Affected Species or Stocks of Marine Mammals

A description of the status, distribution, and seasonal distribution (when applicable) of the affected species or stocks of marine mammals likely to be affected by such activities

Sections III and IV are integrated here to minimize repetition.

Five of the 50 marine mammal species that could occur in the proposed project area are listed under the ESA as ***endangered***, including the sperm, sei, fin, blue, and southern right whales. General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of marine mammals are given in § 3.6.1, § 3.7.1, and § 3.8.1 of the PEIS. The rest of this section deals specifically with species distribution in the proposed project area in the Southwest Atlantic Ocean.

Mysticetes

Southern Right Whale (*Eubalaena australis*)

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 3373 southern right whales off Argentina, 3864 off South Africa, 1980 off Australia, and 2702 off New Zealand Travel by right whales from the coasts of South America and Africa to the waters of the mid-Atlantic have been documented (Best et al. 1993; Rowntree et al. 2001; Mate et al. 2011). Thus, there is potential for mixing of populations between calving grounds on either side of the South Atlantic Ocean, and at foraging areas near South Georgia (Best et al. 1993; Best 2007; Patenaude et al. 2007).

TABLE 3. The habitat, occurrence, regional population sizes, and conservation status of marine mammals that could occur in or near the proposed project area in the Southwest Atlantic Ocean.

Species	Occurrence	Habitat	Population Size	ESA[1]	IUCN[2]	CITES[3]
Mysticetes						
Southern right whale	Uncommon	Coastal, shelf, pelagic	12,000[4] 3,300[5]	EN	LC	I
Pygmy right whale	Rare	Coastal, pelagic	N.A.	NL	LC	I
Blue whale	Rare	Coastal, shelf, pelagic	2300 true[4]; 1500 pygmy[6]	EN	EN	I
Fin whale	Uncommon	Coastal, pelagic	15,000[6]	EN	VU	I
Sei whale	Uncommon	Shelf edges, pelagic	10,000[6]	EN	EN	I
Common minke whale	Common	Shelf, pelagic	515,000[4,7]	NL	LC	I
Antarctic minke whale	Common	Shelf, pelagic	515,000[4,7]	NL	NT	I
Humpback whale	Rare	Coastal, shelf, pelagic	42,000[4]	NL[8]	LC	I
Odontocetes						
Sperm whale	Uncommon	Slope, pelagic	12,069[9]	EN	VU	I
Pygmy sperm whale	Rare	Shelf, slope, pelagic	N.A.	NL	DD	II
Dwarf sperm whale	Rare	Shelf, slope, pelagic	N.A.	NL	DD	II
Arnoux's beaked whale	Uncommon	Pelagic	599,300[10]	NL	DD	I
Cuvier's beaked whale	Uncommon	Slope	599,300[10]	NL	LC	II
Southern bottlenose whale	Uncommon	Pelagic	599,300[10]	NL	LC	I
Shepherd's beaked whale	Uncommon	Pelagic	N.A.	NL	DD	II
Blainville's beaked whale	Rare	Slope, pelagic	N.A.	NL	DD	II
Gray's beaked whale	Uncommon	Pelagic	599,300[10]	NL	DD	II
Hector's beaked whale	Rare	Pelagic	N.A.	NL	DD	II
True's beaked whale	Rare	Pelagic	N.A.	NL	DD	II
Strap-toothed beaked whale	Uncommon	Pelagic	599,300[10]	NL	DD	II
Andrew's beaked whale	Rare	Pelagic	N.A.	NL	DD	II
Spade-toothed beaked whale	Rare	Pelagic	N.A.	NL	DD	II
Risso's dolphin	Uncommon	Slope, shelf, pelagic	18,250[11]	NL	LC	II
Rough-toothed dolphin	Rare	Coastal, pelagic	N.A.	NL	LC	II
Common bottlenose dolphin	Uncommon	Coastal, shelf	77,532[11]	NL	LC	II
Pantropical spotted dolphin	Rare	Coastal, slope, pelagic	3333[11]	NL	LC	II
Atlantic spotted dolphin	Rare	Shelf, offshore	44,715[11]	NL	LC	II
Spinner dolphin	Uncommon	Coastal, pelagic	N.A.	NL	LC	II
Clymene dolphin	Rare	Pelagic	N.A.	NL	LC	II
Striped dolphin	Uncommon	Mainly pelagic	54,807[11]	NL	LC	II
Short-beaked common dolphin	Uncommon	Coastal, pelagic	70,184[11]	NL	LC	II
Fraser's dolphin	Rare	Pelagic	N.A.	NL	LC	II

Species	Occurrence	Habitat	Population Size	ESA[1]	IUCN[2]	CITES[3]
Dusky dolphin	Uncommon	Coastal, shelf	7252[12]	NL	DD	II
Hourglass dolphin	Common	Pelagic	150,000[6]	NL	LC	II
Peale's dolphin	Common	Coastal, shelf	20,000[13]	NL	DD	II
Southern right whale dolphin	Uncommon	Pelagic	N.A.	NL	LC	II
Commerson's dolphin	Common	Coastal, shelf	21,000[14]	NL	LC	II
Killer whale	Uncommon	Coastal, pelagic	25,000[15]	NL	DD	II
Short-finned pilot whale	Rare	Mostly pelagic	200,000[6]	NL	LC	II
Long-finned pilot whale	Common	Shelf, slope, pelagic	200,000[6]	NL	LC	II
False killer whale	Rare	Pelagic	N.A.	NL	NT	II
Spectacled porpoise	Uncommon	Coastal, pelagic	N.A.	NL	LC	II
Pinnipeds						
Antarctic fur seal	Rare	Coastal, pelagic	4.5-6.2 million[16]	NL	LC	II
South American fur seal	Common	Coastal, shelf, slope	99,000[17]	NL	LC	II
Subantarctic fur seal	Uncommon	Coastal, pelagic	400,000[18]	NL	LC	II
South American sea lion	Common	Coastal, shelf	445,000[17]	NL	LC	NL
Crabeater seal	Rare	Coastal, pelagic	5-10 million[19]	NL	LC	NL
Leopard seal	Rare	Coastal, pelagic	222,000-440,000[20]	NL	LC	NL
Southern elephant seal	Uncommon	Coastal, pelagic	750,000[21]	NL	LC	II

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

[1] U.S. *Endangered Species Act* (NOAA 2017): 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] Dwarf and Antarctic minke whales combined

[8] There are 14 distinct population segments (DPSs) of humpback whales recognized under the ESA; the Brazil DPS is not listed (NOAA 2017)

[9] Estimate for the Antarctic, south of 60°S (Whitehead 2002)

[10] All beaked whales south of the Antarctic Convergence; mostly southern bottlenose whales (Kasamatsu and Joyce 1995)

[11] Estimate for the western North Atlantic (Hayes et al. 2018)

[12] Estimate for Patagonian coast (Dans et al. 1997)

[13] Estimate for Southern Patagonian waters, Argentina (Dellabianca et al. 2016)

[14] Total world population (Dawson 2018)

[15] Minimum estimate for Southern Ocean (Branch and Butterworth 2001)

[16] South Georgia population (Hofmeyr 2016)

[17] Total population (Cárdenas-Alayza et al. 2016a)

[18] Global population (Hofmeyr and Bester 2018)

[19] Global population (Bengtson and Stewart 2018)

[20] Global population (Rogers 2018)

[21] Total world population (Hindell et al. 2016)

In the western South Atlantic Ocean, Península Valdés, Argentina, is the main breeding and calving area (Zerbini et al. 2018). It is located just over 200 km from the northwestern portion of the proposed project area. Right whales occurring in breeding and nursing grounds off southern Brazil and Península Valdés, Argentina, may comprise two separate subpopulations that exploit different habitats. Feeding also occurs at these grounds, with breeding success likely influenced by climate-induced variations in food (i.e., krill) availability, such as reduced krill abundance due to global warming (Vighi et al. 2014; Seyboth et al. 2016).

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). Right whales may make use of anti-cyclonic eddies within the Subtropical Convergence for feeding (Zerbini et al. 2016). Areas with potential foraging importance include the outer shelf of southern South America (including the northwest portion of the proposed project area), the South Atlantic Basin, Scotia Sea, and Weddell Sea (Zerbini et al. 2016, 2018).

Pygmy Right Whale (*Caperea marginata*)

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).

The project area is considered to be in the secondary distributional range for this species (Kemper 2018). In the South Atlantic, pygmy right whale records exist for southern Africa, Argentina, the Falkland Islands, and pelagic waters (Baker 1985). One stranding event of a single pygmy right whale occurred in the Falkland Islands during 1950 (Augé et al. 2018). There are no OBIS records of pygmy right whales within or near the project area, but one record exists west of South Georgia and the South Sandwich Islands (53.6ºS, 40.6ºW) (OBIS 2019).

Blue Whale (*Balaenoptera musculus*)

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).

B.m. intermedia (true blue whale) occurs in the Antarctic and *B.m. brevicauda* (pygmy blue whale) inhabits the subantarctic zone (Sears and Perrin 2018). The Antarctic blue whale is typically found south of 55°S during summer, although some are known not to migrate (Branch et al. 2007). The IWC has designated six stocks in the Southern Hemisphere based on feeding areas (Sears and Perrin 2018).

Brach et al. (2007) reported several catches near the proposed project area, particularly near the Falkland Islands, prior to 1974; however, most catches occurred in the waters of the Southern Ocean during January–March (Branch et al. 2007). There are two records in the OBIS database of blue whale sightings in the South Atlantic, including one off the Argentinian coast in 1993 and one northeast of Survey Area 3

in 1913 (42.15ºS, 55.25ºW) (OBIS 2019). Blue whale songs and ~500 sightings have been reported near South Georgia (Sirovic et al. 2016; OBIS 2019). Blue whales were also acoustically detected south of the Falkland Islands during a recent Antarctic Circumnavigation Expedition (Bell 2017). A rare sighting of a mother and calf was made off Brazil in July 2014 (Rocha et al. 2019). One blue whale stranding event was reported in southern Brazil during the 2000s (Prado et al. 2016). Three standings events of individual blue whales occurred in the Falkland Islands during 1940–1962 (Augé et al. 2018).

Fin Whale (*Balaenoptera physalus*)

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). Sergeant (1977) suggested that fin whales tend to follow steep slope contours, either because they detect them readily or because the contours are areas of high biological productivity. However, fin whale movements have been reported to be complex and not all populations follow this simple pattern (Jefferson et al. 2015). 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 50ºS in the austral summer, migrating northward to breed in the winter (Gambell 1985). According to Edwards et al. (2015), the greatest number of sightings near the Falkland Islands (including the proposed project area) have been reported during December and January; however, sightings have also been made in the area from June through November. There were 27 sightings of 57 fin whales made during surveys in Falkland Islands waters during February 1998 to January 2001, including two sightings within the project area and at least three sightings immediately west of the project area (White et al. 2002). Sightings predominantly occurred during November–January in water depths >200 m, but some sightings were also made during September (White et al. 2002). Otherwise, there are four records west/south of the Falkland Islands, three off southeastern Brazil, and ~500 near South Georgia (OBIS 2019). Fin whales were observed offshore southern Argentina during circumpolar surveys during the 1980s (Herr et al. 2017), and detected acoustically south of the Falkland Islands during a recent Antarctic Circumnavigation Expedition (Bell 2017). Fin whales were also detected acoustically in Falkland Island waters during all seasons during monitoring from July 2012 to July 2013, with most detections during austral summer (Premier Oil 2018). There are no OBIS records of fin whales within the project area, but one historical record exists northeast of Survey Area 3 (42.15ºS, 55.25ºW) (OBIS 2019). One stranding event was reported in southern Brazil during the 2000s (Prado et al. 2016). Four strandings events of individual fin whales occurred in the Falkland Islands during April between 1955 and 2002 (Augé et al. 2018).

Sei Whale (*Balaenoptera borealis*)

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). Recent observation records indicate that the sei whale may utilize the Vitória-Trindade Chain off Brazil as calving grounds (Heissler et al. 2016). In the Southern Hemisphere, sei whales typically concentrate between the Subtropical and Antarctic convergences during the summer (Horwood 2018) between 40ºS and 50ºS, with

larger, older whales typically travelling into the northern Antarctic zone while smaller, younger individuals remain in the lower latitudes (Acevedo et al. 2017a).

There were 31 sightings of 45 sei whales during surveys in Falkland Islands waters from February 1998 to January 2001, with one sighting within and one immediately west of the project area; most sightings occurred during March and November and none occurred from August–October (White et al. 2002). Twenty sightings of sei whales were made in the coastal waters of Argentina and in the Falkland Islands from 2004–2008, with the majority of sightings during August–September (Iñíguez et al. 2010). Sixty-five sightings of over 200 sei whales were made in the Magellan Strait and adjacent waters during November–May, during 2004–2015; the majority of sightings occurred during December and January (Acevedo et al. 2017a). Aerial and photographic surveys indicated a minimum of 87 sei whales present in Berkeley Sound, Falkland Islands, during February–May 2017, mostly occurring singly or in pairs and otherwise in groups of up to seven whales (Weir 2017).

There are no sei whale records within the proposed project area in the OBIS database; however, there are 32 records for the Southwest Atlantic, including eight sightings north of the project area during 2001−2014, ten west of Survey Area 2 during 2009–2013, nine near the southern tip of South America during 2012 and 2014, and five between the Falkland Islands and South Georgia during 2000–2001 (OBIS 2019). Nine sightings of 25 individuals were made in the Beagle Channel off the southeastern tip of South America during January 2015 and February 2016 (Reyes et al. 2016). A sei whale sighting was also made near southern South America during visual and acoustic cetacean surveys on board an Argentinian Coast Guard vessel during January and February 2017 (Bell 2017). Three stranding events have been reported in southern Brazil, including one during the 2000s and two during 2010–2013 (Prado et al. 2016). Eight stranding events of individual sei whales occurred in the Falkland Islands during January, March, April, and May between 2002 and 2016 (Augé et al. 2018).

Common Minke Whale (*Balaenoptera acutorostrata*)

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).

The waters of the proposed project area are considered to be within the primary range of the common (dwarf) minke whale (Jefferson et al. 2015). Sixty sightings of 68 minke whales were made during surveys in Falkland Islands waters from February 1998 to January 2001, including five sightings within the project area and ~20 sightings in the immediate vicinity; sightings occurred year-round (except during August), with most sightings during September–January (White et al. 2002). There is one OBIS record of two common minke whales south of Survey Area 2 east of the Falkland Islands, and one offshore record of an individual common minke northeast of the project area (OBIS 2019). One minke whale was observed near southern South America during visual and acoustic cetacean surveys on board an Argentinian Coast Guard vessel during January and February 2017 (Bell 2017). A single minke whale was observed within the Parque Estadual Marinho da Laje de Santos MPA off Brazil's southeastern coast during boat-based cetacean surveys in 2013–2015 (de Oliveira Santos et al. 2017). At least 18 stranding events have been reported in southern Brazil, including one in the 1980s, seven in the 1990s, nine in the 2000s, and one

between 2010 and 2013 (Prado et al. 2016). Four stranding events of individual whales occurred in the Falkland Islands during July between 1992–2003 (Augé et al. 2018).

Antarctic Minke Whale (*Balaenoptera bonaerensis*)

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).

A sighting of two Antarctic minke 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 no OBIS records of Antarctic minke whales within the project area, but two records exist for nearshore waters of Argentina west of Survey Area 2, and there are two records off southern South America (OBIS 2019). At least five strandings have been reported for southern Brazil, including two during the 1990s and three in the 2000s (Prado et al. 2016). One stranding of a single whale occurred in the Falkland Islands during May 2016 (Augé et al. 2018).

Humpback Whale (*Megaptera novaeangliae*)

The humpback whale is found in all ocean basins (Clapham 2018). Based on recent genetic data, there could be three subspecies, occurring in the North Pacific, North Atlantic, and Southern Hemisphere (Jackson et al. 2014). The humpback whale is highly migratory, undertaking one of the world's longest mammalian migrations by traveling between mid- to high-latitude waters where it feeds during spring to fall and low-latitude wintering grounds over shallow banks, where it mates and calves (Winn and Reichley 1985; Bettridge et al. 2015; NOAA 2017). Although considered to be mainly a coastal species, it often traverses deep pelagic areas while migrating (Baker et al. 1998; Garrigue et al. 2002; Zerbini et al. 2011).

In the Southern Hemisphere, humpback whales migrate annually from summer foraging areas in the Antarctic to breeding grounds in tropical seas (Clapham 2018). The IWC recognizes seven breeding populations in the Southern Hemisphere that are linked to six foraging areas in the Antarctic (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) have identified humpback whales at these breeding locations as the Brazil and Gabon/Southwest Africa distinct population segments (DPS) which are both considered not at risk (NOAA 2017).

Breeding stock 'A' consists of whales that occur between ~5°S and 23°S in the coastal waters off Brazil; this population was estimated at 6404 individuals (e.g., Andriolo et al. 2010; Kershaw et al. 2017). It appears to be most abundant at Abrolhos Bank, which is the main breeding area for the humpback in the western South Atlantic (e.g., Martins et al. 2001; Andriolo et al. 2006, 2010). Humpbacks start aggregating in this area in June, and most have migrated southward by November (Engel and Martin 2009) or late-December (Zerbini et al. 2011). Whales migrating southward from Brazil have been shown to traverse offshore, pelagic waters within a narrow migration corridor to the east of the proposed project area (Zerbini et al. 2006, 2011) en route to feeding areas along the Scotia Sea, including the waters around Shag Rocks, South Georgia and the South Sandwich Islands (Stevick et al. 2006; Zerbini et al. 2006, 2011; Engel et al. 2008; Engel and Martin 2009).

Although relatively low genetic diversity is shown by humpbacks of Breeding Stock 'A', migrations and song similarity between Breeding Stock 'A' and Breeding Stock 'B' off the west coast of Africa indicate some interchange (Rosenbaum et al. 2009; Kershaw et al. 2017). Similarities in humpback whale songs have been demonstrated between Brazil and Gabon (Darling and Sousa-Lima 2005), and one female humpback whale was tracked traveling from Brazil to Madagascar, a distance of >9800 km (Stevick et al. 2011).

Prado et al. (2016) reported eight humpback stranding events in southern Brazil from the 1980s to 2013; and Groch et al. (2018) reported 24 humpback strandings along the Brazilian coast from 2004–2016, including 19 calves, four juveniles and one adult. A single humpback stranded near Talavera Island, Argentina, during July 2012 (Lucero et al. 2018). Two strandings of individual humpbacks occurred in the Falkland Islands during June and November between 1984 and 2015 (Augé et al. 2018).

The waters of the proposed project area are considered part of the humpback's secondary range (Jefferson et al. 2015). Four humpback sightings totaling five individuals were made during surveys in Falkland Islands waters, between February 1999 and March 2000 (White et al. 2002). For the South Atlantic, the OBIS database shows numerous sightings along the coast of South America, including one record within Survey Area 2 during February 2000, one record near the Argentinian coast during January 2008, and six historical records north of the project area (OBIS 2019).

Odontocetes

Sperm Whale (*Physeter macrocephalus*)

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 >1000 m deep at latitudes <40º where sea surface temperatures are <15ºC; 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).

There were 21 sightings of 28 sperm whales during surveys in Falkland Islands waters from February 1998 to January 2001, with at least eight sightings within the proposed project area and one immediately west of the project area; sightings occurred year-round in water >200 m deep (White et al. 2002). Surveys conducted between January 2002 and May 2004 by observers on board longliners during hauling operations along the 1000-m isobath east and northeast of the Falkland Islands (including within the proposed project area) indicated that although sperm whales were present throughout the fishing areas, they were concentrated near the steepest depth gradients in north/east/southeast Burdwood Bank and northeast of the Falkland Islands (Yates and Brickle 2007). Yates and Brickle (2007) sighted sperm whales throughout the year, and observed a higher abundance south of 53ºS during November–March and north of 50ºS during May–September. Sperm whales were detected acoustically in Falkland Island waters during all seasons during monitoring from July 2012 to July 2013 (Premier Oil 2018).

In the OBIS database, there is one record of sperm whales within Survey Area 1, 84 records within Survey Area 2, and two within Survey Area 3 (OBIS 2019). An additional 89 records are near the project area, and 10 records are near the Falkland Islands (OBIS 2019). Sperm whales were sighted and/or acoustically detected off southern South America during the 2014–2017 Argentine Southern Ocean Research Partnership cruise (Melcon et al. 2017). Sixteen strandings totaling 39 sperm whales occurred in

the Falkland Islands from 1957–2011 (Augé et al. 2018). There are ~30 stranding reports for southern Brazil from 1983–2014 (Prado et al. 2016; Vianna et al. 2016).

Pygmy (*Kogia breviceps*) and Dwarf (*K. sima*) 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).

Both *Kogia* species are sighted primarily along the continental shelf edge and slope and over deeper waters off the shelf (Hansen et al. 1994; Davis et al. 1998; Jefferson et al. 2015). Stomach content analyses from stranded whales further support this distribution (McAlpine 2018). Recent data indicate that both *Kogia* species feed in the water column and on/near the seabed, likely using echolocation to search for prey (McAlpine 2018). Several studies have suggested that pygmy sperm whales live and feed mostly beyond the continental shelf edge, whereas dwarf sperm whales tend to occur closer to shore, often over the continental shelf and slope (Rice 1998; Wang et al. 2002; MacLeod et al. 2004; McAlpine 2018). Barros et al. (1998), on the other hand, suggested that dwarf sperm whales could be more pelagic and dive deeper than pygmy sperm whales. It has also 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).

The proposed project area is located along the southern edge of the presumed distributional range of *Kogia* spp. There are no records of *Kogia* spp. in proposed project area (OBIS 2019). The only records in the OBIS database for the South Atlantic are for Africa; 57 records of *K. breviceps* and 22 records of *K. sima* (OBIS 2019). Both species have been reported off southern Brazil (e.g., de Oliveira Santos et al. 2010; Costa-Silva et al. 2016). Approximately 60 dwarf sperm whale strandings have been reported in Brazil between 1965 and 2014 (Moura et al. 2016; Prado et al. 2016). Approximately 50 pygmy sperm whale strandings occurred in Brazil during the same time period (Moura et al. 2016; Prado et al. 2016; Vianna et al. 2016).

Arnoux's Beaked Whale (*Berardius arnuxii*)

Arnoux's beaked whale is distributed in deep, cold, temperate, and subpolar waters of the Southern Hemisphere, occurring between 24ºS 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). There are no OBIS records for the Southwest Atlantic (OBIS 2019). At least three stranding events have been reported in southern Brazil since the 2000s (Prado et al. 2016). Stranding records also exist for the coast of Tierra del Fuego, Argentina (Riccialdelli et al. 2017).

Cuvier's Beaked Whale (*Ziphius cavirostris*)

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). There are no OBIS records within or near the proposed project area; the nearest sighting record occurred off southeastern Brazil during 2001 (27.82ºS,45.2ºW) (OBIS 2019).

Southern Bottlenose Whale (*Hyperoodon planifrons*)

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). The Falkland Islands/Tierra del Fuego area is considered a beaked whale key area (MacLeod and Mitchell 2006). Southern bottlenose whales were regularly seen there (18 sightings of 34 individuals) during September–February 1998–2001, including three sightings within the proposed project area (White et al. 2002). There are three records in the OBIS database of sightings in the Southwest Atlantic, one off eastern Brazil during November 2000 and two east of Survey Area 2 during November 2001 (45.75ºS and 53.18ºW) (OBIS 2019).

Shepherd's Beaked Whale (*Tasmacetus shepherdi*)

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 33–50ºS (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). Additional records in the South Atlantic include a sighting in the Scotia Sea and several strandings in Argentina (Grandi et al. 2005; MacLeod et al. 2006; Pitman et al. 2006; Riccialdelli et al. 2017; Mead 2018). Based on the known distributional range of Shepherd's beaked whale (MacLeod et al. 2006; Jefferson et al. 2015), the project area is within its possible range. There are no records for the Southwest Atlantic in the OBIS database (OBIS 2019).

Blainville's Beaked Whale (*Mesoplodon densirostris*)

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). The proposed project area is located at the southernmost extend of this species' distributional range (Jefferson et al. 2015). There are no OBIS records for the Southwest Atlantic (OBIS 2019).

Gray's Beaked Whale (*Mesoplodon grayi*)

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). In the South Atlantic, several stranding records exist for southern Brazil, the southeast coast of South America, and Falkland Islands (MacLeod et al. 2006; Otley et al. 2012; Prado et al. 2016; Riccialdelli et al. 2017).

There were 7 sightings of 15 unidentified beaked whales during surveys in Falkland Islands waters

from February 1998 to January 2001, and one of them was likely a Gray's beaked whale (White et al. 2002). Sightings were made in water >1000 m deep during July through November; none were made in the proposed project area (White et al. 2002). There are no OBIS records within the proposed project area; the only records in the Southwest Atlantic are two sightings of individuals during 1976 and 1992 located on the coast of central Patagonia, Argentina, and one sighting near Elephant Island in 2006 (OBIS 2019).

Hector's Beaked Whale (*Mesoplodon hectori*)

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 while 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 Southwest Atlantic, strandings have been reported for southern Brazil, Argentina, and Falkland Islands (MacLeod et al. 2006; Otley et al. 2012; Prado et al. 2016; Riccialdelli et al. 2017). There are no OBIS records for this species for the South Atlantic (OBIS 2019).

True's Beaked Whale (*Mesoplodon mirus*)

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; MacLeod and Mitchell 2006; MacLeod et al. 2006). 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). Stranding records exist for Brazil (de Souza et al. 2005; MacLeod et al. 2006). Based on stranding and sighting data, the proposed project area is part of the possible range of True's beaked whale (MacLeod et al. 2006; Jefferson et al. 2015). There are no OBIS records for the Southwest Atlantic (OBIS 2019).

Strapped-toothed Beaked Whale (*Mesoplodon layardii*)

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, and South Georgia (Pinedo et al. 2002; MacLeod et al. 2006; Otley et al. 2012; Prado et al. 2016; Riccialdelli et al. 2017). There are no OBIS records within the proposed project area; the only two records for the Southwest Atlantic are two strandings during 1991 of a male and female strap-toothed beaked whale in the San Jorge Gulf, Argentina (OBIS 2019).

Andrew's Beaked Whale (*Mesoplodon bowdoini*)

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 Falkland Islands, Argentina, and Uruguay (Baker 2001; Laporta et al. 2005; MacLeod et al. 2006; Otley et al. 2012; Riccialdelli et al. 2017). There are no OBIS records for the South Atlantic (OBIS 2019).

Spade-toothed Beaked Whale (*Mesoplodon traversii)*

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 (*Grampus griseus*)

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° (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). The variations in Risso's dolphin distribution and seasonal movement patterns near Argentina may be influenced by that of its primary prey, squid (Riccialdelli et al. 2011).

Sightings of Risso's dolphin have been reported on the Patagonian Shelf, Magellan Strait, and elsewhere around southern South America (Riccialdelli et al. 2011; Otley 2012; Jefferson et al. 2014). It has also been sighted during austral spring and fall surveys near southeastern Brazil from 2009 and 2014, in association with common bottlenose dolphins (Di Tullio et al. 2016). Retana and Lewis (2017) reported 11 records west of the project area. Although there are no records within the proposed project area in the OBIS database, 12 records exist along the southeastern Argentinian coast (OBIS 2019). Several dozen stranding events have been reported in coastal waters of southern Argentina (Riccialdelli et al. 2011; Otley 2012). Few stranding records also exist for northern/northeastern Brazil (Toledo et al. 2015; Sánchez-Sarmiento et al. 2018).

Rough-toothed Dolphin (*Steno bredanensis*)

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). The proposed project area is located to the south of its primary distribution range (Jefferson et al. 2015); nonetheless, the rough-toothed dolphin could be encountered. 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). Two rough-toothed dolphins were observed within the Parque Estadual Marinho da Laje de Santos MPA off Brazil's southeastern coast during boat-based cetacean surveys from 2013–2015 (de Oliveira Santos et al. 2017). Rough-toothed dolphins were also acoustically detected off southeastern Brazil during passive acoustic monitoring surveys in February 2016 (Bittencourt et al. 2018). There are no records of rough-toothed dolphin within the project area in the OBIS database; the nearest records occur of central-eastern Brazil (OBIS 2019). There have been ~40 reported strandings in southern Brazil from 1983–2014 (Baptista et al. 2016; Prado et al. 2016; Vianna et al. 2016).

Common Bottlenose Dolphin (*Tursiops truncatus*)

The bottlenose dolphin occurs in tropical, subtropical, and temperate waters throughout the world (Wells and Scott 2018). In the South Atlantic, it occurs as far south Tierra del Fuego (Goodall et al. 2011; Vermeulen et al. 2017; Wells and Scott 2018). Although no sightings have been reported in OBIS (2019) for the proposed project area or the Falkland Islands, several stranding records exist (Otley 2012; Augé et

al. 2018). Hundreds of strandings and/or incidental captures have also been reported in southern Brazil from 1905–2014 (Baptista et al. 2016; Fruet et al. 2016; Prado et al. 2016; Vianna et al. 2016; Alonso et al. 2017). Three sightings of common bottlenose dolphins were made at Trindade Island, Brazil during December 2009–February 2010 surveys (Souza de 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 (Wedekin et al. 2014). There were <15 groups observed during 13 aerial surveys on the Patagonian coast between 1994 and 2007 (Garaffo et al. 2011). In the OBIS database, there are 100 records within 700 km of the project area, including one nearshore southern Argentina and one near South Georgia (OBIS 2019).

Pantropical Spotted Dolphin (*Stenella attenuata*)

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). Based on distribution maps (e.g., Moreno et al. 2005; Jefferson et al. 2015), the proposed project area is located just south of its regular range; nonetheless, it is possible that pantropical spotted dolphins could be encountered. For the South Atlantic, there is one record for Brazil, observed during 2013 (OBIS 2019). Pantropical spotted dolphins have been sighted off Brazil (Moreno et al. 2005). One stranding event was reported in southern Brazil during the 1990s (Prado et al. 2016).

Atlantic Spotted Dolphin (*Stenella frontalis*)

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). There are two forms of Atlantic spotted dolphin – a large, heavily spotted coastal form that is usually found in shelf waters, and a smaller and less-spotted offshore form that occurs in pelagic offshore waters and around oceanic islands (Jefferson et al. 2015). Based on distribution maps (e.g., Moreno et al. 2005; Jefferson et al. 2015), the proposed project area is located just south of its regular range; nonetheless, it is possible that Atlantic spotted dolphins could be encountered. Moreno et al. (2005) summarized records for Brazil. For the South Atlantic, there is one record for Brazil in the OBIS database (OBIS 2019).

Spinner Dolphin (*Stenella longirostris*)

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 40ºN and 40ºS (Jefferson et al. 2015). It is generally considered a pelagic species (Perrin 2018b), but can also be found in coastal waters and around oceanic islands (Rice 1998). Spinner dolphins are extremely gregarious, and usually form large schools in the open sea and small ones in coastal waters (Perrin and Gilpatrick 1994).

Although its primary distributional range appears to be to the north of the proposed project area in the South Atlantic (Moreno et al. 2005; Jefferson et al. 2015), one sighting record has been reported east of Survey Area 2 and another north of the Falkland Islands at 47.4°S, 54.2°W made by the U.K. Royal Navy in November 2001 (OBIS 2019). Sightings off Brazil have also been reported (Moreno et al. 2005; OBIS 2019).

Clymene Dolphin (*Stenella clymene*)

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 700–4500 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).

Although currently available information indicates that the proposed project area likely does not overlap with its distributional range (Moreno et al. 2005; Jefferson et al. 2015), it is possible that clymene dolphins could be encountered. There are no OBIS records for the South Atlantic (OBIS 2019). Two stranding events of clymene dolphins were recorded in the Santa Catarina Coast of southern Brazil from 1983–2014 (Vianna et al. 2016).

Striped Dolphin (*Stenella coeruleoalba*)

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).

The proposed project survey area is immediately south of its distributional range (Moreno et al. 2005; Jefferson et al. 2015). Sightings have been reported off the northern coast of Argentina (Moreno et al. 2005), with 10 records offshore Argentina north of the project area; the nearest record was located at 42.3ºS, 62ºW (OBIS 2019). An additional three records exist near the coast of southeastern Brazil (OBIS 2019). Several stranding events have been reported in southern Brazil from 1983–2014 (Prado et al. 2016; Vianna et al. 2016).

Short-beaked Common Dolphin (*Delphinus delphis*)

The short-beaked common dolphin is found in tropical and warm temperate oceans around the world (Jefferson et al. 2015), ranging from ~60ºN to ~50ºS (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). It can be found in oceanic and coastal habitats; it is common in coastal waters 200–300 m deep and is also associated with prominent underwater topography, such as seamounts (Evans 1994).

Short-beaked common dolphins were observed on the outer-continental shelf off southeastern Brazil during spring and fall surveys during 2009–2014 (Di Tullio et al. 2016), and de Oliveira Santos et al. (2017) reported one sighting within the Parque Estadual Marinho da Laje de Santos MPA off Brazil's southeastern coast during boat-based cetacean surveys from 2013–2015. For the Southwest Atlantic, there are seven OBIS records for eastern South America, west and north of the proposed project area nearshore and offshore Argentina (OBIS 2019). There are at least 23 reported stranding events for short-beaked common dolphin in southern Brazil from 1983–2014 (Prado et al. 2016; Vianna et al. 2016). Strandings and incidental catches in fishing nets have been reported in Argentina (de Castro et al. 2016; Durante et al. 2016).

Fraser's Dolphin (*Lagenodelphis hosei*)

Fraser's dolphin is a tropical oceanic species generally distributed between 30°N and 30°S that generally inhabits deeper, offshore water (Dolar 2018). The proposed project area is located south of the presumed distribution range (Jefferson et al. 2015), and strandings in more temperate waters, such as in Uruguay, are likely extralimital (Dolar 2018). However, there is one record in the OBIS database off central-eastern Argentina, west of the proposed project area (42.9ºS, 65ºW); there are five records off Uruguay, and 17 off southeastern Brazil (OBIS 2019). There are ~15 reported strandings for southern Brazil from 1983–2014 (Prado et al. 2016; Vianna et al. 2016). Strandings and incidental captures in fishing nets have also been reported in Argentina (So et al. 2009; Durante et al. 2016).

Dusky Dolphin (*Lagenorhynchus obscurus*)

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). Along the east coast of South America, it is present from ~36ºS to Southern Patagonia and the Falkland Islands (Otley 2012; Van Waerebeek and Würsig 2018). It is the most common small cetacean near southeastern Argentina (Schiavini et al. 1999) and is incidentally captured in mid-water trawl fisheries in the region (Dans et al. 1997).

Dusky dolphins have been sighted during aerial and boat-based surveys from the southeastern Argentinian coast to the edge of the EEZ; there are also a few records for the proposed project area (Crespo et al. 1997). There were 101 groups of dusky dolphins observed during 13 aerial surveys on the Patagonian coast between 1994 and 2007, all within 200 km from shore (Garaffo et al. 2011). Several observations of dusky dolphin have also been made during deep-sea surveys north and east of the Falkland Islands (Otley 2012), and it has been observed associating with Peale's dolphins in coastal Falkland Islands waters (Weir and Black 2018). Over 300 opportunistic dusky dolphin sightings occurred during annual aerial surveys for bottlenose dolphins between 1981 and 1990 near the Península Valdés coast, Argentina (Vermeulen et al. 2017). During the past decade, the presence of dusky dolphin has increased in the Beagle Channel, southern Argentina, suggesting at least a seasonally-resident population during austral summer and fall (Dellabianca et al. 2018). There are seven records ranging from counts of one to 30 dusky dolphins within Survey Area 2 in the OBIS database, and an additional ~80 records within the Southwest Atlantic beyond the proposed project area, including five records west of Survey Area 1 (OBIS 2019). Strandings and/or fishing entanglements have been reported from Buenos Aires to Tierra del Fuego, Argentina (Crespo et al. 1997), and for the Falkland Islands (Otley 2012; Augé et al. 2018; Wier and Black 2018).

Hourglass Dolphin (*Lagenorhynchus cruciger*)

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 were 177 sightings of 886 hourglass dolphins made during surveys in Falkland Islands waters from February 1998 to January 2001, including within the proposed project area; sightings predominantly occurred from September–February in water deeper than 200 m (White et al. 2002). One hourglass dolphin was sighted in Almirantazgo Sound, Chile, during March 2013 (Acevedo et al. 2017b). There are two records in the OBIS database near the Falkland Islands, 12 records east and southeast of the southern tip of Argentina, and 17 records between Falkland Islands and South Georgia (OBIS 2019). Two stranding events of individual hourglass dolphins occurred in the Falkland Islands during December and January between 1981 and 2004 (Augé et al. 2018).

Peale's Dolphin (*Lagenorhynchus australis*)

Peale's dolphin is endemic to southern South America and ranges from 38–59ºS (Cipriano 2018b). It is known to breed in the Falkland Islands (White et al. 2002). Peale's dolphin was the most frequent and numerous cetacean recorded during surveys in Falkland Island waters from February 1998 to January 2001, with 864 sightings totaling 2617 individuals (White et al. 2002). Sightings were recorded during all months of the year, including numerous observations within the southwestern portion of the proposed project area (White et al. 2002). Twenty-nine sightings occurred during oceanographic (2009) and aerial (1999) surveys off Argentina, west of the project area (Retana and Lewis 2017). There were 134 schools (465 individuals) observed during eight scientific cruises in southern Patagonian waters during November–April between 2009 and 2015, including sightings within and/or near the project area (Dellabianca et al. 2016), and

<15 groups observed during 13 aerial surveys on the Patagonian coast between 1994 and 2007 (Garaffo et al. 2011).

Peale's dolphins were sighted near southern South America during visual and acoustic cetacean surveys on board an Argentinian Coast Guard vessel during January and February 2017 (Bell 2017). In the OBIS database, there are two sightings within Survey Area 2 and ~130 records near the project area (OBIS 2019). One stranding event was reported in southern Brazil during the 1990s (Prado et al. 2016), and five stranding events of individual Peale's dolphins occurred in the Falkland Islands during February and March between 1923 and 1998 (Augé et al. 2018). Strandings have also been reported in Tierra del Fuego Island, southeastern Argentina (San Martín et al. 2016).

Southern Right Whale Dolphin (*Lissodelphis peronii*)

The southern right whale dolphin is distributed between the Subtropical and Antarctic convergences in the Southern Hemisphere, generally between ~30ºS and 65ºS (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). Cold-water currents, such as the Malvinas current off Brazil, might also influence its distribution, extending its range northward (Lipsky and Brownell 2018). One sighting of 120 southern right whale dolphins was made in Survey Area 2 during September 1998; an additional two sightings of six and 20 individuals occurred southeast of the proposed project area during February and September 1999, respectively (White et al. 2002). Two sightings were made in the western Magellan Strait during March and April 2018 (Pinto-Torres et al. 2019). There are no records for the South Atlantic in the OBIS database (OBIS 2019). Two strandings of three southern right whale dolphins occurred in the Falkland Islands during February and September between 1945 and 2004 (Augé et al. 2018).

Commerson's Dolphin (*Cephalorhynchus commersonii*)

Commerson's dolphin principally occurs near Argentina and the Falkland Islands, Strait of Magellan, and the Kerguelen Islands in the Indian Ocean (Dawson 2018). It has been observed individually and cooperatively feeding, travelling, diving, milling, socializing, and resting in coastal and estuarine Patagonian waters, with greater abundances and larger group sizes occurring when sea surface temperatures are seasonally cooler (Coscarella et al. 2010; de Castro et al. 2013). In the Falkland Islands, Commerson's dolphin are distributed mainly coastally and are also known to breed there (White et al. 2002).

One hundred sightings totaling 336 Commerson's dolphins were observed near the Falkland Islands during opportunistic seabird and marine mammal surveys from February 1998 to January 2001, with group sizes varying from one to 11 individuals (White et al. 2002). Commerson's dolphins were observed year-round, except during May, with peak occurrence during April (White et al. 2002). All sightings were made south of 50ºS and most (99%) were within 10 km from shore; no sightings occurred more than 25 km offshore (White et al. 2002). There were 30 groups observed during 13 aerial surveys on the Patagonian coast between 1994 and 2007, all within 400 km from shore (Garaffo et al. 2011). There were 88 schools (212 individuals) observed during eight scientific cruises in southern Patagonian waters during November–April between 2009 and 2015, including sightings within and/or near the proposed project area (Dellabianca et al. 2016). During summer 2004 and 2005 surveys of 12 and five days in duration, respectively, 330 groups were observed within an estuary of San Cruz River, southern Argentina, with one to four individuals per group (de Castro et al. 2013). Retana and Lewis (2017) reported 22 records west of the project area.

Although these dolphins typically prefer water depths <100 m, there are two records within Survey Area 2 and over 500 records in the Southwest Atlantic in the OBIS database, with sightings particularly prevalent nearshore and offshore southeastern Argentina and the Falkland Islands (OBIS 2019). Approximately 23 stranding events were reported in the Falkland Islands between 1866 and 2012 (Otley

2012; Augé et al. 2018). A stranding event was also reported in Brazil during the 1990s (Prado et al. 2016). Commerson's dolphins are incidentally captured and killed in fisheries throughout their range (Coscarella et al. 2010; Cáceres-Saez et al. 2017).

Killer Whale (*Orcinus orca*)

The killer whale is cosmopolitan and globally abundant; it has been observed in all oceans of the world (Ford 2018). It is very common in temperate waters but also occurs in tropical waters (Heyning and Dahlheim 1988) and inhabits coastal and offshore regions (Budylenko 1981). Based on sightings by whaling vessels between 1960 and 1979, killer whales are distributed throughout the South Atlantic (Budylenko 1981; Mikhalev et al. 1981). Mikhalev et al. (1981) noted that they appear to migrate from warmer waters during the winter to higher latitudes during the summer. Sightings of killer whale pods of 1 to >100 individuals were made within and near the project area during November–April, with most sightings during November, January, and April (Budylenko 1981; Mikhalev et al. 1981).

Pinedo et al. (2002) noted that killer whales are relatively common off southern Brazil, where they are known to prey on longline catches (Dalla Rosa and Secchi 2007). They are also known to prey on the Uruguayan pelagic longline fishery (Passadore et al. 2015). Killer whales occur in the Uruguayan fishing grounds throughout the year, but most frequently during autumn and winter, ~300–750 km from shore along the shelf break (Passadore et al. 2014).

Killer whales were only sighted northeast of the Falkland Islands, within and southeast of the proposed project area, during surveys conducted between January 2002 and May 2004 by observers on board longliners during hauling operations along the 1000-m isobath east and northeast of the Falkland Islands (Yates and Brickle 2007). Killer whales were sighted during April-December, with increased abundance from April–June and fewer individuals present during December (Yates and Brickle 2007). Two sightings of four and six individuals were made within Survey Area 2 during surveys in January 1999 and December 2000, respectively, along with two sightings totaling three individuals southwest of Survey Area 2 during April and June 1999 (White et al. 2002). Killer whales were detected acoustically in Falkland Island waters during all seaons during monitoring from July 2012 to July 2013 (Premier Oil 2018). Retana and Lewis (2017) reported 14 records west of the project area.

There are 48 records of killer whales for the Southwest Atlantic near the project area in the OBIS database, including one record of three individuals within Survey Area 2, three records totaling ten whales east of Survey Area 2, and one record of six whales northeast of Survey Area 3 (OBIS 2019). Seven sightings were reported off southeastern Brazil between 1978 and 2017, along with evidence of a killer whale attack on a dead, stranded southern right whale calf whale during July 2008 (Ott et al. 2017). One killer whale sighting was made near southern South America during visual and acoustic cetacean surveys on board an Argentinian Coast Guard vessel during January and February 2017 (Bell 2017). Fourteen killer whale sightings near Argentina were made during aerial surveys in 1999, west of the project area (Renata and Lewis 2017). There have been ~15 reported killer whale stranding events in southern Brazil from 1983–2014 (Prado et al. 2016; Vianna et al. 2016). Four strandings of individual killer whales occurred in the Falkland Islands during June and December between 1986–1996 (Augé et al. 2018).

Short-finned (*Globicephala macrorhynchus*) and Long-finned Pilot Whale (*Globicephala melas*)

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). Long-finned pilot whales are geographically isolated and separated into two subspecies, *G. melas* and *G. melas edwardii* in the Northern and Southern Hemispheres, respectively (Olson

2018). Long-finned pilot whales are one of the most regular sighted species in the Falkland Islands (White et al. 2002). Twenty-seven sightings totaling 872 individual long-finned pilot whales were made during surveys in Falkland Islands waters from February 1998 to January 2001, with multiple sightings within the proposed project area; sightings occurred year-round (except January), with most whales observed during April–September and generally in water deeper than 200 m (White et al. 2002). Pilot whales were detected acoustically in Falkland Island waters during all seaons during monitoring from July 2012 to July 2013 (Premier Oil 2018). Five sightings of long-finned pilot whale occurred near Argentina west of the project area during oceanographic cruises in 2009 and aerial surveys in 1999 (Retana and Lewis 2017). There are eight records of long-finned pilot whales in Survey Area 2 and one record in Survey Area 3 in the OBIS database, in addition to ~100 records in the Southwest Atlantic beyond the project area; there is a single record of short-finned pilot whales off northeastern Brazil (OBIS 2019).

Long-finned pilot whales were observed at depths ~500 m on the outer-continental shelf off southeastern Brazil during spring and fall surveys, 2009–2014 (Di Tullio et al. 2016). There are ~24 stranding records for southern Brazil from 1983–2014 (Domiciano et al. 2016; Prado et al. 2016; Vianna et al. 2016), and one record at Tierra del Fuego, Argentina (Clarke and Goodall 1994). A mass stranding event of 50 long-finned pilot whales occurred in 2009 at Caleta Malaspina, Argentina (4517ºS, 66.5ºW) (Anabella et al. 2017). Sixty-six stranding events totaling 7836 long-finned pilot whales occurred in the Falkland Islands from 1896–2014 (Augé et al. 2018).

False Killer Whale (*Pseudorca crassidens*)

The false killer whale is found worldwide in tropical and temperate waters, generally between 50ºN and 50ºS (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 (Jefferson et al. 2015; Baird 2018b) or inland waters, such as the Magellan Strait, Chile (Haro 2018). It is gregarious and forms strong social bonds, as is evident from its propensity to strand en masse (Baird 2018b), such as the stranding of 14 false killer whales in southern Brazil during June 1995 (Andrade et al. 2001). An additional ~50 stranding events have been reported in southern Brazil from 1983–2014 (Prado et al. 2016; Vianna et al. 2016). Two mass stranding events occurred during February 2013 of 46 false killer whales in the Strait of Magellan (Cáceres-Saez et al. 2018) and 22 whales in the Falkland Islands (Augé et al. 2018).

The proposed project area is within the primary range of the false killer whale in the Southwest Atlantic Ocean (Baird 2018b). Within this portion of its range, false killer whales are known to prey on fishes caught in the Uruguayan pelagic longline fishery (Passadore et al. 2015). Although there are no OBIS records of false killer whales within the project area, there are two records northeast of there, at 41.4ºS, 50.8ºW and 41.7ºS, 48.7ºW; one record also exists west of South Georgia and 18 records are located offshore northeastern Brazil (OBIS 2019).

Spectacled Porpoise (*Phocoena dioptrica*)

The spectacled porpoise is distributed in cool temperate, subantarctic, and Antarctic waters of the Southern Hemisphere (Goodall and Brownell 2018). In the Southwest Atlantic, it occurs from southern Brazil to Tierra del Fuego, Falkland Islands, and South Georgia, and its range extends southwards into the Drake Passage (Jefferson et al. 2015). Spectacled porpoise typically occurs in open water, but has been known to occasionally enter river estuaries and channels (Goodall and Brownell 2018). Based on stomach content and bone stable isotope analyses, spectacled porpoises may forage in oceanic waters near the Antarctic Convergence (Riccialdelli et al. 2010; Goodall and Brownell 2018).

Spectacled porpoise is rarely observed; in the Southwest Atlantic, sightings have occurred off Uruguay, Patagonia, and South Georgia, generally where surface water temperatures are ~5–6ºC and in group sizes of one to five individuals (Goodall and Brownell 2018). In the OBIS database, one record exists for the South Atlantic, west of Survey Area 2 at 47.5ºS, 62.7ºW during 2009 (OBIS 2019).

Spectacled porpoise is known to strand in the Falkland Islands (White et al. 2002); stranding events of single spectacled porpoises were reported in the Falkland Islands during 2011 and 2017 (Costa and Rojas 2017; Augé et al. 2018). A stranding was also recorded in southern Brazil during the 1990s (Prado et al. 2016). Spectacled porpoises strand most frequently on the beaches of Tierra del Fuego where it is the second-most frequently stranding cetacean; it is currently unclear why there are many strandings there (at least 298 to date) and relatively few elsewhere, but Tierra del Fuego's low-sloped beaches and high tides and coastal gillnets may be factors (Goodall and Brownell 2018).

Pinnipeds

Antarctic Fur Seal (*Arctocephalus gazella*)

The Antarctic fur seal is the only fur seal that lives south of the Antarctic Convergence (Acevedo et al. 2011). It has a circumpolar distribution around Antarctica and ranges as far north as the Falkland Islands and Argentina during the non-breeding season (Forcada and Staniland 2018). The largest breeding colonies are on South Georgia, where there is an estimated 2.7 million animals during the breeding season and pup production is in the low hundreds of thousands. Smaller breeding colonies (in the tens of thousands to a few thousand) exist on several other Antarctic islands. The breeding season starts during early November; pups are born in December and weaned by April (Forcada and Staniland 2018). Antarctic fur seals range widely outside the breeding season. Vagrants have been found as far as Brazil, Uruguay, and Argentina as well as the Magellan Strait in southern Chile (summarized in Acevedo et al. 2011).

Female Antarctic fur seals are constrained to forage within ~100 km of their pups while lactating during summer, but can disperse greater than 1000 km onto the continental shelf of Patagonia once pups are weaned (Boyd et al. 2002). Ten females tagged with satellite tags at South Georgia dispersed widely during winter (April–August), following the end of the lactation period, and four of these individuals focused their foraging activity in waters of the South American continental shelf (Boyd et al. 2002), including waters of the proposed project area. Antarctic fur seals foraging in this area concentrated their effort at the shelf break in waters ~500 m deep (Croxall and Wood 2002). Fur seals were the most numerous pinnipeds recorded during surveys in the area from February 1998 to January 2001; although fur seals were not identified to species, some were likely Antarctic fur seals from the South Georgia breeding population (White et al. 2002). There are thousands of records of Antarctic fur seals in the OBIS database (OBIS 2019), including 108 records for the proposed project area for May through October.

South American Fur Seal (*Arctocephalus australis*)

The South American fur seal occurs along the Atlantic coast of South America from southern Brazil to the southernmost tip of Patagonia, extending out to include the Falkland Islands (Cárdenas-Alayza 2018a). Its range extends around the tip of South America along the Pacific coast to as far north as Peru, where it has a discontinuous distribution, being absent along the coast of Chile from ~23°S–43°S (Cárdenas-Alayza 2012). Pacific and Atlantic populations show genetic and morphological differences as well as a difference in the timing of their breeding season (de Oliveira et al. 2008; Pavés et al. 2016; Rodrigues et al. 2018). Animals off Peru and northern Chile are considered a separate subspecies (Cárdenas-Alayza 2018a). On the Atlantic coast, breeding colonies are primarily located to the far north, along the coast of Uruguay, and to the far south, in the Tierra del Fuego region (Túnez et al. 2008). Along

the ~4800 km of coast in between there are several non-breeding colonies and the occasional breeding colony (Cárdenas-Alayza 2018a; Svendson et al. 2013; Túnez et al. 2008).

Ten different breeding sites for South American fur seals have been identified around the Falkland Islands (Baylis et al. 2018b). Breeding occurs from late October through mid-January, with pupping peaking from mid-November to mid-December (Cárdenas-Alayza 2018a). Nine adult females outfitted with satellite tags on Falkland Islands' breeding colonies during May–December 2015 made long foraging trips to the north and west of the Falklands out to ~250 km from breeding colonies (Baylis et al. 2018b). Foraging trips were longer during spring than winter, likely related to the age of their offspring, and fur seals generally remained in water depths less than 400 m. Four adult males also satellite tagged in the Falklands during May through December made extensive foraging trips to the north, with an average distance of ~250 km but as far as 990 km (Baylis et al. 2018a). Those fur seals spent most of their time in water depths less than 200 m. There are no records of South American fur seals within the proposed offshore project area in the OBIS database (OBIS 2019). The closest record is ~270 km to the west.

Subantarctic Fur Seal (*Arctocephalus tropicalis*)

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). Breeding season is from late October to early January. Pups are weaned at about 10 months but females leave their pups within a day of birth to make foraging trips that last for a few days and increase to a few weeks in duration (Hofmeyr and Bester 2018). Males leave breeding colonies in January and do not return until the following October. Foraging trips are generally several hundred kilometers and can be up to 2000 km (Hofmeyr and Bester 2018). Vagrants are found as far north as Brazil (de Moura and Siciliano 2007; Sá Velozo et al. 2009). Genetics show that only about one third of the vagrants arriving in Brazil were from the nearest breeding colony on Gough Island, and that some traveled much further, likely making use of the current system in the region to help carry them there (Ferreira et al. 2008).

Subantarctic fur seals found in Brazil were most often seen there during the austral winter from July through October (de Moura and Siciliano 2007); most were males. Between 2000 and 2010, 74% of pinniped records from the coast of Santa Catarina, Brazil, occurred during July through September (de Oliveira et al. 2011). Subantarctic fur seals were observed in all months except January. There are no records of subantarctic fur seals within the proposed offshore project area in the OBIS database (OBIS 2019).

South American Sea Lion (*Otaria flavescens*)

The South American sea lion is widely distributed along the South American coastline from Peru in the Pacific to southern Brazil in the Atlantic (Cárdenas-Alayza 2018b). On the Atlantic coast, it occurs from Brazil to Tierra del Fuego, including the Falkland Islands (Cárdenas-Alayza 2018b). The northernmost rookery is located on the coast of Uruguay; South American sea lions are also known to breed on the Falkland Islands (Thompson et al. 2005). Breeding occurs during austral summer (December), and pups are born from December through February (Cárdenas-Alayza 2018b). South American sea lions typically do not migrate, but some populations make seasonal movements (Cárdenas-Alayza 2018b). The population on the Falkland Islands has declined more than 90% since 1937, but pup production increased between 1995 and 2003 by 3.8 (Thompson et al. 2005). Initially, the decline was attributed to overharvesting, but Baylis et al. (2015) propose that it may have been caused by environmental changes.

Seventy-seven sightings of 81 individuals were made during surveys in Falkland Islands waters from February 1998 to January 2001; sea lions were observed during all months (White et al. 2002). The majority

were seen in coastal and shelf waters; four sightings were made in the southwestern portion of the proposed project area (White et al. 2002). Although populations from Chile and Argentina are known to make extensive, long-range migrations during the nonbreeding season (e.g., Campagna et al. 2001), individuals from the Falkland Islands primarily forage on the shelf and shelf edge up to the 200-m isobath (Baylis et al. 2015, 2017). However, one adult male traveled between the Falkland Islands and the coast of Argentina during the nonbreeding season (Baylis et al. 2017). An adult male that was satellite-tagged in November 1999 at Península Valdés traveled to the northwestern portion of the proposed project area; another male also approached Survey Area 2 (Campagna et al. 2001). There are 2352 records for coastal and shelf waters of South America in the OBIS database; most records are for waters off Argentina (OBIS 2019). There are 80 records in the northwestern portion of the proposed project area. Retana and Lewis (2017) reported 50 records west of the project area.

Crabeater Seal (*Lobodon carcinophagus*)

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 (de Oliveira et al. 2006). Telemetry studies show that crabeater seals are generally confined to the pack ice, but spend ~14% 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). Crabeater seals found on the coast of Brazil were most often observed during the austral summer and fall, but also in winter months (de Oliveira et al. 2006). Their presence during fall and winter is probably related to post-weaning dispersal. There are no records of crabeater seals within the proposed offshore project area in the OBIS database (OBIS 2019).

Leopard Seal (*Hydrurga leptonyx*)

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.

Most leopard seals remain within the pack ice; however, members of this species regularly visit southern continents during the winter (Rogers 2018). In the Pacific, leopard seals are sighted year-round in southern Chile and observed mostly during the winter in northern and central Chile (Aguayo-Lobo et al. 2011). On the Atlantic coast of South America, leopard seals have been reported in small groups on the Falkland Islands and as lone individuals in Brazil, Uruguay, Tierra del Fuego, Patagonia, and northern Argentina (summarized in Rodríguez et al. 2003). Leopard seals were found in these coastal areas during June through December, with the majority reported from June through September; in the Falkland Islands, they have been reported during spring and early summer. Leopard seals were detected acoustically in Falkland Island waters from summer through winter during monitoring from July 2012 to July 2013 (Premier Oil 2018). There are no records of leopard seals within the proposed offshore survey area in the OBIS database (OBIS 2019).

Southern Elephant Seal (*Mirounga leonina*)

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). Croxall and Wood (2002) reported breeding populations of 350,000 at South Georgia, 3500 at the Falkland Islands, and 25,000 at Península Valdés.

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% of their time at sea each year, up to 90% 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). Juvenile and subadult males have been documented in Brazil, Uruguay, Argentina, Falkland Islands, and South Georgia (Lewis et al. 2006; Oliveira et al. 2011; Mayorga et al. 2015). Individuals north of Argentina are considered vagrants (e.g., Mayorga et al. 2015).

Southern elephant seals are known to occur throughout the proposed project area (White et al. 2002; Campagna et al. 2008). Thirteen sightings of individual southern elephant seals were made during surveys in Falkland Islands waters from February 1998 to January 2001, including seven in the southwestern portion of the proposed project area (White et al. 2002). All sightings north of 50°S were made during January−May, and all records south of 50°S were made during June, August, and November; most sightings were made near the 200-m isobath (White et al. 2002). Three adult females that were tagged during the molt at Península Valdés during February 1992 traveled through the proposed project area (Campagna et al. 1995, 2000). Female juvenile elephant seals equipped with satellite tags foraged in the northwestern portion of Survey Area 2 and in Survey Areas 1 and 3 during August–November; juvenile males were also tracked in the proposed project area (Campagna et al. 2006, 2007). Adult seals that were tagged at Península Valdés during October and November also traveled through the northwestern portion of Survey Area 2 and through Survey Areas 1 and 3 (Campagna et al. 2000).

Twenty-eight sightings were made during oceanographic survey cruises (2009) and aerial surveys (1999) near Argentina, west of the proposed project area (Retana and Lewis 2017). For the South Atlantic, there are ~3000 OBIS records for the nearshore and offshore waters of eastern South America (OBIS 2019); most of the records (2943) are for waters off Argentina and the Falkland Islands, including within and near the proposed project area. There are two records within Survey Area 1, 106 within Area 2, and four within Area 3 (OBIS 2019). Some seals are known to travel between the Falkland Islands and Península Valdés (Lewis et al. 2006). 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); none were tracked entering the proposed project area, but seals did venture northeast of the Falkland Islands. There are a few others records of individuals tagged on South Georgia traveling to the Falklands (Croxall and Wood 2002).

V. TYPE OF INCIDENTAL TAKE AUTHORIZATION REQUESTED

The type of incidental taking authorization that is being requested (i.e., takes by harassment only, takes by harassment, injury and/or death), and the method of incidental taking.

SIO requests an IHA pursuant to Section 101 (a)(5)(D) of the MMPA for incidental take by harassment during its planned seismic surveys in the Southwest Atlantic Ocean during September–October 2019. The operations outlined in § I have the potential to take marine mammals by harassment. Sounds would be generated by the GI airguns used during the surveys, by echosounders, pingers, and by general vessel operations. "Takes" by harassment would potentially result when marine mammals near the activities are exposed to the pulsed sounds generated by the GI airguns or echosounders. The effects would depend on the species of marine mammal, the behavior of the animal at the time of reception of the stimulus, as well as the distance and received level of the sound (see § VII). Disturbance reactions are likely amongst some of the marine mammals near the tracklines of the source vessel.

At most, effects on marine mammals would be anticipated as falling within the MMPA definition of "Level B Harassment" for those species managed by NMFS. No take by serious injury is expected, given the nature of the planned operations and the mitigation measures that are planned (see § XI, MITIGATION MEASURES), and no lethal takes are expected. However, per NMFS requirement, small numbers of Level A takes are also being requested for the remote possibility of low-level physiological effects. Because of the characteristics of the proposed study and the proposed monitoring and mitigation measures, in addition to the general avoidance by marine mammals of loud sounds, Level A takes are considered highly unlikely.

VI. NUMBERS OF MARINE MAMMALS THAT COULD BE TAKEN

By age, sex, and reproductive condition (if possible), the number of marine mammals (by species) that may be taken by each type of taking identified in [section V], and the number of times such takings by each type of taking are likely to occur.

The material for § VI and § VII has been combined and presented in reverse order to minimize duplication between sections.

VII. ANTICIPATED IMPACT ON SPECIES OR STOCKS

The anticipated impact of the activity upon the species or stock of marine mammal.

The material for § VI and § VII has been combined and presented in reverse order to minimize duplication between sections.

- First we summarize the potential impacts on marine mammals of airgun operations, as called for in § VII, and refer to recent literature that has become available since the PEIS was released in 2011. A more comprehensive review of the relevant background information appears in § 3.6.4.3, § 3.7.4.3, and Appendix E of the PEIS.
- Then we summarize the potential impacts of operations by the echosounders. A more comprehensive review of the relevant background information appears in § 3.6.4.3, § 3.7.4.3, and Appendix E of the PEIS.
- Finally, we estimate the numbers of marine mammals that could be affected by the proposed surveys in the Southwest Atlantic Ocean during September–October 2019. This section includes a description of the rationale for the estimates of the potential numbers of harassment "takes" during the planned surveys, as called for in § VI.

Summary of Potential Effects of Airgun Sounds

As noted in the PEIS (§ 3.6.4.3, § 3.7.4.3, § 3.8.4.3), the effects of sounds from airguns could include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and at least in theory, temporary or permanent hearing impairment, or non-auditory physical or physiological effects (Richardson et al. 1995; Gordon et al. 2004; Nowacek et al. 2007; Southall et al. 2007; Erbe 2012; Peng et al. 2015; Erbe et al. 2016; Kunc et al. 2016; National Academies of Sciences, Engineering, and Medicine 2017). In some cases, a behavioral response to a sound can reduce the overall exposure to that sound (e.g., Finneran et al. 2015; Wensveen et al. 2015).

Permanent hearing impairment (PTS), in the unlikely event that it occurred, would constitute injury, but temporary threshold shift (TTS) is not considered an injury (Southall et al. 2007; Le Prell 2012). Rather, the onset of TTS has been considered an indicator that, if the animal is exposed to higher levels of that sound, physical damage is ultimately a possibility. Nonetheless, research has shown that sound exposure can cause cochlear neural degeneration, even when threshold shifts and hair cell damage are reversible (Kujawa and Liberman 2009; Liberman 2016). These findings have raised some doubts as to whether TTS should continue to be considered a non-injurious effect (Weilgart 2014; Tougaard et al. 2015, 2016). Although the possibility cannot be entirely excluded, it is unlikely that the proposed surveys would result in any cases of temporary or permanent hearing impairment, or any significant non-auditory physical or physiological effects. If marine mammals encounter a survey while it is underway, some behavioral disturbance could result, but this would be localized and short-term.

Tolerance

Numerous studies have shown that pulsed sounds from airguns are often readily detectable in the water at distances of many kilometers (e.g., Nieukirk et al. 2012). Several studies have shown that marine mammals at distances more than a few kilometers from operating seismic vessels often show no apparent response. That is often true even in cases when the pulsed sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. Although various baleen and toothed whales, and (less frequently) pinnipeds have been shown to react behaviorally to airgun pulses under some conditions, at other times mammals of all three types have shown no overt reactions. The relative responsiveness of baleen and toothed whales are quite variable.

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% when a seismic survey was operating 450–2800 km away. Based on preliminary modeling, Wittekind et al. (2016) reported that airgun sounds could reduce the communication range of blue and fin whales at a distance of 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). 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. Sills et al. (2017) reported that recorded airguns sounds masked the detection of low-frequency sounds by ringed and spotted seals, especially at the onset of the airgun pulse when signal amplitude was variable.

Disturbance Reactions

Disturbance includes a variety of effects, including subtle to conspicuous changes in behavior, movement, and displacement. Based on NMFS (2001, p. 9293), National Research Council (NRC 2005), and Southall et al. (2007), we believe that simple exposure to sound, or brief reactions that do not disrupt behavioral patterns in a potentially significant manner, do not constitute harassment or "taking". By potentially significant, we mean, 'in a manner that might have deleterious effects to the well-being of individual marine mammals or their populations'.

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors (Richardson et al. 1995; Wartzok et al. 2004; Southall et al. 2007; Weilgart 2007; Ellison et al. 2012). If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or population (e.g., New et al. 2013a). 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 (Lusseau and Bejder 2007; Weilgart 2007; New et al. 2013b; Nowacek et al. 2015; Forney et al. 2017). Some studies have attempted modeling to assess consequences of effects from underwater noise at the population level (e.g., New et al. 2013b; King et al. 2015; Costa et al. 2016a,b; Ellison et al. 2016; Harwood et al. 2016; Nowacek et al. 2016; Farmer et al. 2017). Various authors have noted that some marine mammals that show no obvious avoidance or behavioral changes may still be adversely affected by sound (e.g., Weilgart 2007; Wright et al. 2011; Gomez et al. 2016).

Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate how many marine mammals would be present within a particular distance of industrial activities and/or exposed to a particular level of industrial sound. In most cases, this approach likely overestimates the numbers of marine mammals that would be affected in some biologically important manner.

The sound criteria used to estimate how many marine mammals could be disturbed to some biologically important degree by a seismic program are based primarily on behavioral observations of a few species. Detailed studies have been done on humpback, gray, bowhead, and sperm whales. Less

detailed data are available for some other species of baleen whales and small toothed whales, but for many species, there are no data on responses to marine seismic surveys.

Baleen Whales.—Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable. Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, baleen whales exposed to strong noise pulses from airguns often react by deviating from their normal migration route and/or interrupting their feeding and moving away. In the cases of migrating gray and bowhead whales, the observed changes in behavior appeared to be of little or no biological consequence to the animals. They simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors (Malme et al. 1984; Malme and Miles 1985; Richardson et al. 1995).

Responses of *humpback whales* to seismic surveys have been studied during migration, on summer feeding grounds, and on Angolan winter breeding grounds; there has also been discussion of effects on the Brazilian wintering grounds. Off Western Australia, avoidance reactions began at 5–8 km from the array, and those reactions kept most pods ~3–4 km from the operating seismic vessel; there was localized displacement during migration of 4–5 km by traveling pods and 7–12 km by more sensitive resting pods of cow-calf pairs (McCauley et al. 1998, 2000). However, some individual humpback whales, especially males, approached within distances of 100–400 m.

Dunlop et al. (2015) reported that humpback whales responded to a vessel operating a 20 in^3 airgun by decreasing their dive time and speed of southward migration; however, the same responses were obtained during control trials without an active airgun, suggesting that humpbacks responded to the source vessel rather than the airgun. A ramp up was not superior to triggering humpbacks to move away from the vessel compared with a constant source at a higher level of 140 in^3, although an increase in distance from the airgun array was noted for both sources (Dunlop et al. 2016a). Avoidance was also shown when no airguns were operational, indicating that the presence of the vessel itself had an effect on the response (Dunlop et al. 2016a,b). Overall, the results showed that humpbacks were more likely to avoid active airgun arrays (of 20 and 140 in^3) within 3 km and at levels of at least 140 dB re 1 $\mu Pa^2 \cdot s$ (Dunlop et al. 2017a). Responses to ramp up and use of a 3130 in^3 array elicited greater behavioral changes in humpbacks when compared with small arrays (Dunlop et al. 2016c). Humpbacks reduced their southbound migration, or deviated from their path thereby avoiding the active array, when they were within 4 km of the active large airgun source, where received levels were >135 dB re 1 $\mu Pa^2 \cdot s$ (Dunlop et al. 2017b). These results are consistent with earlier studies (e.g., McCauley et al. 2000).

In the northwest Atlantic, sighting rates were significantly greater during non-seismic periods compared with periods when a full array was operating, and humpback whales were more likely to swim away and less likely to swim towards a vessel during seismic vs. non-seismic periods (Moulton and Holst 2010). In contrast, sightings of humpback whales from seismic vessels off the U.K. during 1994–2010 indicated that detection rates were similar during seismic and non-seismic periods, although sample sizes were small (Stone 2015). It has been suggested that South Atlantic humpback whales wintering off Brazil may be displaced or even strand upon exposure to seismic surveys (Engel et al. 2004), but data from subsequent years indicated that there was no observable direct correlation between strandings and seismic surveys (IWC 2007).

There are no data on reactions of *right whales* to seismic surveys. However, Rolland et al. (2012) suggested that ship noise causes increased stress in right whales; they showed that baseline levels of stress-related faecal hormone metabolites decreased in North Atlantic right whales with a 6-dB decrease in

underwater noise from vessels. Wright et al. (2011), Atkinson et al. (2015), Houser et al. (2016), and Lyamin et al. (2016) also reported that sound could be a potential source of stress for marine mammals.

Bowhead whales show that their responsiveness can be quite variable depending on their activity (migrating vs. feeding). Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn, in particular, are unusually responsive, with substantial avoidance occurring out to distances of 20–30 km from a medium-sized airgun source (Miller et al. 1999; Richardson et al. 1999). Subtle but statistically significant changes in surfacing–respiration–dive cycles were shown by traveling and socializing bowheads exposed to airgun sounds in the Beaufort Sea, including shorter surfacings, shorter dives, and decreased number of blows per surfacing (Robertson et al. 2013). More recent research on bowhead whales corroborates earlier evidence that, during the summer feeding season, bowheads are less responsive to seismic sources (e.g., Miller et al. 2005; Robertson et al. 2013).

Bowhead whale calls detected in the presence and absence of airgun sounds have been studied extensively in the Beaufort Sea. Bowheads continue to produce calls of the usual types when exposed to airgun sounds on their summering grounds, although numbers of calls detected are significantly lower in the presence than in the absence of airgun pulses (Blackwell et al. 2013, 2015). Blackwell et al. (2013) reported that calling rates in 2007 declined significantly where received SPLs from airgun sounds were 116–129 dB re 1 μPa; at SPLs <108 dB re 1 μPa, calling rates were not affected. When data for 2007–2010 were analyzed, Blackwell et al. (2015) reported an initial increase in calling rates when airgun pulses became detectable; however, calling rates leveled off at a received $CSEL_{10\text{-min}}$ (cumulative SEL over a 10-min period) of ~94 dB re 1 $\mu Pa^2 \cdot s$, decreased at $CSEL_{10\text{-min}}$ >127 dB re 1 $\mu Pa^2 \cdot s$, and whales were nearly silent at $CSEL_{10\text{-min}}$ >160 dB re 1 $\mu Pa^2 \cdot s$. Thus, bowhead whales in the Beaufort Sea apparently decreased their calling rates in response to seismic operations, although movement out of the area could also have contributed to the lower call detection rate (Blackwell et al. 2013, 2015).

A multivariate analysis of factors affecting the distribution of calling bowhead whales during their fall migration in 2009 noted that the southern edge of the distribution of calling whales was significantly closer to shore with increasing levels of airgun sound from a seismic survey a few hundred kilometers to the east of the study area (i.e., behind the westward-migrating whales; McDonald et al. 2010, 2011). It was not known whether this statistical effect represented a stronger tendency for quieting of the whales farther offshore in deeper water upon exposure to airgun sound, or an actual inshore displacement of whales.

There was no indication that *western gray whales* exposed to seismic sound were displaced from their overall feeding grounds near Sakhalin Island during seismic programs in 1997 (Würsig et al. 1999) or 2001 (Johnson et al. 2007; Meier et al. 2007; Yazvenko et al. 2007a). However, there were indications of subtle behavioral effects among whales that remained in the areas exposed to airgun sounds (Würsig et al. 1999; Gailey et al. 2007; Weller et al. 2006a) and localized redistribution of some individuals within the nearshore feeding ground so as to avoid close approaches by the seismic vessel (Weller et al. 2002, 2006b; Yazvenko et al. 2007a). Despite the evidence of subtle changes in some quantitative measures of behavior and local redistribution of some individuals, there was no apparent change in the frequency of feeding, as evident from mud plumes visible at the surface (Yazvenko et al. 2007b).

Similarly, no large changes in gray whale movement, respiration, or distribution patterns were observed during seismic programs conducted in 2010 (Bröker et al. 2015; Gailey et al. 2016). Although sighting distances of gray whales from shore increased slightly during a 2-week seismic survey, this result was not significant (Muir et al. 2015). However, there may have been a possible localized avoidance response to high sound levels in the area (Muir et al. 2016). The lack of strong avoidance or other strong responses during the 2001 and 2010 programs was presumably in part a result of the comprehensive combination of real-time monitoring and mitigation measures designed to avoid exposing western gray

whales to received SPLs above ~163 dB re 1 μPa_{rms} (Johnson et al. 2007; Nowacek et al. 2012, 2013b). In contrast, preliminary data collected during a seismic program in 2015 showed some displacement of animals from the feeding area and responses to lower sound levels than expected (Gailey et al. 2017; Sychenko et al. 2017).

Gray whales in British Columbia exposed to seismic survey sound levels up to ~170 dB re 1 μPa did not appear to be strongly disturbed (Bain and Williams 2006). The few whales that were observed moved away from the airguns but toward deeper water where sound levels were said to be higher due to propagation effects (Bain and Williams 2006).

Various species of *Balaenoptera* (blue, sei, fin, and minke whales) have occasionally been seen in areas ensonified by airgun pulses. Sightings by observers on seismic vessels using large arrays off the U.K. from 1994 to 2010 showed that the detection rate for minke whales was significantly higher when airguns were not operating; however, during surveys with small arrays, the detection rates for minke whales were similar during seismic and non-seismic periods (Stone 2015). Sighting rates for fin and sei whales were similar when large arrays of airguns were operating vs. silent (Stone 2015). All baleen whales combined tended to exhibit localized avoidance, remaining significantly farther (on average) from large arrays (median closest point of approach or CPA of ~1.5 km) during seismic operations compared with non-seismic periods (median CPA ~1.0 km; Stone 2015). In addition, fin and minke whales were more often oriented away from the vessel while a large airgun array was active compared with periods of inactivity (Stone 2015). Singing fin whales in the Mediterranean moved away from an operating airgun array, and their song notes had lower bandwidths during periods with vs. without airgun sounds (Castellote et al. 2012).

During seismic surveys in the northwest Atlantic, baleen whales as a group showed localized avoidance of the operating array (Moulton and Holst 2010). Sighting rates were significantly lower during seismic operations compared with non-seismic periods. Baleen whales were seen on average 200 m farther from the vessel during airgun activities vs. non-seismic periods, and these whales more often swam away from the vessel when seismic operations were underway compared with periods when no airguns were operating (Moulton and Holst 2010). Blue whales were seen significantly farther from the vessel during single airgun operations, ramp up, and all other airgun operations compared with non-seismic periods (Moulton and Holst 2010). Similarly, fin whales were seen at significantly farther distances during ramp up than during periods without airgun operations; there was also a trend for fin whales to be sighted farther from the vessel during other airgun operations, but the difference was not significant (Moulton and Holst 2010). Minke whales were seen significantly farther from the vessel during periods with than without seismic operations (Moulton and Holst 2010). Minke whales were also more likely to swim away and less likely to approach during seismic operations compared to periods when airguns were not operating (Moulton and Holst 2010). However, Matos (2015) reported no change in sighting rates of minke whales in Vestfjorden, Norway, during ongoing seismic surveys outside of the fjord. Vilela et al. (2016) cautioned that environmental conditions should be taken into account when comparing sighting rates during seismic surveys, as spatial modeling showed that differences in sighting rates of rorquals (fin and minke whales) during seismic periods and non-seismic periods during a survey in the Gulf of Cadiz could be explained by environmental variables.

Data on short-term reactions by cetaceans to impulsive noises are not necessarily indicative of long-term or biologically significant effects. It is not known whether impulsive sounds affect reproductive rate or distribution and habitat use in subsequent days or years. However, gray whales have continued to migrate annually along the west coast of North America with substantial increases in the population over recent years, despite intermittent seismic exploration (and much ship traffic) in that area for decades. In addition,

bowhead whales have continued to travel to the eastern Beaufort Sea each summer, and their numbers have increased notably, despite seismic exploration in their summer and autumn range for many years.

Pirotta et al. (2018) used a dynamic state model of behavior and physiology to assess the consequences of disturbance (e.g., seismic surveys) on whales (in this case, blue whales). They found that the impact of localized, acute disturbance (e.g., seismic surveys) depended on the whale's behavioral response, with whales that remained in the affected area having a greater risk of reduced reproductive success than whales that avoided the disturbance. Chronic, but weaker disturbance (e.g., vessel traffic) appeared to have less effect on reproductive success.

Toothed Whales.—Little systematic information is available about reactions of toothed whales to sound pulses. However, there are recent systematic studies on sperm whales, and there is an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring studies. Seismic operators and protected species observers on seismic vessels regularly see dolphins and other small toothed whales near operating airgun arrays, but in general there is a tendency for most delphinids to show some avoidance of operating seismic vessels (e.g., Stone and Tasker 2006; Moulton and Holst 2010; Barry et al. 2012; Wole and Myade 2014; Stone 2015; Monaco et al. 2016). In most cases, the avoidance radii for delphinids appear to be small, on the order of 1 km or less, and some individuals show no apparent avoidance.

Observations from seismic vessels using large arrays off the U.K. from 1994–2010 indicated that detection rates were significantly higher for killer whales, white-beaked dolphins, and Atlantic white-sided dolphins when airguns were not operating; detection rates during seismic vs. non-seismic periods were similar during seismic surveys using small arrays (Stone 2015). Detection rates for long-finned pilot whales, Risso's dolphins, bottlenose dolphins, and short-beaked common dolphins were similar during seismic (small or large array) vs. non-seismic operations (Stone 2015). CPA distances for killer whales, white-beaked dolphins, and Atlantic white-sided dolphins were significantly farther (>0.5 km) from large airgun arrays during periods of airgun activity compared with periods of inactivity, with significantly more animals traveling away from the vessel during airgun operation (Stone 2015). Observers' records suggested that fewer cetaceans were feeding and fewer delphinids were interacting with the survey vessel (e.g., bow-riding) during periods with airguns operating (Stone 2015).

During seismic surveys in the northwest Atlantic, delphinids as a group showed some localized avoidance of the operating array (Moulton and Holst 2010). The mean initial detection distance was significantly farther (by ~200 m) during seismic operations compared with periods when the seismic source was not active; however, there was no significant difference between sighting rates (Moulton and Holst 2010). The same results were evident when only long-finned pilot whales were considered.

Preliminary findings of a monitoring study of *narwhals* in Melville Bay, Greenland (summer and fall 2012) showed no short-term effects of seismic survey activity on narwhal distribution, abundance, migration timing, and feeding habits (Heide-Jørgensen et al. 2013a). In addition, there were no reported effects on narwhal hunting. These findings do not seemingly support a suggestion by Heide-Jørgensen et al. (2013b) that seismic surveys in Baffin Bay may have delayed the migration timing of narwhals, thereby increasing the risk of narwhals to ice entrapment.

The beluga, however, is a species that (at least at times) shows long-distance (10s of km) avoidance of seismic vessels (e.g., Miller et al. 2005). Captive bottlenose dolphins and beluga whales exhibited changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys, but the animals tolerated high received levels of sound before exhibiting aversive behaviors (e.g., Finneran et al. 2000, 2002, 2005). Schlundt et al. (2016) also reported that bottlenose dolphins exposed to multiple airgun pulses exhibited some anticipatory behavior.

Most studies of *sperm whales* exposed to airgun sounds indicate that the sperm whale shows considerable tolerance of airgun pulses; in most cases the whales do not show strong avoidance (e.g., Stone and Tasker 2006; Moulton and Holst 2010). However, foraging behavior can be altered upon exposure to airgun sound (e.g., Miller et al. 2009) which, according to Farmer et al. (2017), could have significant consequences on individual fitness. Based on data collected by observers on seismic vessels off the U.K. from 1994–2010, detection rates for sperm whales were similar when large arrays of airguns were operating vs. silent; however, during surveys with small arrays, the detection rate was significantly higher when the airguns were not in operation (Stone 2015). Preliminary data from the Gulf of Mexico show a correlation between reduced sperm whale acoustic activity during periods with airgun operations (Sidorovskaia et al. 2014).

There are almost no specific data on the behavioral reactions of *beaked whales* to seismic surveys. Most beaked whales tend to avoid approaching vessels of other types (e.g., Würsig et al. 1998) and/or change their behavior in response to sounds from vessels (e.g., Pirotta et al. 2012). Thus, it is likely that most beaked whales would also show strong avoidance of an approaching seismic vessel. Observations from seismic vessels off the U.K. from 1994–2010 indicated that detection rates of beaked whales were significantly higher ($p<0.05$) when airguns were not operating vs. when a large array was in operation, although sample sizes were small (Stone 2015). Some northern bottlenose whales remained in the general area and continued to produce high-frequency clicks when exposed to sound pulses from distant seismic surveys (e.g., Simard et al. 2005).

The limited available data suggest that *harbor porpoises* show stronger avoidance of seismic operations than do Dall's porpoises. Based on data collected by observers on seismic vessels off the U.K. from 1994–2010, detection rates of harbor porpoises were significantly higher when airguns were silent vs. when large or small arrays were operating (Stone 2015). In addition, harbor porpoises were seen farther away from the array when it was operating vs. silent, and were most often seen traveling away from the airgun array when it was in operation (Stone 2015). Thompson et al. (2013) reported decreased densities and reduced acoustic detections of harbor porpoise in response to a seismic survey in Moray Firth, Scotland, at ranges of 5–10 km (SPLs of 165–172 dB re 1 μPa, SELs of 145–151 dB $\mu Pa^2 \cdot s$). For the same survey, Pirotta et al. (2014) reported that the probability of recording a porpoise buzz decreased by 15% in the ensonified area, and that the probability was positively related to the distance from the seismic ship; the decreased buzzing occurrence may indicate reduced foraging efficiency. Nonetheless, animals returned to the area within a few hours (Thompson et al. 2013). In a captive facility, harbor porpoise showed avoidance of a pool with elevated sound levels, but search time for prey within that pool was no different than in a quieter pool (Kok et al. 2017).

Kastelein et al. (2013a) reported that a harbor porpoise showed no response to an impulse sound with an SEL below 65 dB, but a 50% brief response rate was noted at an SEL of 92 dB and an SPL of 122 dB re 1 $\mu Pa_{0\text{-peak}}$. However, Kastelein et al. (2012a) reported a 50% detection threshold at a SEL of 60 dB to a similar impulse sound; this difference is likely attributable to the different transducers used during the two studies (Kastelein et al. 2013a). Van Beest et al. (2018) exposed five harbor porpoise to a single 10 in^3 airgun for 1 min at 2–3 s intervals at ranges of 420–690 m and levels of 135–147 dB $\mu Pa^2 \cdot s$. One porpoise moved away from the sound source but returned to natural movement patters within 8 h, and two porpoises had shorter and shallower dives but returned to natural behaviors within 24 h.

Odontocete reactions to large arrays of airguns are variable and, at least for delphinids, seem to be confined to a smaller radius than has been observed for the more responsive of the mysticetes and some other odontocetes. A ≥170 dB disturbance criterion (rather than ≥160 dB) is considered appropriate for delphinids (in particular mid-frequency cetaceans), which tend to be less responsive than the more

responsive cetaceans. NMFS is currently developing new guidance for predicting behavioral effects (Scholik-Schlomer 2015). As behavioral responses are not consistently associated with received levels, some authors have made recommendations on different approaches to assess behavioral reactions (e.g., Gomez et al. 2016; Harris et al. 2017).

Pinnipeds.—Pinnipeds are not likely to show a strong avoidance reaction to an airgun array. Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds and only slight (if any) changes in behavior. However, telemetry work has suggested that avoidance and other behavioral reactions may be stronger than evident to date from visual studies (Thompson et al. 1998). Observations from seismic vessels operating large arrays off the U.K. from 1994–2010 showed that the detection rate for gray seals was significantly higher when airguns were not operating; for surveys using small arrays, the detection rates were similar during seismic vs. non-seismic operations (Stone 2015). No significant differences in detection rates were apparent for harbor seals during seismic and non-seismic periods (Stone 2015). There were no significant differences in CPA distances of gray or harbor seals during seismic vs. non-seismic periods (Stone 2015). Lalas and McConnell (2015) made observations of New Zealand fur seals from a seismic vessel operating a 3090 in^3 airgun array in New Zealand during 2009. However, the results from the study were inconclusive in showing whether New Zealand fur seals respond to seismic sounds. Reichmuth et al. (2016) exposed captive spotted and ringed seals to single airgun pulses; only mild behavioral responses were observed.

Hearing Impairment and Other Physical Effects

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. TTS has been demonstrated and studied in certain captive odontocetes and pinnipeds exposed to strong sounds (reviewed by Southall et al. 2007; Finneran 2015). However, there has been no specific documentation of TTS let alone permanent hearing damage, i.e., PTS, in free-ranging marine mammals exposed to sequences of airgun pulses during realistic field conditions.

Additional data are needed to determine the received sound levels at which small odontocetes would start to incur TTS upon exposure to repeated, low-frequency pulses of airgun sound with variable received levels. To determine how close an airgun array would need to approach in order to elicit TTS, one would (as a minimum) need to allow for the sequence of distances at which airgun pulses would occur, and for the dependence of received SEL on distance in the region of the seismic operation (e.g., Breitzke and Bohlen 2010; Laws 2012). At the present state of knowledge, it is also necessary to assume that the effect is directly related to total received energy (SEL); however, this assumption is likely an over-simplification (Finneran 2012). There is recent evidence that auditory effects in a given animal are not a simple function of received acoustic energy (Finneran 2015). Frequency, duration of the exposure, and occurrence of gaps within the exposure can also influence the auditory effect (Finneran and Schlundt 2010, 2011, 2013; Finneran et al. 2010a,b; Popov et al. 2011, 2013; Finneran 2012, 2015; Kastelein et al. 2012b,c; 2013b,c, 2014, 2015a, 2016a,b; Ketten 2012; Supin et al. 2016).

Recent data have shown that the SEL required for TTS onset to occur increases with intermittent exposures, with some auditory recovery during silent periods between signals (Finneran et al. 2010b; Finneran and Schlundt 2011). Studies on bottlenose dolphins by Finneran et al. (2015) indicate that the potential for seismic surveys using airguns to cause auditory effects on dolphins could be lower than previously thought. Based on behavioral tests, no measurable TTS was detected in three bottlenose dolphins after exposure to 10 impulses from a seismic airgun with a cumulative SEL of up to ~195 dB re 1 $\mu Pa^2 \cdot s$ (Finneran et al. 2015; Schlundt et al. 2016). However, auditory evoked potential measurements were more variable; one dolphin showed a small (9 dB) threshold shift at 8 kHz (Finneran et al. 2015; Schlundt et al. 2016).

Recent studies have also shown that the SEL necessary to elicit TTS can depend substantially on frequency, with susceptibility to TTS increasing with increasing frequency above 3 kHz (Finneran and Schlundt 2010, 2011; Finneran 2012). When beluga whales were exposed to fatiguing noise with sound levels of 165 dB re 1 μPa for durations of 1–30 min at frequencies of 11.2–90 kHz, the highest TTS with the longest recovery time was produced by the lower frequencies (11.2 and 22.5 kHz); TTS effects also gradually increased with prolonged exposure time (Popov et al. 2013). Additionally, Popov et al. (2015) demonstrated that the impacts of TTS include deterioration of signal discrimination. Kastelein et al. (2015b) reported that exposure to multiple pulses with most energy at low frequencies can lead to TTS at higher frequencies in some cetaceans, such as the harbor porpoise. When a porpoise was exposed to 10 and 20 consecutive shots (mean shot interval ~17 s) from two airguns with a SEL_{cum} of 188 and 191 $\mu Pa^2 \cdot s$, respectively, significant TTS occurred at a hearing frequency of 4 kHz and not at lower hearing frequencies that were tested, despite the fact that most of the airgun energy was <1 kHz; recovery occurred within 12 min post exposure (Kastelein et al. 2017).

Popov et al. (2016) reported that TTS produced by exposure to a fatiguing noise was larger during the first session (or naïve subject state) with a beluga whale than TTS that resulted from the same sound in subsequent sessions (experienced subject state). Similarly, several other studies have shown that some marine mammals (e.g., bottlenose dolphins, false killer whales) can decrease their hearing sensitivity in order to mitigate the impacts of exposure to loud sounds (e.g., Nachtigall and Supin 2013, 2014, 2015, 2016; Nachtigall et al. 2017).

Previous information on TTS for odontocetes was primarily derived from studies on the bottlenose dolphin and beluga, and that for pinnipeds has mostly been obtained from California sea lions and elephant seals (see § 3.6.4.3, § 3.7.4.3, § 3.8.4.3 and Appendix E of the PEIS). Thus, it is inappropriate to assume that onset of TTS occurs at similar received levels in all cetaceans or pinnipeds (*cf.* Southall et al. 2007; NMFS 2016a). Some cetaceans or pinnipeds could incur TTS at lower sound exposures than are necessary to elicit TTS in the beluga and bottlenose dolphin or California sea lion and elephant seal, respectively.

Several studies on TTS in porpoises (e.g., Lucke et al. 2009; Popov et al. 2011; Kastelein et al. 2012c, 2013b,c, 2014, 2015a) have indicated that received levels that elicit onset of TTS are lower in porpoises than in other odontocetes. Kastelein et al. (2012c) exposed a harbor porpoise to octave band noise centered at 4 kHz for extended periods. A 6-dB TTS occurred with SELs of 163 dB and 172 dB for low-intensity sound and medium-intensity sound, respectively; high-intensity sound caused a 9-dB TTS at a SEL of 175 dB. Kastelein et al. (2013b) exposed a harbor porpoise to a long, continuous 1.5-kHz tone, which induced a 14-dB TTS with a total SEL of 190 dB. Popov et al. (2011) examined the effects of fatiguing noise on the hearing threshold of Yangtze finless porpoises when exposed to frequencies of 32–128 kHz at 140–160 dB re 1 μPa for 1–30 min. They found that an exposure of higher level and shorter duration produced a higher TTS than an exposure of equal SEL but of lower level and longer duration. Popov et al. (2011) reported a TTS of 25 dB for a Yangtze finless porpoise that was exposed to high levels of 3-min pulses of half-octave band noise centered at 45 kHz with an SEL of 163 dB.

For the harbor porpoise, Tougaard et al. (2015) suggested an exposure limit for TTS as an SEL of 100–110 dB above the pure tone hearing threshold at a specific frequency; they also suggested an exposure limit of $L_{eq\text{-}fast}$ (rms average over the duration of the pulse) of 45 dB above the hearing threshold for behavioral responses (i.e., negative phonotaxis). According to Wensveen et al. (2014) and Tougaard et al. (2015), M-weighting, as used by Southall et al. (2007), might not be appropriate for the harbor porpoise. Thus, Wensveen et al. (2014) developed six auditory weighting functions for the harbor porpoise that could be useful in predicting TTS onset. Mulsow et al. (2015) suggested that basing weighting functions on equal latency/loudness contours may be more appropriate than M-weighting for marine mammals. Simulation

modeling to assess the risk of sound exposure to marine mammals (gray seal and harbor porpoise) showed that SEL is most strongly influenced by the weighting function (Donovan et al. 2017). Houser et al. (2017) provide a review of the development and application of auditory weighting functions, as well as recommendations for future work.

Initial evidence from exposures to non-pulses has also suggested that some pinnipeds (harbor seals in particular) incur TTS at somewhat lower received levels than do most small odontocetes exposed for similar durations (Kastak et al. 1999, 2005, 2008; Ketten et al. 2001). Kastelein et al. (2012b) exposed two harbor seals to octave-band white noise centered at 4 kHz at three mean received SPLs of 124, 136, and 148 dB re 1 µPa; TTS >2.5 dB was induced at an SEL of 170 dB (136 dB SPL for 60 min), and the maximum TTS of 10 dB occurred after a 120-min exposure to 148 dB re 1 µPa or an SEL of 187 dB. Kastelein et al. (2013c) reported that a harbor seal unintentionally exposed to the same sound source with a mean received SPL of 163 dB re 1 µPa for 1 h induced a 44 dB TTS. For a harbor seal exposed to octave-band white noise centered at 4 kHz for 60 min with mean SPLs of 124–148 re 1 µPa, the onset of PTS would require a level of at least 22 dB above the TTS onset (Kastelein et al. 2013c). Reichmuth et al. (2016) exposed captive spotted and ringed seals to single airgun pulses with SELs of 165–181 dB and SPLs (peak to peak) of 190–207 re 1 µPa; no low-frequency TTS was observed.

Hermannsen et al. (2015) reported that there is little risk of hearing damage to harbor seals or harbor porpoises when using single airguns in shallow water. Similarly, it is unlikely that a marine mammal would remain close enough to a large airgun array for sufficiently long to incur TTS, let alone PTS. However, Gedamke et al. (2011), based on preliminary simulation modeling that attempted to allow for various uncertainties in assumptions and variability around population means, suggested that some baleen whales whose CPA to a seismic vessel is 1 km or more could experience TTS.

There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal, even with large arrays of airguns. However, given the possibility that some mammals close to an airgun array might incur at least mild TTS, there has been further speculation about the possibility that some individuals occurring very close to airguns might incur PTS (e.g., Richardson et al. 1995, p. 372*ff*; Gedamke et al. 2011). In terrestrial animals, exposure to sounds sufficiently strong to elicit a large TTS induces physiological and structural changes in the inner ear, and at some high level of sound exposure, these phenomena become non-recoverable (Le Prell 2012). At this level of sound exposure, TTS grades into PTS. Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage, but repeated or (in some cases) single exposures to a level well above that causing TTS onset might elicit PTS (e.g., Kastak and Reichmuth 2007; Kastak et al. 2008).

The new noise exposure criteria for marine mammals that were recently released by NMFS (2016a, 2018a) account for the newly-available scientific data on TTS, the expected offset between TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive, and other relevant factors. For impulsive sounds, such airgun pulses, the thresholds use dual metrics of cumulative SEL (SEL_{cum} over 24 hours) and Peak SPL_{flat}. Onset of PTS is assumed to be 15 dB higher when considering SEL_{cum} and 6 dB higher when considering SPL_{flat}. Different thresholds are provided for the various hearing groups, including LF cetaceans (e.g., baleen whales), MF cetaceans (e.g., most delphinids), HF cetaceans (e.g., porpoise and *Kogia* spp.), phocids underwater (PW), and otariids underwater (OW).

Nowacek et al. (2013a) concluded that current scientific data indicate that seismic airguns have a low probability of directly harming marine life, except at close range. Several aspects of the planned monitoring and mitigation measures for this project are designed to detect marine mammals occurring near the airgun array and to avoid exposing them to sound pulses that might, at least in theory, cause hearing

impairment (see § XI and § XIII). Also, many marine mammals and (to a limited degree) sea turtles show some avoidance of the area where received levels of airgun sound are high enough such that hearing impairment could potentially occur. In those cases, the avoidance responses of the animals themselves would reduce or (most likely) avoid any possibility of hearing impairment. Aarts et al. (2016) noted that an understanding of animal movement is necessary in order to estimate the impact of anthropogenic sound on cetaceans.

Non-auditory physical effects may also occur in marine mammals exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that might (in theory) occur in mammals close to a strong sound source include stress, neurological effects, bubble formation, and other types of organ or tissue damage. Gray and Van Waerebeek (2011) have suggested a cause-effect relationship between a seismic survey off Liberia in 2009 and the erratic movement, postural instability, and akinesia in a pantropical spotted dolphin based on spatially and temporally close association with the airgun array. It is possible that some marine mammal species (i.e., beaked whales) are especially susceptible to injury and/or stranding when exposed to strong transient sounds (e.g., Southall et al. 2007). Ten cases of cetacean strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys and strandings (Castellote and Llorens 2016). An analysis of stranding data found that the number of long-finned pilot whale stranding along Ireland's coast increased with seismic surveys operating offshore (McGeady et al. 2016). However, there is no definitive evidence that any of these effects occur even for marine mammals in close proximity to large arrays of airguns. Morell et al. (2017) examined the inner ears of long-finned pilot whales after a mass stranding in Scotland and reported damage to the cochlea compatible with over-exposure from underwater noise; however, no seismic surveys were occurring in the vicinity in the days leading up to the stranding.

Since 1991, there have been 67 Marine Mammal Unusual Mortality Events (UME) in the U.S. (NMFS 2018b). In a hearing to examine the Bureau of Ocean Energy Management's 2017–2022 OCS Oil and Gas Leasing Program (http://www.energy.senate.gov/public/index.cfm/hearings-and-business-meetings?ID=110E5E8F-3A65-4BEC-9D25-5D843A0284D3), it was Dr. Knapp's (a geologist from the University of South Carolina) interpretation that there was no evidence to suggest a correlation between UMEs and seismic surveys given the similar percentages of UMEs in the Pacific, Atlantic, and Gulf of Mexico, and the greater activity of oil and gas exploration in the Gulf of Mexico.

Non-auditory effects, if they occur at all, would presumably be limited to short distances and to activities that extend over a prolonged period. Marine mammals that show behavioral avoidance of seismic vessels, including most baleen whales, some odontocetes, and some pinnipeds, are especially unlikely to incur non-auditory physical effects. The brief duration of exposure of any given mammal, the large proportion of survey effort in deeper water, and the planned monitoring and mitigation measures would further reduce the probability of exposure of marine mammals to sounds strong enough to induce non-auditory physical effects.

Possible Effects of Other Acoustic Sources

The Kongsberg EM300 MBES, a Knudsen 3260 SBP, and a 12-kHz pinger would be operated from the source vessel during the proposed surveys, but not during transits. Information about this equipment, or similar, was provided in § 2.2.3.1 of the PEIS. A review of the anticipated potential effects (or lack thereof) of MBESs and SBPs on marine mammals and sea turtles appears in § 3.4.4.3, § 3.6.4.3, § 3.7.4.3, § 3.8.4.3, and Appendix E of the PEIS.

There has been some recent attention given to the effects of MBES on marine mammals, as a result of a report issued in September 2013 by an IWC independent scientific review panel linking the operation of an MBES to a mass stranding of melon-headed whales (*Peponocephala electra*; Southall et al. 2013) off Madagascar. During May–June 2008, ~100 melon-headed whales entered and stranded in the Loza Lagoon system in northwest Madagascar at the same time that a 12-kHz MBES survey was being conducted ~65 km away off the coast. In conducting a retrospective review of available information on the event, an independent scientific review panel concluded that the Kongsberg EM 120 MBES was the most plausible behavioral trigger for the animals initially entering the lagoon system and eventually stranding. The independent scientific review panel, however, identified that an unequivocal conclusion on causality of the event was not possible because of the lack of information about the event and a number of potentially contributing factors. Additionally, the independent review panel report indicated that this incident was likely the result of a complicated confluence of environmental, social, and other factors that have a very low probability of occurring again in the future, but recommended that the potential be considered in environmental planning. It should be noted that this event is the first known marine mammal mass stranding closely associated with the operation of an MBES. Leading scientific experts knowledgeable about MBES expressed concerns about the independent scientific review panel analyses and findings (Bernstein 2013).

Reference has also been made that two beaked whales stranded in the Gulf of California in 2002 were observed during a seismic survey in the region by the R/V *Ewing* (Malakoff 2002, Cox et al. 2006 *in* PEIS:3-136), which used a similar MBES system. As noted in the PEIS, however, "The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence" (Hogarth 2002, Yoder 2002 *in* PEIS:3-190).

Lurton (2016) modeled MBES radiation characteristics (pulse design, source level, and radiation directivity pattern) applied to a low-frequency (12-kHz), 240-dB source-level system similar to that used on R/V *Thompson*. Using Southall et al. (2007) thresholds, he found that injury impacts were possible only at very short distances, e.g., at 5 m for maximum SPL and 12 m for cumulative SEL for cetaceans; corresponding distances for behavioral response were 9 m and 70 m. For pinnipeds, "all ranges are multiplied by a factor of 4" (Lurton 2016:209).

There is no available information on marine mammal behavioral response to MBES sounds (Southall et al. 2013) or sea turtle responses to MBES systems. Much of the literature on marine mammal response to sonars relates to the types of sonars used in naval operations, including low-frequency, mid-frequency, and high-frequency active sonars (see review by Southall et al. 2016). However, the MBES sounds are quite different from naval sonars. Ping duration of the MBES is very short relative to naval sonars. Also, at any given location, an individual marine mammal would be in the beam of the MBES for much less time given the generally downward orientation of the beam and its narrow fore-aft beamwidth; naval sonars often use near-horizontally-directed sound. In addition, naval sonars have higher duty cycles. These factors would all reduce the sound energy received from the MBES relative to that from naval sonars.

In the fall of 2006, an Ocean Acoustic Waveguide Remote Sensing (OAWRS) experiment was carried out in the Gulf of Maine (Gong et al. 2014); the OAWRS emitted three frequency-modulated (FM) pulses centered at frequencies of 415, 734, and 949 Hz (Risch et al. 2012). Risch et al. (2012) found a reduction in humpback whale song in the Stellwagen Bank National Marine Sanctuary during OAWRS activities that were carried out ~200 km away; received levels in the sanctuary were 88–110 dB re 1 µPa. In contrast, Gong et al. (2014) reported no effect of the OAWRS signals on humpback whale vocalizations in the Gulf of Maine. Range to the source, ambient noise, and/or behavioral state may have differentially influenced the behavioral responses of humpbacks in the two areas (Risch et al. 2014).

Deng et al. (2014) measured the spectral properties of pulses transmitted by three 200-kHz echosounders and found that they generated weaker sounds at frequencies below the center frequency (90–130 kHz). These sounds are within the hearing range of some marine mammals, and the authors suggested that they could be strong enough to elicit behavioral responses within close proximity to the sources, although they would be well below potentially harmful levels. Hastie et al. (2014) reported behavioral responses by gray seals to echosounders with frequencies of 200 and 375 kHz. Short-finned pilot whales increased their heading variance in response to an EK60 echosounder with a resonant frequency of 38 kHz (Quick et al. 2017), and significantly fewer beaked whale vocalizations were detected while an EK60 echosounder was active vs. passive (Cholewiak et al. 2017).

This new information presented here is in agreement with the assessment presented in § 3.6.7, 3.7.7, and 3.8.7 of the PEIS that operation of MBESs and SBPs is not likely to impact marine mammals, (1) given the lower acoustic exposures relative to airguns and (2) because the intermittent and/or narrow downward-directed nature of these sounds would result in no more than one or two brief ping exposures of any individual marine mammal given the movement and speed of the vessel.

Other Possible Effects of Seismic Surveys

Other possible effects of seismic surveys on marine mammals include masking by vessel noise, disturbance by vessel presence or noise, and injury or mortality from collisions with vessels or entanglement in seismic gear. Vessel noise from R/V *Thompson* could affect marine animals in the proposed project area. Houghton et al. (2015) proposed that vessel speed is the most important predictor of received noise levels. Sounds produced by large vessels generally dominate ambient noise at frequencies from 20–300 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) and humpback whales (Blair et al. 2016).

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. 2016; Jones 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). 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 behaviour (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). Similarly, harbor seals increased the minimum frequency and amplitude of their calls in response to vessel noise (Matthews 2017); however, harp seals did not increase their call frequencies in environments with increased low-frequency sounds (Terhune and Bosker 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 project 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).

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; Oakley et al. 2017). Based on modeling, Halliday et al. (2017) suggested that shipping noise can be audible more than 100 km away and could affect the behavior of a marine mammal at a distance of 52 km in the case of tankers.

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). Physical presence of vessels, not just ship noise, has been shown to disturb the foraging activity of bottlenose dolphins (Pirotta et al. 2015) and blue whales (Lesage et al. 2017). 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.

The PEIS concluded that 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.

Another concern with vessel traffic is the potential for striking marine mammals (e.g., Redfern et al. 2013). Information on vessel strikes is reviewed in § 3.6.4.4 and § 3.8.4.4 of the PEIS. Wiley et al. (2016) concluded that reducing ship speed is one of the most reliable ways to avoid ship strikes. However, McKenna et al. (2015) noted the potential absence of lateral avoidance demonstrated by blue whales and perhaps other large whale species to vessels (McKenna et al. 2015). The PEIS concluded that the risk of collision of seismic vessels or towed/deployed equipment with marine mammals exists but is extremely unlikely, because of the relatively slow operating speed (typically 7–9 km/h) of the vessel during seismic operations, and the generally straight-line movement of the seismic vessel. During the proposed cruise, most (70%) of the seismic survey effort is expected to occur at a speed of ~15 km/h, and 30% is expected to occur at 9 km/h. However, the number of seismic survey km are low relative to other fast-moving vessels in the area. There has been no history of marine mammal vessel strikes with any of the vessels in the U.S. academic research fleet in the last two decades.

Numbers of Marine Mammals that could be "Taken by Harassment"

All takes would be anticipated to be Level B "takes by harassment" as described in § I, involving temporary changes in behavior. As required by NMFS, Level A takes have been requested; given the very small EZs and the proposed mitigation measures to be applied, injurious takes would not be expected. (However, as noted earlier and in the PEIS, there is no specific information demonstrating that injurious Level A "takes" would occur even in the absence of the planned mitigation measures.) In the sections below, we describe methods to estimate the number of potential exposures to Level B and Level A sound levels and present estimates of the numbers of marine mammals that could be affected during the proposed seismic surveys. The estimates are based on consideration of the number of marine mammals that could be disturbed appreciably by the seismic surveys in the Southwest Atlantic Ocean. The main sources of distributional and numerical data used in deriving the estimates are described in the next subsection and in Appendix B.

It is assumed that, during simultaneous operations of the airgun array and the other sources, any marine mammals close enough to be affected by the MBES and SBP would already be affected by the airguns. However, whether or not the airguns are operating simultaneously with the other sources, marine mammals are expected to exhibit no more than short-term and inconsequential responses to the MBES and SBP, given their characteristics (e.g., narrow downward-directed beam) and other considerations described in § 3.6.4.3, § 3.7.4.3, § 3.8.4.3, and Appendix E of the PEIS. Such reactions are not considered to constitute "taking" (NMFS 2001). Therefore, no additional allowance is included for animals that could be affected by sound sources other than airguns.

Basis for Estimating "Take by Harassment"

The Level B estimates are based on a consideration of the number of marine mammals that could be within the area around the operating airgun array where received levels of sound ≥160 dB re 1 μPa_{rms} are predicted to occur (see Table 1). The estimated numbers are based on the densities (numbers per unit area) of marine mammals expected to occur in the area in the absence of a seismic survey. To the extent that marine mammals tend to move away from seismic sources before the sound level reaches the criterion level and tend not to approach an operating airgun array, these estimates likely overestimate the numbers actually exposed to the specified level of sound. The overestimation is expected to be particularly large when dealing with the higher sound level criteria, i.e., the PTS thresholds (Level A), as animals are more likely to move away when received levels are higher. Likewise, they are less likely to approach within the PTS threshold radii than they are to approach within the considerably larger ≥160 dB (Level B) radius.

The preferred source of density data for the species that might be encountered in the proposed project area north of the Falkland Islands was AECOM/NSF (2014). For species not included in the AECOM database, NOAA-SWFSC LOA (2013 *in* AECOM/NSF 2014) was used, with the exception of hourglass dolphin, southern bottlenose whale, and southern elephant seal which were more abundant during surveys by White et al. (2002). When densities were not available from AECOM/NSF (2014) or NOAA-SWFSC LOA (2013 *in* AECOM/NSF 2014), densities were estimated using sightings and effort during aerial- and vessel-based surveys conducted in and adjacent to the proposed project area. The three other major sources of animal abundance included White et al. (2002), De Tullio et al. (2016), and Garaffo et al. (2011). Table 4 shows estimated densities for cetacean and pinniped species that could occur in the proposed project area; data sources and density calculations are described in detail in Appendix B. There is uncertainty about the representativeness of the data and the assumptions used below. Thus, for some species, the densities derived from past surveys may not be representative of the densities that would be encountered during the

TABLE 4. Densities and estimates of the possible numbers of individuals that could be exposed to Level B and Level A thresholds for various hearing groups during the proposed seismic surveys in the Southwest Atlantic Ocean. Species in italics are listed as endangered under the ESA.

Species	Estimated Density[1] (#/km²)	Calculated Take, NMFS Daily Method[2]		Level A + Level B as % of Population[5]	Requested Take Authorization[6]
		Level B[3]	Level A[4]		
LF Cetaceans					
Southern right whale	0.00080	*11*	*0*	0.3	***11***
Pygmy right whale	N.A.	-	-	-	**2[7]**
Blue whale	0.00005	*1*	*0*	<0.1	***3[7]***
Fin whale	0.01820	*252*	*2*	1.7	***254***
Sei whale	0.00636	*88*	*1*	0.9	***89***
Common (dwarf) minke whale	0.07790	1080	7	0.2	**1087**
Antarctic minke whale	0.07790	1080	7	0.2	**1087**
Humpback whale	0.00066	9	0	<0.1	**9**
MF Cetaceans					
Sperm whale	*0.00207*	*29*	*0*	*0.2*	***29***
Arnoux's beaked whale	0.01138	159	0	<0.1	**159**
Cuvier's beaked whale	0.00055	8	0	<0.1	**8**
Southern bottlenose whale	0.00791	110	0	<0.1	**110**
Shepherd's beaked whale	0.00627	88	0	-	**88**
Blainville's beaked whale	0.00005	1	0	-	**7[7]**
Gray's beaked whale	0.00189	26	0	<0.1	**26**
Hector's beaked whale	0.00021	3	0	-	**3**
True's beaked whale	0.00005	1	0	-	**2[7]**
Strap-toothed beaked whale	0.00058	8	0	<0.1	**8**
Andrew's beaked whale	0.00016	2	0	-	**2**
Spade-toothed beaked whale	0.00005	1	0	-	**2[7]**
Risso's dolphin	0.00436	61	0	0.3	**61**
Rough-toothed dolphin	0.00595	83	0	-	**83**
Common bottlenose dolphin	0.05091	711	0	0.9	**711**
Pantropical spotted dolphin	0.00377	53	0	1.6	**53**
Atlantic spotted dolphin	0.22517	3143	0	7.0	**3143**
Spinner dolphin	0.01498	209	0	-	**209**
Clymene dolphin	0.01162	162	0	-	**162**
Striped dolphin	0.00719	100	0	0.2	**100**
Short-beaked common dolphin	0.71717	10,004	6	14.3	**10,010**
Fraser's dolphin	N.A.	-	-	-	**283[7]**
Dusky dolphin	0.12867[8]	1034	1	14.3	**1035**
Southern right whale dolphin	0.00616	86	0	-	**86**
Killer whale	0.01538	215	0	0.9	**215**
Short-finned pilot whale	0.00209	29	0	<0.1	**41[7]**
Long-finned pilot whale	0.21456	2993	2	1.5	**2995**
False killer whale	N.A.	-	-	-	**5[7]**

HF Cetaceans					
Pygmy sperm whale	N.A.	-	-	-	**2[9]**
Dwarf sperm whale	N.A.	-	-	-	**2[9]**
Hourglass dolphin	0.14871	1975	101	1.4	**2076**
Peale's dolphin	0.03014	400	21	2.1	**421**
Commerson's dolphin	0.06763[8]	94	46	0.7	**140**
Spectacled porpoise	0.00150[8]	2	1	-	**3**
Otariids					
Antarctic fur seal	0.00017	2	0	<0.1	**2**
South American fur seal	0.01642	229	0	0.2	**229**
Subantarctic fur seal	0.00034	5	0	<0.1	**5**
South American sea lion	0.00249	35	0	<0.1	**35**
Phocids					
Crabeater seal	0.00649	90	1	<0.1	**91**
Leopard seal	0.00162	23	0	<0.1	**23**
Southern elephant seal	0.00155	22	0	<0.1	**22**

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

[1] See text and Appendix B for density sources.

[2] 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.

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

[4] Level A takes if there were no mitigation measures.

[5] Requested Level A and B takes (used by NMFS as proxy for number of individuals exposed) expressed as % of population (see Table 4).

[6] Requested take authorization is Level A plus Level B calculated takes, unless otherwise indicated.

[7] Requested take authorization (Level B only) increased to mean group size from Bradford et al. (2017) if available. Mean group sizes for pygmy right whale and false killer whale from Jefferson et al. (2015) and Mobley et al. (2000), respectively.

[8] Density provided is for shallow water <100 m deep; a correction factor for densities in deeper water was applied (see Appendix B).

[9] Requested take authorization (Level B only) increased to 2 individuals.

proposed seismic surveys. However, the approach used here is based on the best available data. The calculated exposures that are based on these densities are best estimates for the proposed surveys.

The estimated numbers of individuals potentially exposed are based on the 160-dB re 1 μPa_{rms} criterion for all cetaceans and pinnipeds. It is assumed that marine mammals exposed to airgun sounds that strong could change their behavior sufficiently to be considered "taken by harassment". Table 4 shows the estimates of the number of marine mammals that potentially could be exposed to ≥160 dB re 1 μPa_{rms} during the seismic surveys in the Southwest Atlantic Ocean if no animals moved away from the survey vessel. The *Requested Take Authorization* is given in the far-right column of Table 4. Except for five cetacean species with estimated densities of zero (pygmy right, pygmy sperm, dwarf sperm, and false killer whales; and Fraser's dolphin), we have included a *Requested Take Authorization* for marine mammals based on the calculations shown in Appendix C. For species with estimated densities of zero and for those for which the estimated takes were smaller than the mean group size (blue whale and some beaked whales), *Requested Take Authorization*s were increased to mean group sizes (see footnotes in Table 4).

It should be noted that the following estimates of exposures assume that the proposed surveys would be completed; in fact, the calculated takes have been increased by 25% (see below). Thus, the following estimates of the numbers of marine mammals potentially exposed to Level B sounds ≥160 dB re 1 μPa_{rms} are precautionary and probably overestimate the actual numbers of marine mammals that could be involved.

Consideration should be given to the hypothesis that delphinids are less responsive to airgun sounds than are mysticetes, as referenced in both the PEIS and §4.1.1.1 of this document. The 160-dB (rms) criterion currently applied by NMFS, on which the Level B estimates are based, was developed primarily using data from gray and bowhead whales. The estimates of "takes by harassment" of delphinids are thus considered precautionary. Available data suggest that the current use of a 160-dB criterion could be improved upon, as behavioral response might not occur for some percentage of marine mammals exposed to received levels >160 dB, whereas other individuals or groups might respond in a manner considered as "taken" to sound levels <160 dB (NMFS 2013). It has become evident that the context of an exposure of a marine mammal to sound can affect the animal's initial response to the sound (NMFS 2013).

Potential Number of Marine Mammals Exposed

The number of marine mammals that could be exposed to airgun sounds with received levels ≥160 dB re 1 μPa_{rms} (Level B) for marine mammals on one or more occasions have been estimated using a method required by NMFS for calculating the marine area that would be within the Level B threshold around the operating seismic source, along with the expected density of animals in the area. This method was developed to account in some way for the number of exposures as well as the number of individuals exposed. It involves selecting seismic trackline(s) that could be surveyed on one day during the 5-kt surveys (~120 n.mi. or 222 km per day) and 8-kt surveys (192 n.mi. or 356 km per day) with a proportion occurring in water depth ranges (shallow, intermediate, deep) that is roughly similar to that of the entire survey.

The area expected to be ensonified on that one day was determined by entering the planned survey lines into a MapInfo GIS, using the GIS to identify the relevant areas by "drawing" the applicable 160-dB and PTS threshold buffers around each seismic line. The ensonified areas were then multiplied by the number of survey days (16 and 12 days for 5-kt and 8-kt surveys, respectively) and increased by 25% (see Appendix C for more details). These values for the 5- and 8-kt surveys were then added to provide a value for the total survey. The approach assumes that no marine mammals would move away or toward the trackline in response to increasing sound levels before the levels reach the specific thresholds as R/V *Thompson* approaches.

The estimate of the number of cetaceans that could be exposed to seismic sounds with received levels ≥160 dB re 1 μPa_{rms} in the survey area is 24,506 (Table 4). That total includes 384 cetaceans listed under the ESA: 11 southern right whales, 254 fin whales, 89 sei whales, 29 sperm whales, and 1 blue whale, representing 0.3%, 1.7%, 0.9%, 0.2%, and <0.1% of their regional populations, respectively. In addition, 407 beaked whales could be exposed. Most (87%) of the cetaceans potentially exposed would be MF cetaceans, including estimates of 10,010 short-beaked common dolphins, 3143 Atlantic spotted dolphin, and 2995 long-finned pilot whales. Most (79%) of the HF cetaceans exposed to ≥160 dB re 1 μPa_{rms} would be hourglass dolphins. In addition, 407 pinnipeds could be exposed, including 236 fur seals, 35 South American sea lions, and 136 seals.

Conclusions

The proposed seismic project would involve towing a very small source, a pair of 45-in^3 GI airguns, that introduces pulsed sounds into the ocean. Routine vessel operations, other than the proposed seismic operations, are conventionally assumed not to affect marine mammals sufficiently to constitute "taking". In §3.6.7, 3.7.7, and 3.8.7, the PEIS concluded that outside the Gulf of Alaska, airgun operations with implementation of the proposed monitoring and mitigation measures could result in a small number of Level B behavioral effects in some cetaceans and pinnipeds, that Level A effects were unlikely, and that operations were unlikely to adversely affect ESA-listed species. However, NMFS requires the calculation and request of potential Level A takes (following a different methodology than used in the PEIS). For

several past NSF-funded seismic surveys, NMFS issued small numbers of Level A take for some marine mammal species for the remote possibility of low-level physiological effects; however, NMFS expected neither mortality nor serious injury of marine mammals to result from the surveys (e.g, NMFS 2015, 2016b,c, NMFS 2017a,b). Level A takes are considered highly unlikely, as predicted Level A EZs are small, and mitigation measures would further reduce the chances of, if not eliminate, any such takes.

Estimates of the numbers of marine mammals that could be exposed to airgun sounds during the proposed program have been presented, together with the requested "take authorization". The estimated numbers of animals potentially exposed to sound levels sufficient to cause Level A and/or B harassment are low percentages of the regional population sizes (Table 4). The calculated take estimates are likely overestimates of the actual number of animals that would be exposed to and would react to the seismic sounds. The relatively short-term exposures are unlikely to result in any long-term negative consequences for the individuals or their populations. Therefore, no significant impacts on marine mammals would be anticipated from the proposed activities.

In decades of NSF-funded seismic surveys carried out by vessels in the U.S. academic research fleet, PSOs and other crew members have not observed any seismic sound-related marine mammal injuries or mortality. Also, actual numbers of animals potentially exposed to sound levels sufficient to cause disturbance (i.e., are considered takes) have almost always been much lower than predicted and authorized takes. For example, during an NSF-funded, ~5000-km, 2-D seismic survey conducted by the *Langseth* off the coast of North Carolina in September–October 2014, only 296 cetaceans were observed within the predicted 160-dB zone and potentially taken, representing <2% of the 15,498 takes authorized by NMFS (RPS 2015). During an USGS-funded, ~2700 km, 2-D seismic survey conducted by the *Langseth* along the U.S. east coast in August–September 2014, only three unidentified dolphins were observed within the predicted 160-dB zone and potentially taken, representing <0.03% of the 11,367 authorized takes (RPS 2014b). Furthermore, as defined, all animals exposed to sound levels >160 dB are Level B 'takes' whether or not a behavioral response occurred. The 160-dB zone, which is based on predicted sound levels, is thought to be conservative; thus, not all animals detected within this zone would be expected to have been exposed to actual sound levels >160 dB.

VIII. ANTICIPATED IMPACT ON SUBSISTENCE

The anticipated impact of the activity on the availability of the species or stocks of marine mammals for subsistence uses.

There is no subsistence hunting near the proposed project area, so the proposed activities would not have any impact on the availability of the species or stocks for subsistence users.

IX. ANTICIPATED IMPACT ON HABITAT

The anticipated impact of the activity upon the habitat of the marine mammal populations, and the likelihood of restoration of the affected habitat.

The proposed seismic surveys would not result in any permanent impact on habitats used by marine mammals or to the food sources they use. The main impact issue associated with the proposed activity would be temporarily elevated noise levels and the associated direct effects on marine mammals, as discussed in § VII, above. Effects of seismic sound on marine invertebrates (crustaceans and cephalopods), marine fish, and their fisheries are discussed in § 3.2.4 and § 3.3.4 and Appendix D of the PEIS. The PEIS concluded that there could be changes in behavior and other non-lethal, short-term, temporary impacts, and

injurious or mortal impacts on a small number of individuals within a few meters of a high-energy acoustic source, but that there would be no significant impacts of NSF-funded marine seismic research on populations.

X. Anticipated Impact of Loss or Modification of Habitat on Marine Mammals

The anticipated impact of the loss or modification of the habitat on the marine mammal populations involved.

The proposed activity is not expected to have any habitat-related effects that could cause significant or long-term consequences for individual marine mammals or their populations, because operations would be limited in duration. However, a small minority of the marine mammals that are present near the proposed activity may be temporarily displaced as much as a few kilometers by the planned activity.

XI. Mitigation Measures

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, their habitat, and on their availability for subsistence uses, paying particular attention to rookeries, mating grounds, and areas of similar significance.

Marine mammals and sea turtles are known to occur in the proposed project area. To minimize the likelihood that impacts would occur to the species and stocks, GI airgun operations would be conducted in accordance with regulations by NMFS under the MMPA and the ESA, including obtaining permission for incidental harassment or incidental 'take' of marine mammals and other endangered species.

The following subsections provide more detailed information about the mitigation measures that are an integral part of the planned activity. The procedures described here are based on protocols used during previous NSF-funded seismic research cruises as approved by NMFS, and on best practices recommended in Richardson et al (1995), Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al. (2013), Wright (2014), Wright and Cosentino (2015), and Acosta et al. (2017).

Planning Phase

As discussed in § 2.4.1.1 of the PEIS, mitigation of potential impacts from the proposed activity begins during the planning phase. Several factors were considered during the planning phase of the proposed activity, including

***Energy Source*.—**Part of the considerations for the proposed surveys was to evaluate what source level was necessary to meet the research objectives. It was decided that the scientific objectives could be met using a low-energy source consisting of two 45-in^3 GI guns (total volume of 90 in^3) at a tow depth of ~2–4 m. The SIO portable MCS system's energy source level is one of the smallest source levels used by the science community for conducting seismic research.

***Survey Timing*.—**The PIs worked with SIO, UW, and NSF to identify potential times to carry out the survey, taking into consideration key factors such as environmental conditions (e.g., the seasonal presence of marine mammals), weather conditions, equipment, and optimal timing for other proposed research cruises. Except for some baleen whales, most marine mammal species are expected to occur in the area year-round, so altering the timing of the proposed project likely would result in no net benefits for those species.

Mitigation Zones.—During the planning phase, mitigation zones for the proposed seismic surveys were not derived from the farfield signature but calculated based on modeling by L-DEO for both the EZ for Level A takes and safety zones (160 dB re 1μPa_{rms}) for Level B takes. The background information and methodology for this are provided in Appendix A. Table 1 shows the distances at which the 160- and 175-dB re 1μPa_{rms} sound levels are expected to be received for the two 45-in^3 GI airguns. The 160-dB level is the behavioral disturbance criterion that is used to estimate anticipated Level B takes for marine mammals; a 175-dB level is used by NMFS to determine behavioral disturbance for sea turtles. NMFS guidance for assessing the effects of anthropogenic sound on marine mammal hearing (NMFS 2016a, 2018a) established new thresholds for PTS onset or Level A Harassment (injury), for marine mammal species. The distances to the PTS thresholds for the various marine mammal hearing groups are provided in Table 2.

The NSF/USGS PEIS defined a low-energy source as any towed acoustic source whose received level is ≤180 dB re 1 μPa_{rms} (the Level A threshold under the former NMFS acoustic guidance) at 100 m, including any single or any two GI airguns and a single pair of clustered airguns with individual volumes of ≤250 in^3. In § 2.4.2 of the PEIS, Alternative B (the Preferred Alternative) conservatively applied a 100-EZ for all low-energy acoustic sources in water depths >100 m. Consistent with the PEIS, that approach is used here for the pair of 45-in^3 GI airguns in all water depths. The 100-m EZ would also be used as the EZ for sea turtles. If marine mammals or sea turtles are detected in or about to enter the appropriate EZ, the airguns would be shut down immediately. Enforcement of mitigation zones via shut downs would be implemented in the Operational Phase, as noted below. A fixed 160-dB "Safety Zone" was not defined for the same suite of low-energy sources in the NSF/USGS PEIS.

Mitigation During Operations

Mitigation measures that would be adopted include (1) vessel speed or course alteration, provided that doing so would not compromise operational safety requirements, (2) GI-airgun shut down within EZs, and (3) ramp-up procedures. Although power-down procedures are often standard operating practice for seismic surveys, they would not be used here because powering down from two airguns to one airgun would make only a small difference in the EZs—probably not enough to allow continued one-airgun operations if a mammal or turtle came within the safety radius for two airguns.

Speed or Course Alteration

If a marine mammal or sea turtle is detected outside the EZ, based on its position and the relative motion, is likely to enter the EZ, the vessel's speed and/or direct course could be changed. This would be done if operationally practicable while minimizing the effect on the planned science objectives. The activities and movements of the marine mammal or sea turtle (relative to the seismic vessel) would then be closely monitored to determine whether the animal is approaching the applicable EZ. If the animal appears likely to enter the EZ, further mitigative actions would be taken, i.e., either further course alterations or a shut down of the seismic source. Typically, during seismic operations, the source vessel is unable to change speed or course and one or more alternative mitigation measures (see below) would need to be implemented.

Shut-down Procedures

If a marine mammal or turtle is detected outside the EZ but is likely to enter the EZ, and if the vessel's speed and/or course cannot be changed to avoid having the animal enter the EZ, the GI airguns would be shut down before the animal is within the EZ. Likewise, if a mammal or turtle is already within the EZ when first detected, the GI airguns would be shut down immediately. The operating airguns would also be shut down in the event an ESA-listed seabird were observed diving or foraging within the designated EZ. Following a shut down, seismic activity would not resume until the marine mammal or turtle has cleared the EZ, or until the PSO is confident that the animal has left the vicinity of the vessel. The animal would be considered to have cleared the EZ zone if

- it is visually observed to have left the EZ, or
- it has not been seen within the zone for 15 min in the case of small odontocetes and sea turtles, or
- it has not been seen within the zone for 30 min in the case of mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, and beaked whales.

Ramp-up Procedures

A ramp-up procedure would be followed when the pair of GI airguns begins operating after a specified period without GI airgun operations. It is proposed that, for the present survey, this period would be 15 min. Ramp up would not occur if a marine mammal or sea turtle has not cleared the EZ as described earlier. Ramp up would begin with one GI airgun 45 in^3, and the second GI airgun would be added after 5 min. During ramp up, the PSOs would monitor the EZ, and if marine mammals or turtles are sighted, a shut down would be implemented as though the full array were operational.

If the EZ has not been visible for at least 30 min prior to the start of operations in either daylight or nighttime, ramp up would not commence. If one GI airgun has operated, ramp up to full power would be permissible at night or in poor visibility, on the assumption that marine mammals and turtles would be alerted to the approaching seismic vessel by the sounds from the single GI airgun and could move away if they choose. A ramp up from a shut down may occur at night, but only where the safety radius is small enough to be visible. Ramp up of the GI airguns would not be initiated if a sea turtle or marine mammal is sighted within or near the applicable EZ during day or night.

XII. PLAN OF COOPERATION

Where the proposed activity would take place in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, the applicant must submit either a plan of cooperation or information that identifies what measures have been taken and/or will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses. A plan must include the following:

(i) A statement that the applicant has notified and provided the affected subsistence community with a draft plan of cooperation;

(ii) A schedule for meeting with the affected subsistence communities to discuss proposed activities and to resolve potential conflicts regarding any aspects of either the operation or the plan of cooperation;

(iii) A description of what measures the applicant has taken and/or will take to ensure that proposed activities will not interfere with subsistence whaling or sealing; and

(iv) What plans the applicant has to continue to meet with the affected communities, both prior to and while conducting activity, to resolve conflicts and to notify the communities of any changes in the operation.

Not applicable. The proposed activity would take place in the Southwest Atlantic Ocean, and no activities would take place in or near a traditional Arctic subsistence hunting area.

XIII. MONITORING AND REPORTING PLAN

> The suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species, the level of taking or impacts on populations of marine mammals that are expected to be present while conducting activities and suggested means of minimizing burdens by coordinating such reporting requirements with other schemes already applicable to persons conducting such activity. Monitoring plans should include a description of the survey techniques that would be used to determine the movement and activity of marine mammals near the activity site(s) including migration and other habitat uses, such as feeding...

SIO proposes to sponsor marine mammal monitoring during the present project, in order to implement the proposed mitigation measures that require real-time monitoring, and to satisfy the anticipated monitoring requirements of the IHA. SIO's proposed Monitoring Plan is described below. SIO understands that this Monitoring Plan would be subject to review by NMFS, and that refinements may be required.

The monitoring work described here has been planned as a self-contained project independent of any other related monitoring projects that may be occurring simultaneously in the same regions. SIO is prepared to discuss coordination of its monitoring program with any related work that might be done by other groups insofar as this is practical and desirable.

Vessel-based Visual Monitoring

PSO observations would take place during daytime GI airgun operations and nighttime start ups of the airguns. GI airgun operations would be suspended when marine mammals, turtles, or diving ESA-listed seabirds are observed within, or about to enter, designated EZs [see § XI above] where there is concern about potential effects on hearing or other physical effects. PSOs would also watch for marine mammals and turtles near the seismic vessel for at least 30 min prior to the planned start of airgun operations. When feasible, PSOs would also make observations during daytime periods when the seismic system is not operating for comparison of animal abundance and behavior. PSOs would also watch for any potential impacts of the acoustic sources on fish.

Three PSOs would be appointed by SIO, with NMFS Office of Protected Resources concurrence. One dedicated PSO would monitor the EZ during all daytime seismic operations. PSOs would normally work in shifts of 4-hour duration or less. The vessel crew would also be instructed to assist in detecting marine mammals and turtles.

R/V *Thompson* is a suitable platform from which PSOs would watch for marine mammals and turtles. Standard equipment for marine mammal observers would be 7 x 50 reticle 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 shut down.

PSO Data and Documentation

PSOs would record data to estimate the numbers of marine mammals, turtles, and diving ESA-listed seabirds exposed to various received sound levels and to document apparent disturbance reactions or lack thereof. They would also record any observations of fish potentially affected by the sound sources. Data would be used to estimate numbers of marine mammals potentially 'taken' by harassment (as defined in the MMPA). They would also provide information needed to order a power down or shut

down of the airguns when a marine mammal, sea turtle, or diving ESA-listed seabird 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.
2. Time, location, heading, speed, activity of the vessel, sea state, visibility, and sun glare.

The data listed under (2) 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.

All observations and shut downs 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.

Results from the vessel-based observations would provide

1. The basis for real-time mitigation (GI airgun shut down).
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, turtles, and diving ESA-listed seabirds in the area where the seismic study is conducted.
4. Information to compare the distance and distribution of marine mammals, turtles, and diving ESA-listed seabirds relative to the source vessel at times with and without seismic activity.
5. Data on the behavior and movement patterns of marine mammals and turtles seen at times with and without seismic activity.
6. any observations of fish potentially affected by the sound sources.

A report would be submitted to NMFS and NSF within 90 days after the end of the cruise. The report would describe the operations that were conducted and sightings of marine mammals and turtles near the operations. The report would provide full documentation of methods, results, and interpretation pertaining to all monitoring. The 90-day report would summarize the dates and locations of seismic operations, all marine mammal, turtle, and diving ESA-listed seabird sightings (dates, times, locations, activities, associated seismic survey activities), and any observations of fish potentially affected by the sound sources. The report would also include estimates of the number and nature of exposures that could result in "takes" of marine mammals by harassment or in other ways.

XIV. Coordinating Research to Reduce and Evaluate Incidental Take

Suggested means of learning of, encouraging, and coordinating research opportunities, plans, and activities relating to reducing such incidental taking and evaluating its effects.

SIO and NSF would coordinate the planned marine mammal monitoring program associated with the seismic survey with other parties that may have interest in this area. SIO and NSF would coordinate with applicable U.S. agencies (e.g., NMFS), and would comply with their requirements.

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LIST OF APPENDICES

APPENDIX A: DETERMINATION OF MITIGATION ZONES

APPENDIX B: MARINE MAMMAL DENSITIES

APPENDIX C: MARINE MAMMAL TAKE CALCULATIONS

APPENDIX D: ENSONIFIED AREAS FOR MARINE MAMMAL TAKE CALCULATIONS

APPENDIX A: DETERMINATION OF MITIGATION ZONES

During the planning phase, mitigation zones for the proposed marine seismic surveys were calculated based on modeling by L-DEO for both the exclusion zones (EZ) for Level A takes and safety zones (160 dB re 1µPa_{rms}) for Level B takes. Received sound levels have been predicted by L-DEO's model (Diebold et al. 2010, provided as Appendix H in the PEIS) as a function of distance from the airguns, for the two 45-in^3 GI 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 homogeneous ocean layer, unbounded by a seafloor). In addition, propagation measurements of pulses from the 36-airgun array at a tow depth of 6 m have been reported in deep water (~1600 m), intermediate water depth on the slope (~600–1100 m), and shallow water (~50 m) in the Gulf of Mexico (GoM) 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 mitigation radii, as at those sites the calibration hydrophone was located at a roughly constant depth of 350–500 m, which may not intersect all the sound pressure level (SPL) isopleths at their widest point from the sea surface down to the maximum relevant water depth (~2000 m) for marine mammals. Figures 2 and 3 in Appendix H of the PEIS show how the values along the maximum SPL line that connects the points where the isopleths attain their maximum width (providing the maximum distance associated with each sound level) may differ from values obtained along a constant depth line. At short ranges, where the direct arrivals dominate and the effects of seafloor interactions are minimal, the data recorded 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 mitigation model—constructed from the maximum SPL through the entire water column at varying distances from the airgun array—is the most relevant. The results are summarized below.

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 (Fig. 12 and 14 in Appendix H of the PEIS). 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 (Fig. 11, 12, and 16 in Appendix H of the PEIS). Aside from local topography effects, the region around the critical distance (~5 km in Fig. 11 and 12, and ~4 km in Fig. 16 in Appendix H of the PEIS) is where the observed levels rise closest to the mitigation model curve. However, the observed sound levels are found to fall almost entirely below the mitigation model curve (Fig. 11, 12, and 16 in Appendix H of the PEIS). Thus, analysis of the GoM calibration measurements demonstrates that although simple, the L-DEO model is a robust tool for conservatively estimating mitigation radii.

In shallow water (<100 m), the depth of the calibration hydrophone (18 m) used during the GoM calibration survey was appropriate to sample the maximum sound level in the water column, and the field measurements reported in Table 1 of Tolstoy et al. (2009) for the 36-airgun array at a tow depth of 6 m can be used to derive mitigation radii.

The proposed surveys would acquire data with two 45-in^3 GI guns at a tow depth of 2–4 m. For deep water (>1000 m), we use the deep-water radii obtained from L-DEO model results down to a maximum water depth of 2000 m for the airgun array with 2-m (Fig. A-1) and 8-m (Fig. A-2) airgun separation.

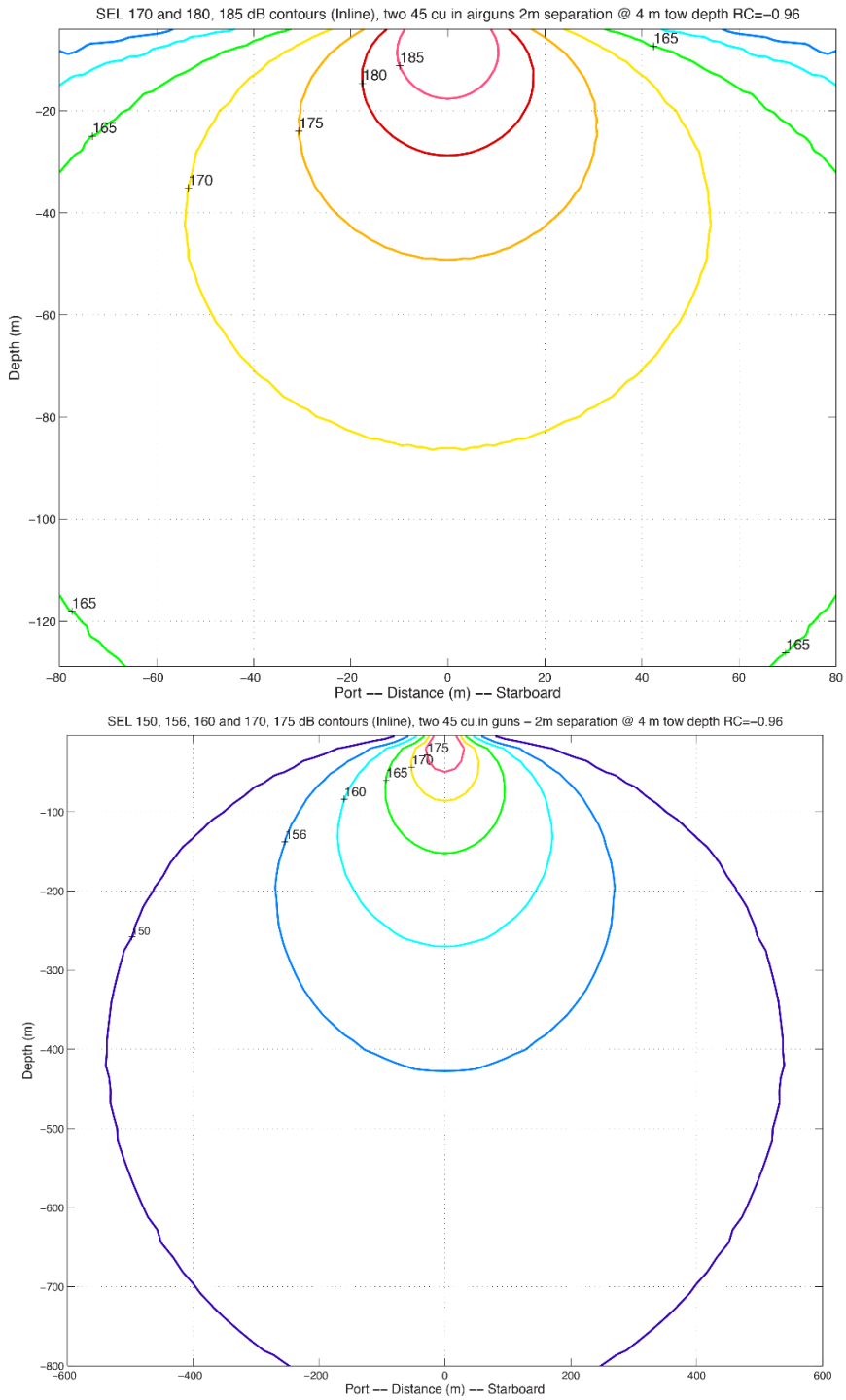

FIGURE A-1. Modeled deep-water received sound exposure levels (SELs) from the two 45-in^3 GI guns, with a 2-m gun separation, planned for use during the proposed surveys in the Southwest Atlantic Ocean at a 4-m tow depth. Received rms levels (SPLs) are expected to be ~10 dB higher. The radius to the 150-dB SEL isopleth is a proxy for the 160-dB rms isopleth. The lower plot is a zoomed-in version of the upper plot.

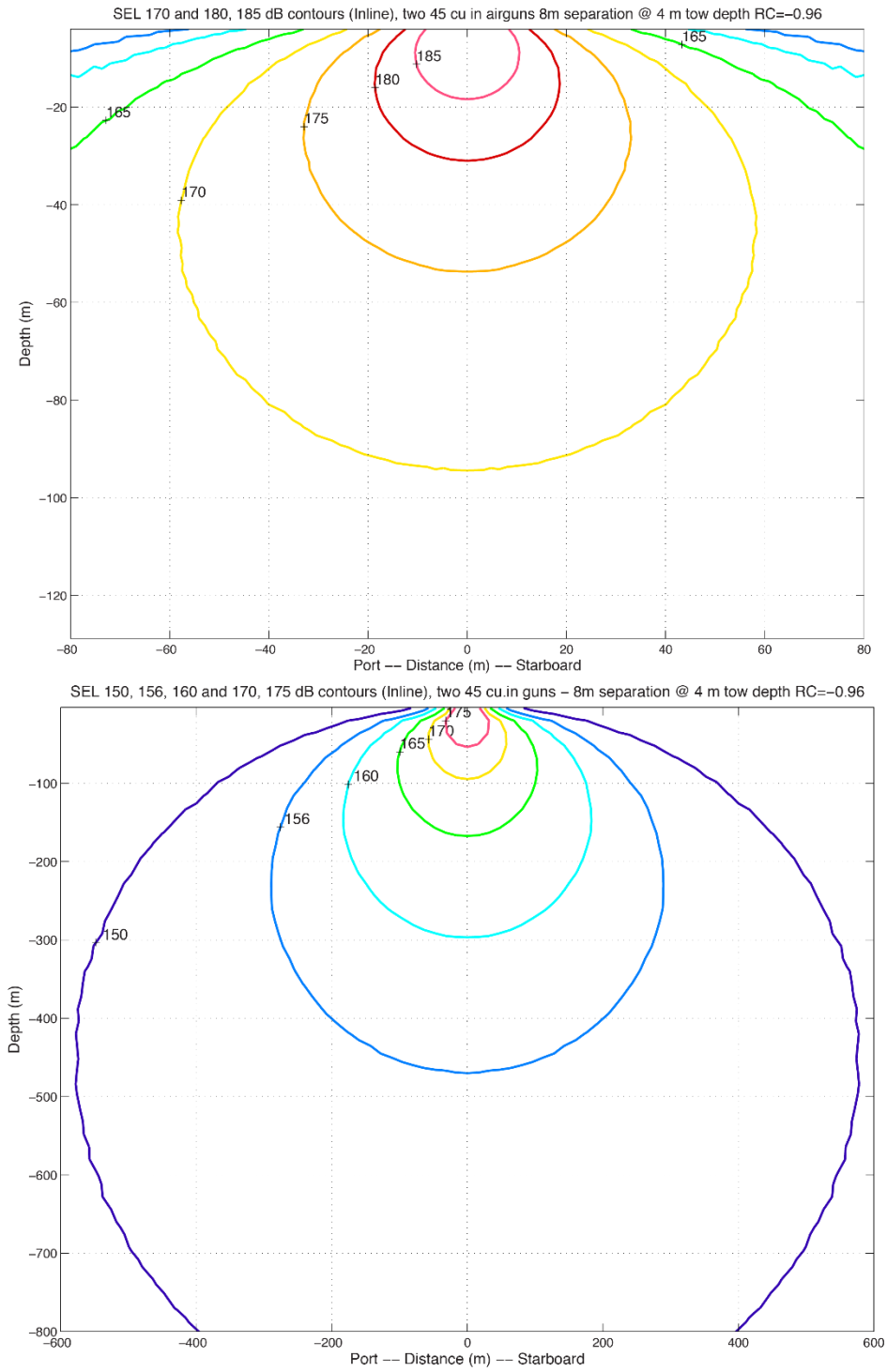

FIGURE A-2. Modeled deep-water received sound exposure levels (SELs) from the two 45-in^3 GI guns, with an 8-m gun separation, planned for use during the proposed surveys in the Southwest Atlantic Ocean at a 4-m tow depth. Received rms levels (SPLs) are expected to be ~10 dB higher. The radius to the 150-dB SEL isopleth is a proxy for the 160-dB rms isopleth. The lower plot is a zoomed-in version of the upper plot.

The radii for intermediate water depths (100–1000 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 (Fig. 16 in Appendix H of the PEIS).

The shallow-water radii are obtained by scaling the empirically derived measurements from the GoM calibration survey to account for the differences in source volume and tow depth between the calibration survey (6000 in^3; 6-m tow depth) and the proposed survey (90 in^3; 4-m tow depth); whereas the shallow water in the GoM may not exactly replicate the shallow water environment at the proposed survey sites, it has been shown to serve as a good and very conservative proxy (Crone et al. 2014). A simple scaling factor is calculated from the ratios of the isopleths determined by the deep-water L-DEO model, which are essentially a measure of the energy radiated by the source array.

For the 150-dB Sound Exposure Level (SEL)[1], the corresponding deep-water maximum radii are 539 m for the 2-GI airgun array (at 4 m tow depth) with a 2-m airgun separation (Fig. A-1), 578 m for the 2-GI airgun array with a 8-m airgun separation (Fig. A-2), and 7244 m for the 6000 in^3 array at a 6-m tow depth (Fig. A-3). This yields a scaling factor of 0.074 and 0.08 for the 2- and 8-m separation configurations, respectively. Similarly, the 165 dB SEL corresponds to deep-water maximum radii of 95 m for the 2-GI gun 2-m separation configuration (Fig. A-1), 103 m for the 2-GI gun 8-m separation configuration (Fig. A-2), and 1284 m for the 6000 in^3 array (Fig. A-3). This yields scaling factors of 0.074 and 0.08 for the 2- and 8-m separation configurations, respectively. Measured 160- and 175-dB re 1μPa_{rms} distances in shallow water for the 36-airgun array towed at 6 m depth were 17.5 km and 2.84 km, respectively, based on a 95th percentile fit (Tolstoy et al. 2009). Multiplying by the scaling factors to account for the tow depth difference between the arrays yields distances of 1295 m and 1400 m for the 160-dB sound level for the 2-GI gun array with 2- and 8-m airgun separation, respectively. The 175-dB sound level distances for the 2-GI gun array with 2- and 8-m airgun separation, and 210 m and 227 m, respectively.

Table A-1 shows the distances at which the 160- and 175-dB re 1μPa_{rms} sound levels are expected to be received for the two different airgun configurations at the maximum 4-m tow depth at various depth categories. The 160-dB level is the behavioral disturbance criterion that is used to estimate anticipated Level B takes for marine mammals; a 175-dB level is used by NMFS, as well as the U.S. Navy (USN 2017), to determine behavioral disturbance for sea turtles.

A recent retrospective analysis of acoustic propagation of R/V *Langseth* sources in a coastal/shelf environment from the Cascadia Margin off Washington suggests that predicted (modeled) radii (using an approach similar to that used here) for R/V *Langseth* sources were 2–3 times larger than measured in shallow water, so in fact, as expected, were very conservative (Crone et al. 2014). Similarly, data collected by Crone et al. (2017) during a survey off New Jersey in 2014 and 2015 confirmed that in situ measurements and estimates of the 160- and 180-dB distances collected by R/V *Langseth* hydrophone streamer were 2–3 times smaller than the predicted operational mitigation radii.

[1] SEL (measured in dB re 1 $\mu Pa^2 \cdot s$) is a measure of the received energy in the pulse and represents the SPL that would be measured if the pulse energy were spread evenly across a 1-s period. Because actual seismic pulses are less than 1 s in duration in most situations, this means that the SEL value for a given pulse is usually lower than the SPL calculated for the actual duration of the pulse. In this EA, we assume that rms pressure levels of received seismic pulses would be 10 dB higher than the SEL values predicted by L-DEO's model.

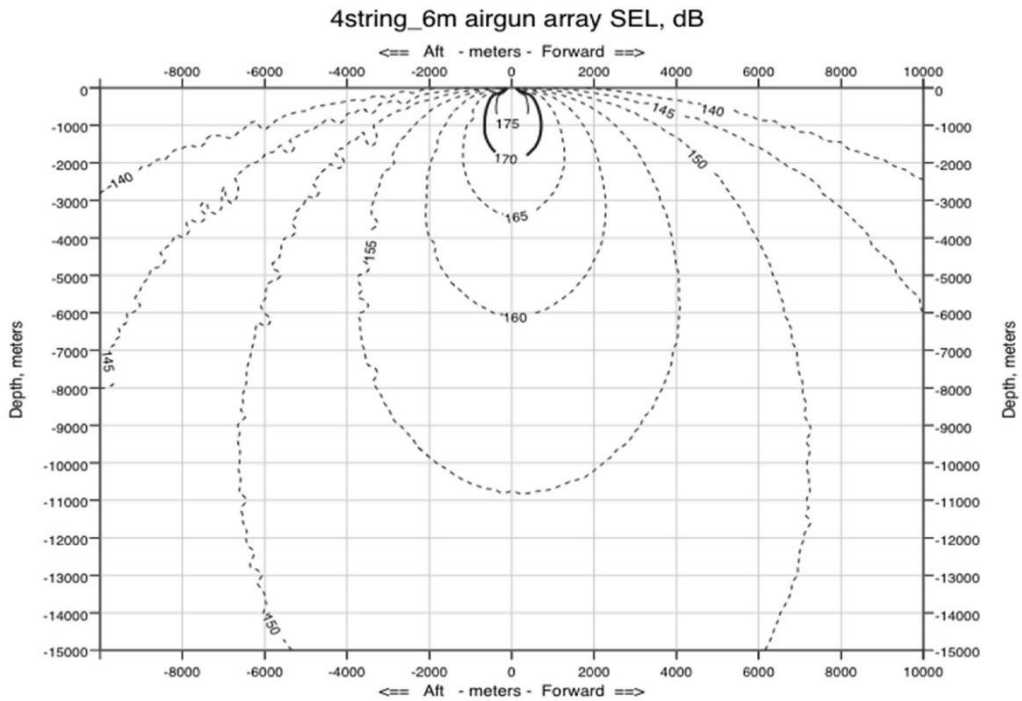

FIGURE A-3. Modeled deep-water received sound exposure levels (SELs) from the 36-airgun array at a 6-m tow depth used during the GoM calibration survey. Received rms levels (SPLs) are expected to be ~10 dB higher. The plot provides the radius to the 150-dB SEL isopleth as a proxy for the 160-dB rms isopleth.

TABLE A-1. Level B. Predicted distances to the 160 dB re 1 μPa$_{rms}$ and 175-dB sound levels that could be received from two 45-in^3 GI guns (at a tow depth of 4 m) that would be used during the seismic surveys in the Southwest Atlantic Ocean during September–October 2019 (model results provided by L-DEO). The 160-dB criterion applies to all marine mammals; the 175-dB criterion applies to sea turtles.

Airgun Configuration	**Water Depth (m)**	**Predicted Distances (m) to Various Received Sound Levels**	
		160 dB re 1 μPa$_{rms}$	**175 dB re 1 μPa$_{rms}$**
Two 45-in^3 GI guns / 2-m gun separation	>1000	539[1]	95[1]
	100-1000	809[2]	143[2]
	<100	1295[3]	210[3]
Two 45-in^3 GI guns / 8-m gun separation	>1000	578[1]	103[1]
	100-1000	867[2]	155[2]
	<100	1400[3]	227[3]

[1] Distance is based on L-DEO model results.
[2] Distance is based on L-DEO model results with a 1.5 × correction factor between deep and intermediate water depths.
[3] Distance is based on empirically derived measurements in the GoM with scaling applied to account for differences in tow depth.

In fact, five separate comparisons conducted of the L-DEO model with in situ received level[2] have confirmed that the L-DEO model generated conservative EZs, resulting in significantly larger EZs than required by the National Marine Fisheries Service (NMFS).

In July 2016, the National Oceanic and Atmospheric Administration's (NOAA) NMFS released new technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (NMFS 2016a, 2018a). The guidance established new thresholds for permanent threshold shift (PTS) onset or Level A Harassment (injury), for marine mammal species. The new noise exposure criteria for marine mammals account for the newly-available scientific data on temporary threshold shifts (TTS), the expected offset between TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive, and other relevant factors, as summarized by Finneran (2016). Onset of PTS was assumed to be 15 dB or 6 dB higher when considering SELcum and SPLflat, respectively. For impulsive sounds, such airgun pulses, the new guidance incorporates marine mammal auditory weighting functions (Fig. A-4) and dual metrics of cumulative sound exposure level (SEL_{cum} over 24 hours) and peak sound pressure levels (SPL_{flat}). Different thresholds are provided for the various hearing groups, including low-frequency (LF) cetaceans (e.g., baleen whales), mid-frequency (MF) cetaceans (e.g., most delphinids), high-frequency (HF) cetaceans (e.g., porpoise and *Kogia* spp.), phocids underwater (PW), and otariids underwater (OW). As required by NMFS (2016a, 2018b), the largest distance of the dual criteria (SEL_{cum} or Peak SPL_{flat}) would be used as the EZ and for calculating takes. Here, for the 2-m gun separation configuration, SEL_{cum} is used for LF cetaceans, and Peak SPL_{flat} is used for all other hearing groups; Peak SPL_{flat} is used for all hearing groups for the 8-m gun separation configuration. The new guidance did not alter the current threshold, 160 dB re $1\mu Pa_{rms}$, for Level B harassment (behavior).

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.

[2] L-DEO surveys off the Yucatán Peninsula in 2004 (Barton et al. 2006; Diebold et al. 2006), in the Gulf of Mexico in 2008 (Tolstoy et al. 2009; Diebold et al. 2010), off Washington and Oregon in 2012 (Crone et al. 2014), and off New Jersey in 2014 and 2015 (Crone et al. 2017).

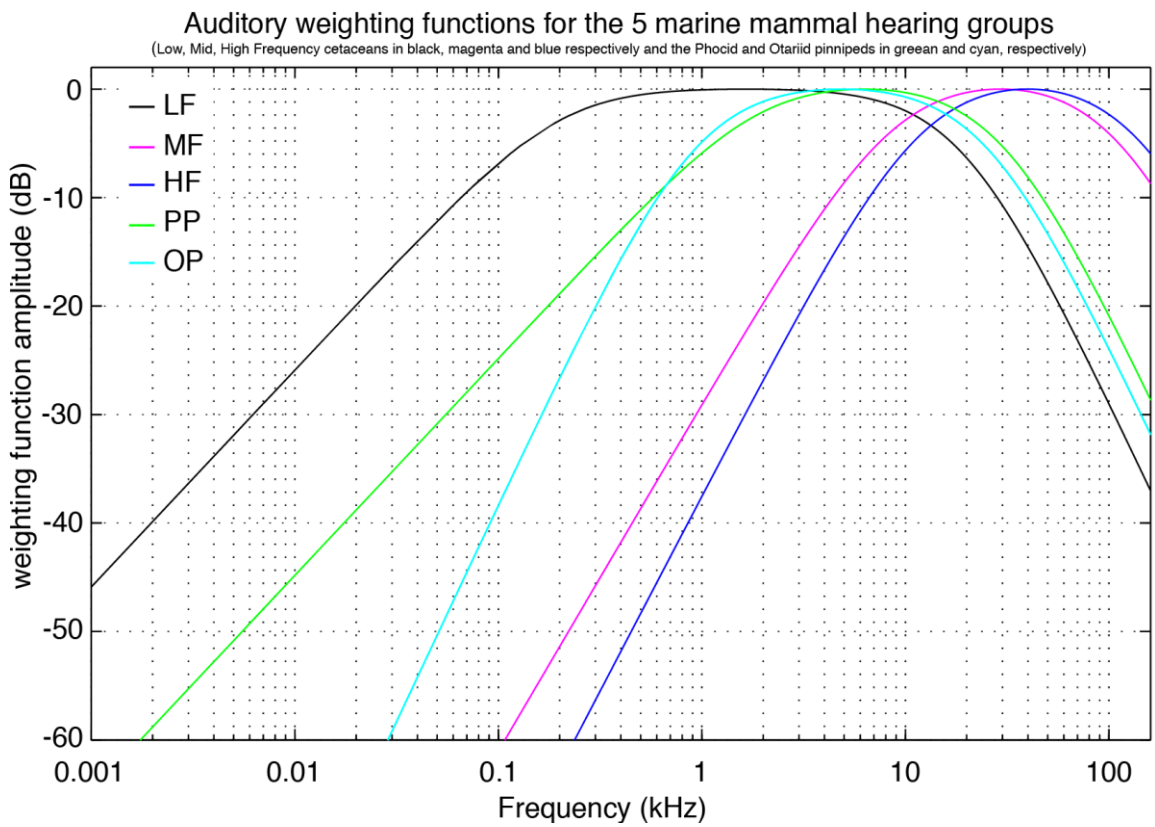

FIGURE A-4. Auditory weighting functions from NMFS technical guidance.

To estimate SEL_{cum} and Peak SPL, we used the acoustic modeling developed at L-DEO (same as used for Level B takes) with a small grid step in both the inline and depth directions. The propagation modeling takes into account all airgun interactions at short distances from the source including interactions between subarrays which we do 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.

PTS onset acoustic thresholds estimated in the NMFS User Spreadsheet rely on overriding default values and calculating individual adjustment factors (dB) and by using the difference between levels with and without weighting functions for each of the five categories of hearing groups. The new adjustment factors in the spreadsheet allow for the calculation of SEL_{cum} isopleths in the spreadsheet and account for the accumulation (Safe Distance Methodology) using the source characteristics (duty cycle and speed) after Sivle et al. (2014). The methodology (input) for calculating the distances to the SEL_{cum} PTS thresholds (Level A) for the airgun array is shown in Table A-2.

TABLE A-2. SEL_{cum} Methodology Parameters (Sivle et al. 2014)†.

Airgun Configuration	Source Velocity (meters/second)	1/Repetition rate^ (seconds)
Two 45-in^3 GI guns / 2-m gun separation	2.5722	9.7192
Two 45-in^3 GI guns / 8-m gun separation	4.1156	12.1490

† Methodology assumes propagation of 20logR. ^ Time between onset of successive pulses. Activity duration (time) independent. The source velocity and 1/Repetition rate were used as inputs to the NMFS User Spreadsheet.

For the LF cetaceans, during operations with the airgun array that has the 2-m airgun separation configuration, we estimated a new adjustment value by computing the distance from the geometrical center of the source to where the 183 dB SEL_{cum} isopleth is the largest. We first ran the modeling for a single shot without applying any weighting function; the maximum 183 dB SEL_{cum} isopleth was located at 15.38 m from the source. We then ran the modeling for a single shot with the LF cetacean weighting function applied to the full spectrum; the maximum 183 dB SEL_{cum} isopleth was located at 7.20 m from the source. The difference between 15.38 m and 7.20 m gives an adjustment factor of 6.59 dB assuming a propagation of $20\log_{10}$(Radial distance) (Table A-3). The adjustment factor for LF cetaceans during operations with the array configuration that has 8-m airgun separation is 8.26 dB (Table A-3).

For MF and HF cetaceans, and OW and PW pinnipeds, the modeling for a single shot with the weighted function applied leads to 0-m isopleths; the adjustment factors thus cannot be derived the same way as for LF cetaceans. Hence, for MF and HF cetaceans, and OW and PW pinnipeds, the difference between weighted and unweighted spectral source levels at each frequency up to 3 kHz was integrated to actually calculate these adjustment factors in dB. These calculations also account for the accumulation (Safe Distance Methodology) using the source characteristics (duty cycle and speed) after Sivle et al. (2014).

For the different airgun array configurations, the results for single shot SEL source level modeling are shown in Table A-3. The weighting function calculations, thresholds for SEL_{cum}, and the distances to the PTS thresholds are shown in Table A-4 for the 2-m airgun separation configuration, and in Table A-5 for the 8-m airgun separation configuration. Figure A-5 shows the impact of weighting functions by hearing group for the 2- and 8-m airgun separation configurations. For the 2-m airgun separation configuration, Figures A-6 and A-7 show the modeled received sound levels for single shot SEL without applying auditory weighting functions for various hearing groups, and Figure A-8 shows the modeled received sound levels for single shot SEL with weighting for LF cetaceans. For the 8-m airgun separation configuration, Figures A-9 and A-10 show the modeled received sound levels for single shot SEL without applying auditory weighting functions for various hearing groups, and Figure A-11 shows the modeled received sound levels for single shot SEL with weighting for LF cetaceans.

The thresholds for Peak SPL_{flat} for the two airgun array configurations, as well as the distances to the PTS thresholds, are shown in Table A-6. Figures A-12 and A-13 and Figures A-14 and A-15 show the modeled received sound levels to the Peak SPL_{flat} thresholds, for a single shot, without applying a high-pass filter, for the 2-m and 8-m airgun separation configurations, respectively.

TABLE A-3. Table showing the results for one single SEL source level modeling for the two different airgun array configurations without and with applying weighting function to the five hearing groups. The modified farfield signature is estimated using the distance from the source array geometrical center to where the SEL_{cum} threshold is the largest. A propagation of 20 $\log_{10}$ (Radial distance) is used to estimate the modified farfield SEL.

	SEL_{cum} Threshold (dB)				
	183	**185**	**155**	**185**	**203**
Two 45-in^3 GI guns / 2-m gun separation					
Distance (m) (no weighting function)	15.3852	12.3810	409.3403	12.3810	1.6535
Modified Farfield SEL	206.7421	206.8551	207.2417	206.8551	207.3681
Distance (m) (with weighting function)	7.202	N/A	N/A	N/A	N/A
Adjustment (dB)	- 6.59	N/A	N/A	N/A	N/A
Two 45-in^3 GI guns / 8-m gun separation					
Distance (m) (no weighting function)	15.9209	12.2241	427.0022	12.2241	N/A (<1m)
Modified Farfield SEL	207.0394	206.7443	207.6086	206.7443	203
Distance (m) (with weighting function)	6.145	N/A	N/A	N/A	N/A
Adjustment (dB)	- 8.26	N/A	N/A	N/A	N/A

N.A. means not applicable or not available.

The NSF/USGS PEIS defined a low-energy source as any towed acoustic source whose received level is ≤180 dB re 1 μPa_{rms} (the Level A threshold under the former NMFS acoustic guidance) at 100 m, including any single or any two GI airguns and a single pair of clustered airguns with individual volumes of ≤250 in^3. In § 2.4.2 of the PEIS, Alternative B (the Preferred Alternative) conservatively applied a 100-m EZ for all low-energy acoustic sources in water depths >100 m. Consistent with the PEIS, that approach would be used here for the pair of 45-in^3 GI airguns for all water depths. The 100-m EZ would also be used as the EZ for sea turtles, although current guidance by NMFS suggests a Level A criterion of 195 dB re 1 μPa_{rms} or an EZ of 10–11 m in deep water for the airgun array (see Fig. A-1 and A-2). If marine mammals or sea turtles are detected in or about to enter the EZ, the airguns would be shut down immediately. Enforcement of mitigation zones via shut downs would be implemented in the Operational Phase, as noted below. A fixed 160-dB "Safety Zone" was not defined for the same suite of low-energy sources in the NSF/USGS PEIS; therefore, L-DEO model results are used here to determine the 160-dB radius for the pair of 45-in^3 GI airguns (see Table A-1).

Enforcement of mitigation zones via shut downs would be implemented in the Operational Phase, as noted below. This document has been prepared in accordance with the current NOAA acoustic practices, and the procedures are based on best practices noted by Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al. (2013a), Wright (2014), Wright and Cosentino (2015), and Acosta et al. (2017).

TABLE A-4. NMFS User Spreadsheet. Results for single shot SEL source level modeling for the two GI guns, in the 2-m airgun separation configuration, with weighting function calculations for the SEL_{cum} criteria, as well as resulting isopleths to thresholds for various hearing groups.

STEP 1: GENERAL PROJECT INFORMATION		
PROJECT TITLE	R/V Revelle - SIO	
PROJECT/SOURCE INFORMATION	two 45 cu.in g-guns 2 m separation @ a 4 m tow depth	
Please include any assumptions		
PROJECT CONTACT		
STEP 2: WEIGHTING FACTOR ADJUSTMENT		Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value
Weighting Factor Adjustment (kHz)[Y]	NA	Override WFA: Using LDEO modeling
[Y] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab		
		† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 62), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

F2: ALTERNATIVE METHOD† TO CALCULATE PK and SEL_{cum} (SINGLE STRIKE/SHOT/PULSE EQUIVALENT)

SEL_{cum}

Source Velocity (meters/second)	2.05778
1/Repetition rate^ (seconds)	12.149

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

^Time between onset of successive pulses.

Modified farfield SEL	206.7421	206.8551	207.2417	206.8551	207.3681
Source Factor	3.88749E+19	3.98997E+19	4.36144E+19	3.98997E+19	4.49024E+19

RESULTANT ISOPLETHS*

*Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	6.5	0.0	0.0	0.1	0.0

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	
a	1	1.6	1.8	1	2	
b	2	2	2	2	2	
f_1	0.2	8.8	12	1.9	0.94	
f_2	19	110	140	30	25	
C	0.13	1.2	1.36	0.75	0.64	
Adjustment (dB)†	-6.59	-54.54	-63.64	-24.57	-30.30	OVERIDE Using LDEO Modeling

†For LF cetaceans, the adjustment factor (dB) is derived by estimating the radial distance of the 183-dB isopleth without applying the weighting function and a second time with applying the weighting function. Adjustment was derived using a propagation of $20\log_{10}$ (Radial distance) and the modified farfield signature. For MF and HF cetaceans and pinnipeds, the difference between weighted–unweighted spectral source levels at each frequency was integrated to calculate adjustment factors (see spectrum levels in Figure 5A).

TABLE A-5. NMFS User Spreadsheet. Results for single shot SEL source level modeling for the two GI guns, in the 8-m airgun separation configuration, with weighting function calculations for the SEL_{cum} criteria, as well as resulting isopleths to thresholds for various hearing groups.

STEP 1: GENERAL PROJECT INFORMATION	
PROJECT TITLE	R/V Revelle - SIO
PROJECT/SOURCE INFORMATION Please include any assumptions	two 45 cu.in g-guns 8 m separation @ a 4 m tow depth
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT		Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value
Weighting Factor Adjustment (kHz)[¥]	NA	Override WFA: Using LDEO modeling
[¥] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab		† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 62), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

F2: ALTERNATIVE METHOD[†] TO CALCULATE PK and SEL_{cum} (SINGLE STRIKE/SHOT/PULSE EQUIVALENT)

SEL_{cum}

Source Velocity (meters/second)	5.14444
1/Repetition rate^ (seconds)	9.71923

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

^Time between onset of successive pulses.

Modified farfield SEL	207.0394	206.7443	207.6086	206.7443	203
Source Factor	5.20365E+19	4.86181E+19	5.93237E+19	4.86181E+19	2.0529E+19

RESULTANT ISOPLETHS*

*Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	2.4	0.0	0.0	0.0	0.0

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	
a	1	1.6	1.8	1	2	
b	2	2	2	2	2	
f_1	0.2	8.8	12	1.9	0.94	
f_2	19	110	140	30	25	
C	0.13	1.2	1.36	0.75	0.64	
Adjustment (dB)[†]	-8.26	-55.38	-64.50	-25.13	-31.19	OVERIDE Using LDEO Modeling

[†]For LF cetaceans, the adjustment factor (dB) is derived by estimating the radial distance of the 183-dB isopleth without applying the weighting function and a second time with applying the weighting function. Adjustment was derived using a propagation of $20\log_{10}$ (Radial distance) and the modified farfield signature. For MF and HF cetaceans and pinnipeds, the difference between weighted–unweighted spectral source levels at each frequency was integrated to calculate adjustment factors (see spectrum levels in Figure 5B).

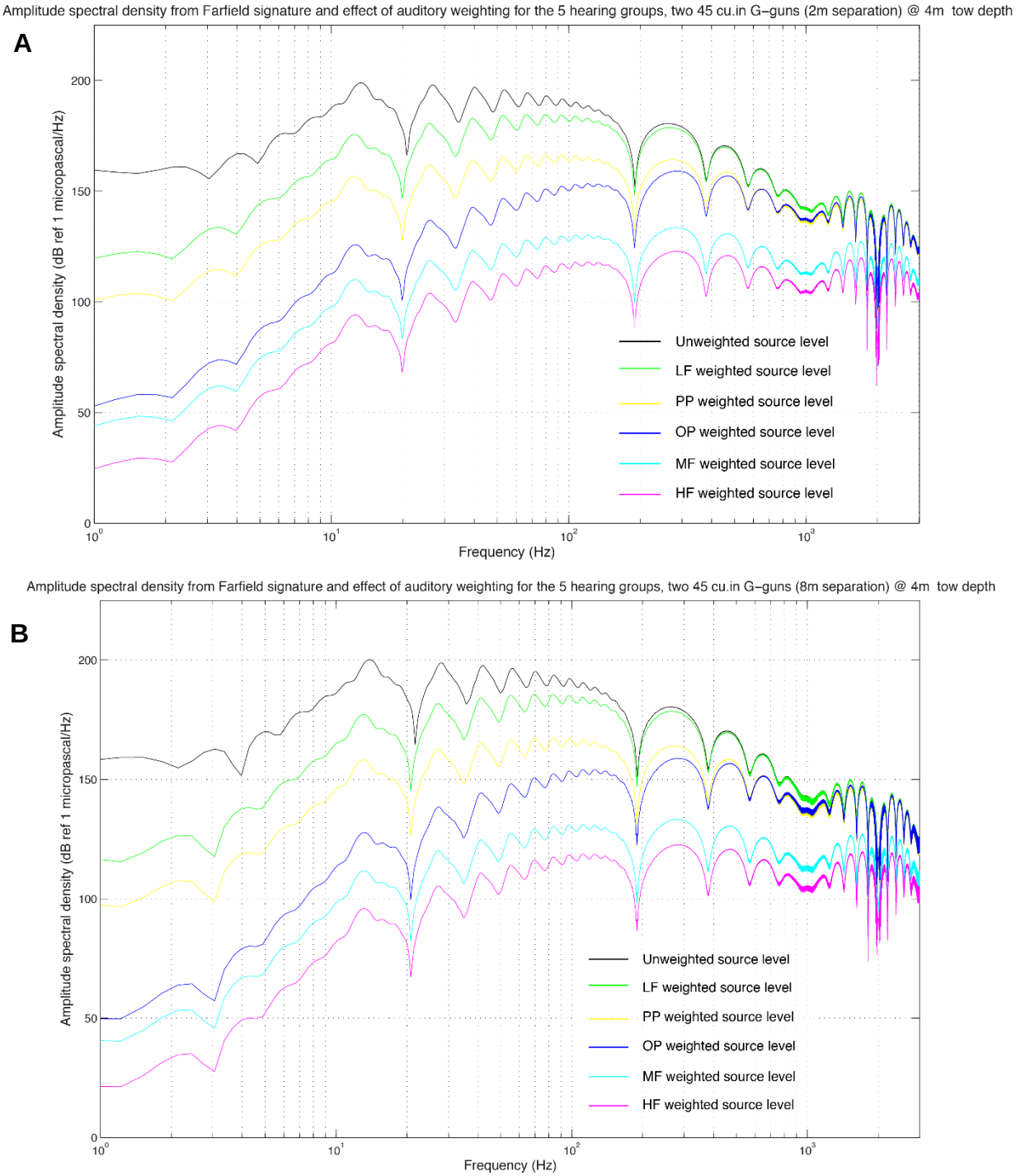

FIGURE A-5. Modeled amplitude spectral density of the two GI guns farfield signature for the (A) 2-m airgun separation and (B) 8-m airgun separation configurations. Amplitude spectral density before (black) and after (colors) applying the auditory weighting functions for LF, MF, and HF cetaceans, Phocid Pinnipeds (PP), and Otariid Pinnipeds (OP). Modeled spectral levels are used to calculate the difference between the unweighted and weighted source level at each frequency and to derive the adjustment factors for the hearing groups as inputs into the NMFS User Spreadsheet.

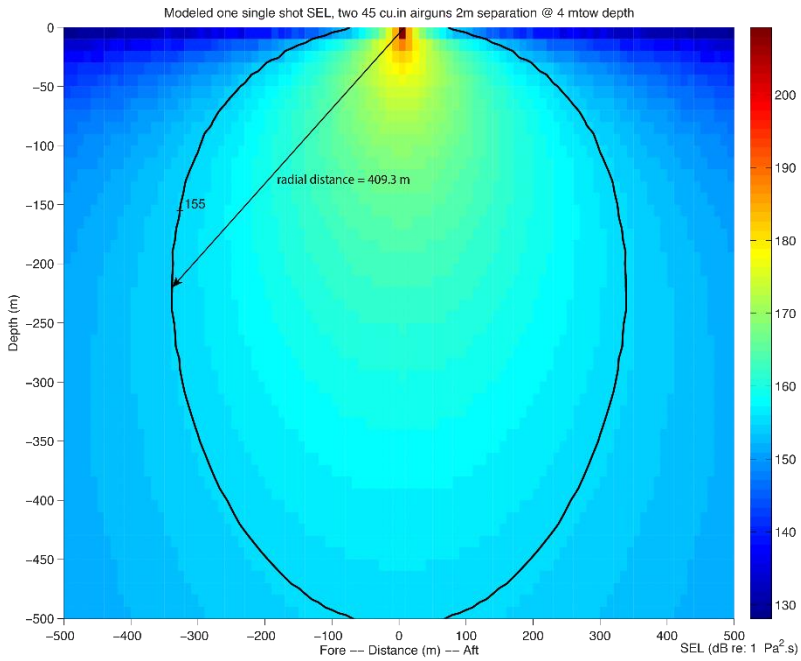

FIGURE A-6. Modeled received sound levels (SELs) in deep water from the two 45 in^3 GI guns, with 2-m gun separation, at a 4-m tow depth. The plot provides the distance from the geometrical center of the source array to the 155-dB SEL isopleth.

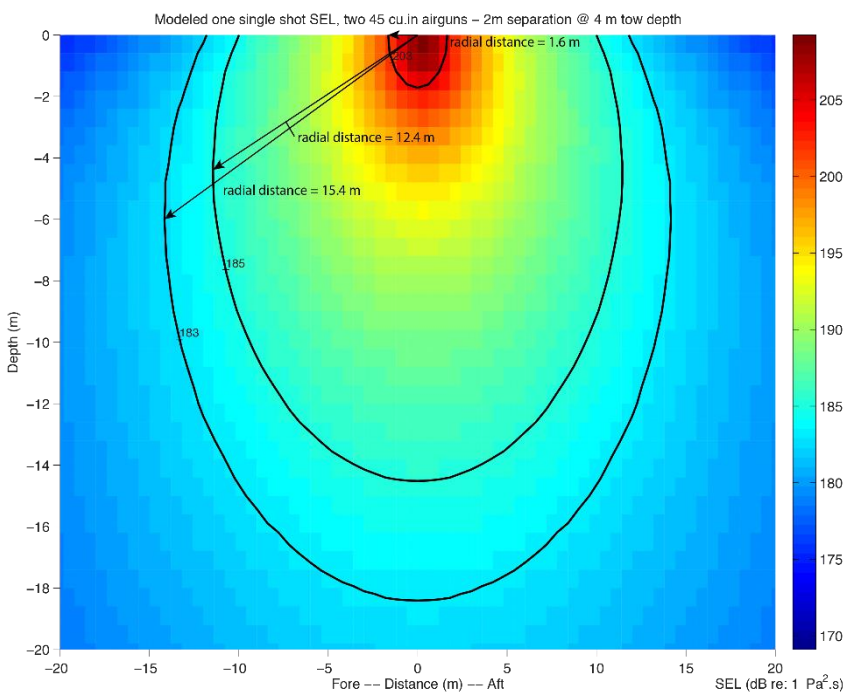

FIGURE A-7. Modeled received sound levels (SELs) in deep water from the two 45 in^3 GI guns, with 2-m gun separation, at a 4-m tow depth. The plot provides the distance from the geometrical center of the source array to the 183-, 185-, and 203-dB SEL isopleths**.**

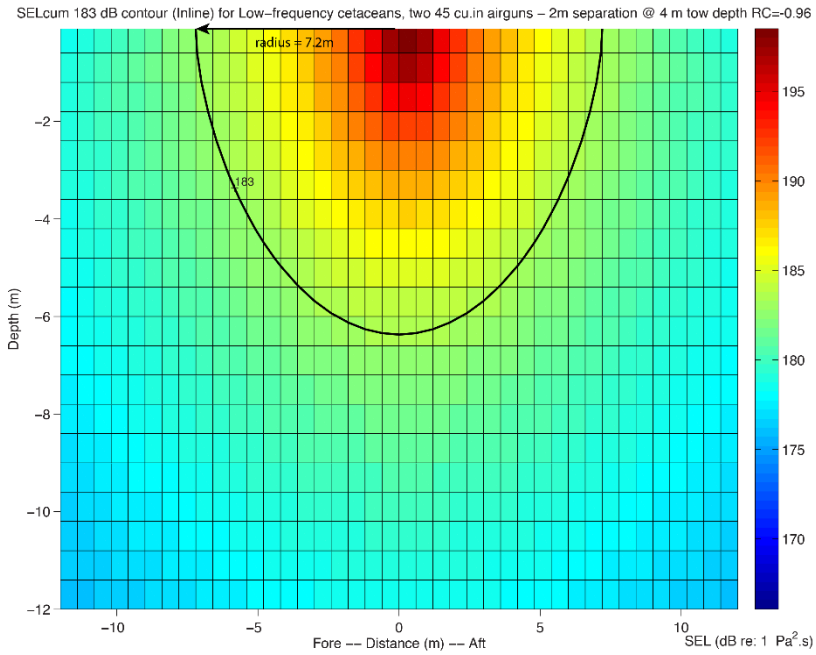

FIGURE A-8. Modeled received sound exposure levels (SELs) from the two 45 in^3 GI guns, with a 2-m airgun separation, at a 4-m tow depth, after applying the auditory weighting function for the LF cetaceans following the NMFS Technical Guidance. The plot provides the radial distance to the 183-dB SEL_{cum} isopleth for one shot. The difference in radial distances between Fig. A-7 and this figure allows us to estimate the adjustment in dB.

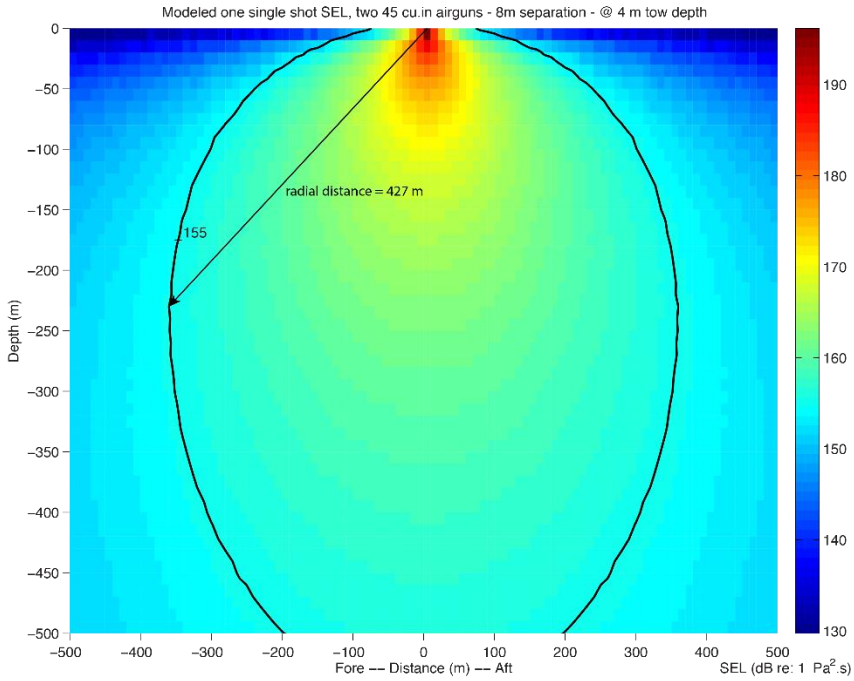

FIGURE A-9. Modeled received sound levels (SELs) in deep water from the two 45 in^3 GI airguns, with 8-m airgun separation, at a 4-m tow depth. The plot provides the distance from the geometrical center of the source array to the 155-dB SEL isopleth.

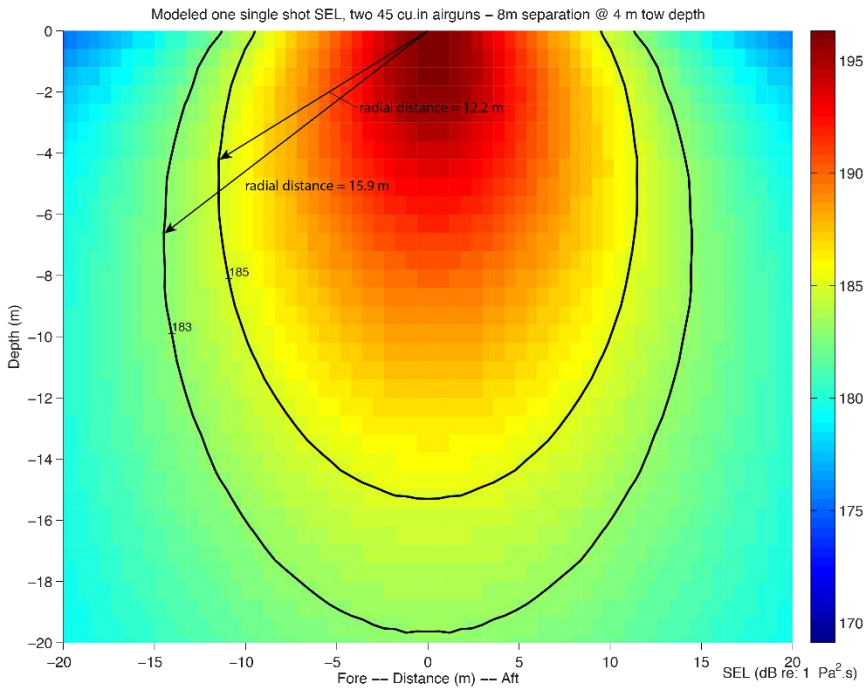

FIGURE A-10. Modeled received sound levels (SELs) in deep water from the two 45 in^3 GI airguns, with 8-m airgun separation, at a 4-m tow depth. The plot provides the distance from the geometrical center of the source array to the 183-, 185-, and 203-dB SEL isopleths.

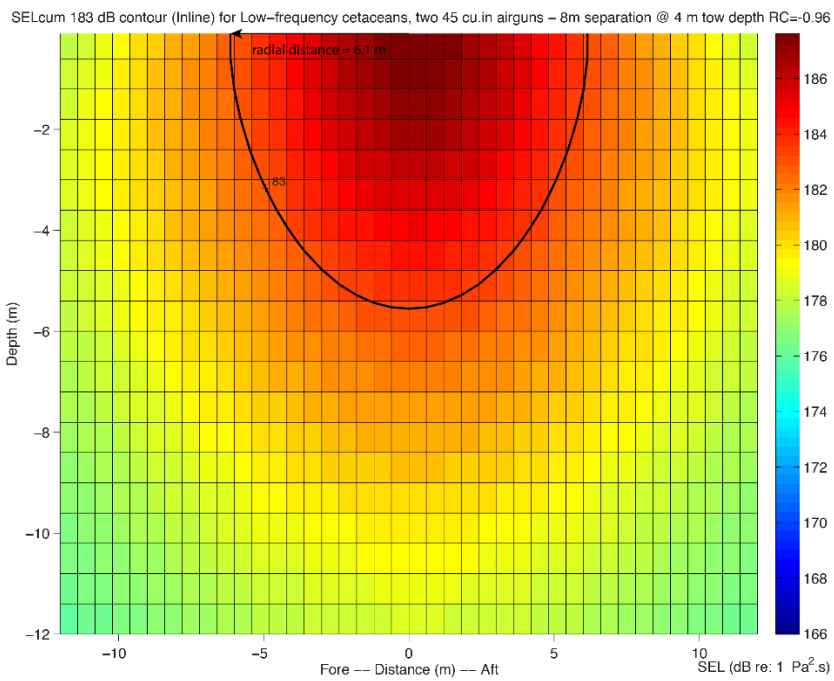

FIGURE A-11. Modeled received sound exposure levels (SELs) from the two 45 in^3 GI airguns, with an 8-m airgun separation, at a 4-m tow depth, after applying the auditory weighting function for the LF cetaceans following the NMFS Technical Guidance. The plot provides the radial distance to the 183-dB SEL_{cum} isopleth for one shot. The difference in radial distances between Fig. A-10 and this figure allows us to estimate the adjustment in dB.

TABLE A-6. NMFS Level A acoustic thresholds (Peak SPL_{flat}) for impulsive sources for marine mammals and predicted distances to Level A thresholds for various marine mammal hearing groups that could be received from the different airgun configurations during the proposed seismic surveys in the Southwest Atlantic Ocean.

	Hearing Group				
	Low-Frequency Cetaceans	**Mid-Frequency Cetaceans**	**High-Frequency Cetaceans**	**Phocid Pinnipeds**	**Otariid Pinnipeds**
PK Threshold (dB)	**219**	**230**	**202**	**218**	**232**
Two 45-in^3 GI guns / 2-m gun separation					
Modified PK Farfield	232.7862	229.8245	232.9136*	232.8230	225.6248
Radius to Threshold (m)	4.89	0.98	34.62	5.51	0.48
Two 45-in^3 GI guns / 8-m gun separation					
Modified PK Farfield	228.7710	N/A	233.0119*	230.0845	N/A
Radius to Threshold (m)	3.08	N/A	34.84	4.02	N/A

N.A. means not applicable or not available.
[1] Using radial distance (35.13 m and 35.53 m for the 2- and 8-m airgun separation configurations, respectively); for other hearing groups, radius and radial distance are the same.

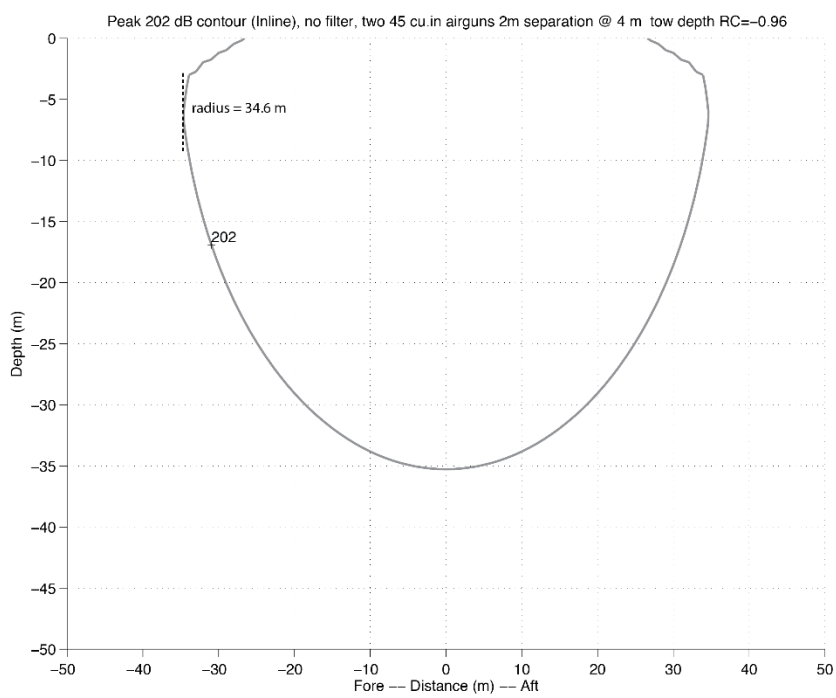

FIGURE A-12. Modeled deep-water received Peak SPL from two 45-in^3 GI guns, in a 2-m gun separation configuration, at a 4-m tow depth. The plot provides the radial distance and radius from the source geometrical center to the 202-dB Peak isopleth.

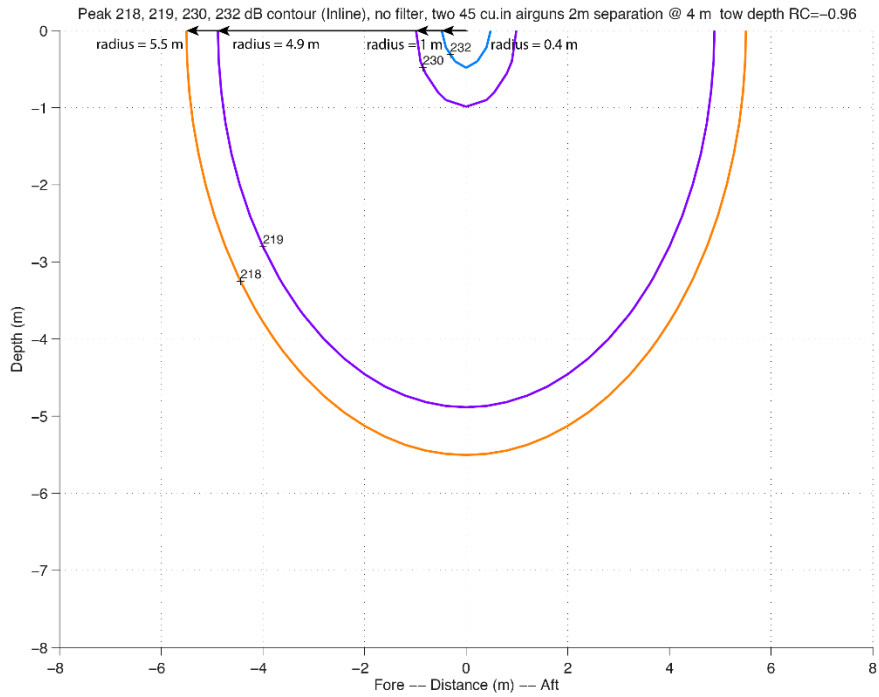

FIGURE A-13. Modeled deep-water received Peak SPL from two 45-in^3 GI airguns, with a 2-m airgun separation configuration, at a 4-m tow depth. The plot provides the radial distances (radii) from the source geometrical center to the 218-, 219-, 230-, and 232-dB Peak isopleths.

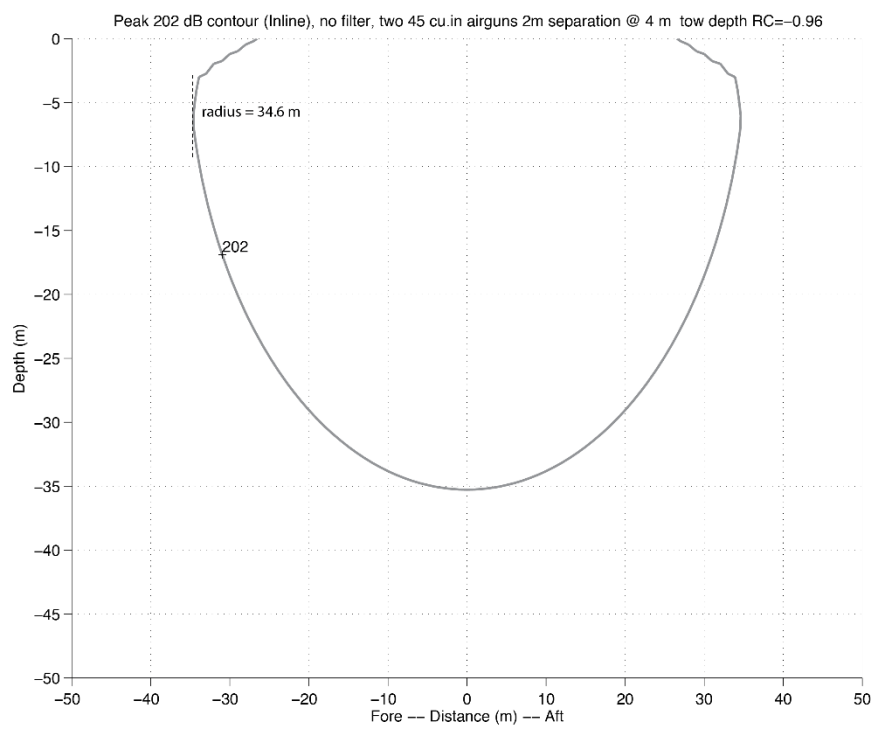

FIGURE A-14. Modeled deep-water received Peak SPL from two 45-in^3 GI airguns, in an 8-m airgun separation configuration, at a 4-m tow depth. The plot provides the radial distance and radius from the source geometrical center to the 202-dB Peak isopleth.

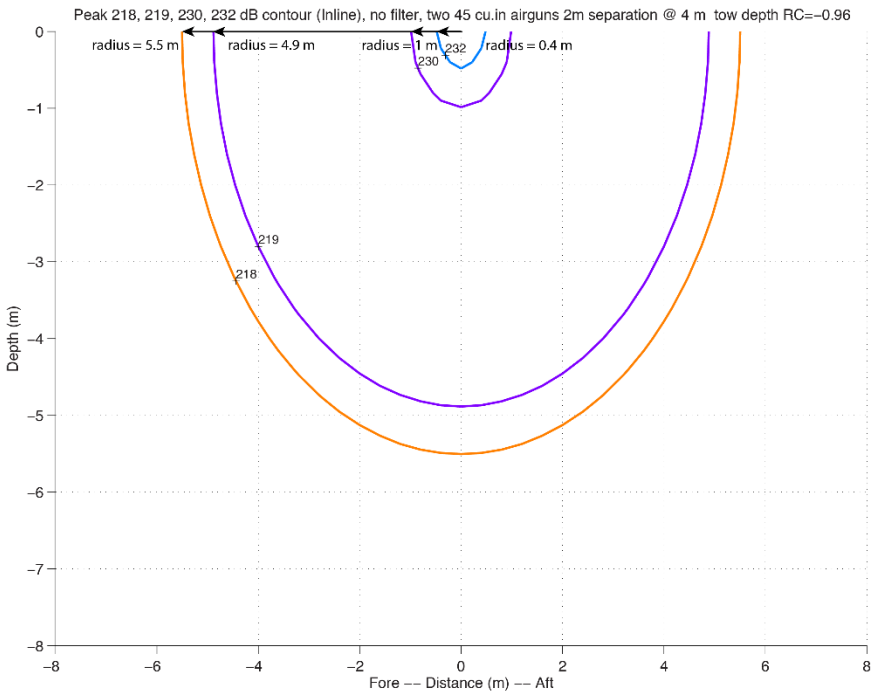

FIGURE A-15. Modeled deep-water received Peak SPL from two 45-in^3 GI airguns, with an 8-m airgun separation configuration, at a 4-m tow depth. The plot provides the radial distances (radii) from the source geometrical center to the 218-, 219-, 230-, and 232-dB Peak isopleths.

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APPENDIX B: MARINE MAMMAL DENSITIES

The preferred source of density data for the species that might be encountered in the proposed project area north of the Falkland Islands was AECOM/NSF (2014). For species not included in the AECOM database, the first alternative source used was NOAA-SWFSC LOA (2013 *in* AECOM/NSF 2014), with the exception of hourglass dolphin, southern bottlenose whale, and southern elephant seal which were more abundant during surveys by White et al. (2002). When densities were not available from AECOM/NSF (2014) or NOAA-SWFSC LOA (2013 *in* AECOM/NSF 2014), densities were estimated using sightings and effort during aerial- and vessel-based surveys conducted in and adjacent to the proposed project area. There were three major sources of these latter data and a few additional sources of density or sightings and effort based on single species surveys. The three major sources of animal abundance are:

1. White et al. (2002) conducted vessel-based surveys of birds from February 1998 to January 2001 in the vicinity of the Falkland Islands which included coverage of the southern part of the proposed seismic project area. Their report provides data of two types. The first is the total number of sightings and total number of km of survey effort which are provided for all species and species groups. The second source is maps with sightings/km of birds and marine mammals in blocks 15 minutes of latitude × 30 minutes of longitude which are provided for common species.

2. De Tullio et al. (2016) conducted vessel-based surveys north of the proposed project area during austral spring and fall of 2009–2015. Surveys were conducted along the continental slope which is the similar habitat as would be covered by the proposed seismic surveys. They provide summaries of their survey data for the northern and southern parts of their survey area, and we used only data from the southern part. Their summaries included number of sightings for each species, mean pod size, and survey effort.

3. Garaffo et al. (2011) conducted 13 aerial surveys from 1994–2007 in shelf waters directly west from the proposed project area. They provide survey effort and number of sightings for dusky, Commerson's, and common dolphins. Bottlenose and Peale's dolphins were also sighted in lower numbers but those numbers are not reported.

Two methods were used to estimate the densities of marine mammals in the proposed seismic survey areas from the above surveys. For the common species sighted during the White et al. (2002) surveys, they provided maps showing density ranges in cells throughout their survey area. In cases where separate maps were given for austral winter and summer, we used maps for the summer period or periods that overlapped with the timing of the proposed seismic surveys. Densities during summer are expected to have similar or higher densities of the species present as the spring period proposed for the seismic surveys. The encounter rates (animals/km) for all surveyed blocks above 50ºS latitude were averaged to obtain a mean encounter rate which was then put into the distance formula (1) using correction for detection or f(0), and availability or g(0), biases given in Bradford et al. (2017) for vessel-based surveys or Forney and Barlow (1998) for aerial surveys for the species or species with similar behavior.

(1) $\text{Density} = [n \times s \times f(0)] / [2L \times g(0)]$

Where n is the number of sightings, s is the mean group size and L is the number of km of survey effort.

The second method was used when the number of sightings, mean group size, and the survey effort (in km) were given. Those were entered into the distance formula (1) to calculate the density using the

correction factors given in Bradford et al. (2017) for vessel-based surveys and Forney and Barlow (1998) for aerial surveys. The paper by Garaffo et al. (2011) did not state the group sizes encountered for their sightings so we used the group sizes in di Tullio et al. (2016) except for dusky dolphin which they did not encounter. We used the group size from Crespo et al. (1997) for dusky dolphin.

When species could not be determined during the survey, but the sightings were identified to genus (i.e., minke and beaked whales), we calculated the density for all animals in that genus and prorated the density for the genus to densities for the individual species based on data on relative occurrence of each species in stranding records (Otley et al. 2012). Unidentified whales, small cetaceans, unidentified dolphins, etc., were prorated based on the number of sightings for each identified species and added to the density for individual species that would be included in the particular unidentified category.

There is uncertainty about the representativeness of the data and the assumptions. Thus, for some species (e.g., Atlantic spotted dolphin, short-beaked common dolphin), the densities derived from past surveys may not be representative of the densities that would be encountered during the proposed seismic surveys, as the data were collected from a different area or during different season. However, the approach used here is based on the best available data.

Table B-1 gives the sources of the data for estimation of density for each species with the sources of correction factors used. It also includes a brief explanation of the rationale for using upward or downward changes in the density because it had been obtained for areas outside of the proposed project area. For example, the density for southern right whales was obtained from AECOM/NSF (2014), for the summer feeding areas south of the proposed project area; during the proposed survey period, whales that might be encountered would be migrating from wintering areas north of the survey area to summer feeding areas south of there, so a correction factor was applied.

TABLE B-1. Sources of density data used (N.A. means not available).

Species	Reported density (#/km^2)	Adjustment	Density used (#/km^2)	Density reference	Comments
Mysticetes					
Southern right whale	0.007965	0.1	0.000797	AECOM/NSF (2014)	reduced to 0.1x because density from summer feeding area
Pygmy right whale	N.A.		N.A.	Not available	not identified in area but could possibly occur there
Blue whale	0.000051		0.000051	AECOM/NSF (2014)	
Fin whale	0.018204		0.018204	AECOM/NSF (2014)	
Sei whale	0.006359		0.006359	AECOM/NSF (2014)	
Common (dwarf) minke whale	0.077896		0.077896	AECOM/NSF (2014)	assumed species equally abundant based on several studies
Antarctic minke whale	0.077896		0.077896	AECOM/NSF (2014)	assumed species equally abundant based on several studies
Humpback whale	0.000661		0.000661	AECOM/NSF (2014)	White et al. (2002) had 5 sightings and lower density
Odontocetes					
Sperm whale	0.002069		0.002069	AECOM/NSF (2014)	
Pygmy sperm whale	N.A.		N.A.	Not expected	present in warmer waters farther north but could be present
Dwarf sperm whale	N.A.		N.A.	Not expected	present in warmer waters farther north but could be present
Arnoux's beaked whale	0.011379		0.011379	AECOM/NSF (2014)	
Cuvier's beaked whale	0.000548		0.000548	AECOM/NSF (2014)	
Southern bottlenose whale	0.007906		0.007906	White et al. (2002)	NOAA-SWFSC LOA 2013 density too low for this area
Shepherd's beaked whale	0.006269		0.006269	AECOM/NSF (2014)	
Blainville's beaked whale	0.001323	0.04	0.000053	White et al. (2002)	density for all mesoplodont beaked whales
Gray's beaked whale	0.001885		0.001885	AECOM/NSF (2014)	
Hector's beaked whale	0.001323	0.16	0.000212	White et al. (2002)	see text for description of assignment of unidentified to species
True's beaked whale	0.001323	0.04	0.000053	White et al. (2002)	for all mesoplodont beaked whales
Strap-toothed beaked whale	0.001323	0.44	0.000582	White et al. (2002)	
Andrew's beaked whale	0.001323	0.12	0.000159	White et al. (2002)	
Spade-toothed beaked whale	0.001323	0.04	0.000053	White et al. (2002)	
Risso's dolphin	0.004358		0.004358	di Tullio et al. (2016)	north of seismic area so may overestimate density
Rough-toothed dolphin	0.005954		0.005954	Wedekin et al. (2014)	north of seismic area so may overestimate density
Common bottlenose dolphin	0.050914		0.050914	di Tullio et al. (2016)	
Pantropical spotted dolphin	0.003767		0.003767	de Boer (2010)	
Atlantic spotted dolphin	0.225166		0.225166	di Tullio et al. (2016)	
Spinner dolphin	0.014978		0.014978	di Tullio et al. (2016)	
Clymene dolphin	0.011624		0.011624	di Tullio et al. (2016)	
Striped dolphin	0.007193		0.007193	di Tullio et al. (2016)	
Short-beaked common dolphin	0.717166		0.717166	Garaffo et al. (2011)	from surveys farther north so may overestimate density
Fraser's dolphin	N.A.		N.A.	Not available	not expected to occur but may be encountered
Dusky dolphin <1000 m	0.128668	1	0.128668	Garaffo et al. (2011)	mean group size from di Tullio et al. (2016)
Dusky dolphin >1000 m	0.128668	0.01	0.001287	Garaffo et al. (2011)	does not normally occur in water depths >1000 m
Hourglass dolphin	0.148709		0.148709	White et al. (2002)	NOAA-SWFSC LOA 2013 density was 0.0015 which was too low
Peale's dolphin	0.030138		0.030138	Dellabianca et al. (2016)	
Southern right whale dolphin	0.006161		0.006161	AECOM/NSF (2014)	
Commerson's dolphin <100 m	0.067632		0.067632	Dellabianca et al. (2016)	
Commerson's dolphin >100 m	0.067632	0.1	0.006763	Dellabianca et al. (2016)	not common in water >100 m but may be encountered
Killer whale	0.015380		0.015380	AECOM/NSF (2014)	
Short-finned pilot whale	0.002085		0.002085	de Boer (2010)	warm water species:
Long-finned pilot whale	0.214557		0.214557	AECOM/NSF (2014)	
False killer whale	N.A.		N.A.	Not available	not expected to occur but may be encountered
Spectacled porpoise <100 m	0.001500		0.001500	NOAA-SWFSC LOA (2013)	
Spectacled porpoise >100 m	0.001500	0.1	0.000150	NOAA-SWFSC LOA (2013)	not expected to occur but may be encountered
Pinnipeds					
Antarctic fur seal	0.041082	0.01	0.000411	White et al. (2002)	not identified to species; prorated among species
South American fur seal	0.041082	0.97	0.039850	White et al. (2002)	not identified to species; prorated among species
Subantarctic fur seal	0.041082	0.02	0.000822	White et al. (2002)	not identified to species; prorated among species
Crabeater seal	0.648650	0.01	0.006487	NOAA-SWFSC LOA (2013)	density /100 because far from ice
Leopard seal	0.016220	0.10	0.001622	NOAA-SWFSC LOA (2013)	density /10 because far from ice
Southern elephant seal	0.001548		0.001548	White et al. (2002)	NOAA-SWFSC LOA 2013 density too low
South American sea lion	0.006036		0.006036	White et al. (2002)	

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APPENDIX C: MARINE MAMMAL TAKE CALCULATIONS

Species	Reported Density (#/km^2)	Correction Factor	Estimated Density (#/km^2)	Population Size	Hearing Group	Level B Ensonified Area km^2 (160 dB)	Level A Ensonified Area km^2	Total Takes	Level B Takes	Level A Takes	% of Population (Total Takes)
Mysticetes											
Southern right whale	0.00797	0.10	0.00080	3300	LF	13958	91	11	11	0	0.3
Pygmy right whale	N.A.		N.A.	N.A.	LF	13958	91	N.A.	N.A.	N.A.	N.A.
Blue whale	0.00005		0.00005	2300	LF	13958	91	1	1	0	<0.01
Fin whale	0.01820		0.01820	15000	LF	13958	91	254	252	2	1.7
Sei whale	0.00636		0.00636	10000	LF	13958	91	89	88	1	0.9
Common (dwarf) minke whale	0.07790		0.07790	515000	LF	13958	91	1087	1080	7	0.2
Antarctic minke whale	0.07790		0.07790	515000	LF	13958	91	1087	1080	7	0.2
Humpback whale	0.00066		0.00066	42000	LF	13958	91	9	9	0	<0.01
Odontocetes											
Sperm whale	0.00207		0.00207	12069	MF	13958	9	29	29	0	0.2
Pygmy sperm whale	N.A.		N.A.	N.A.	HF	13958	681	N.A.	N.A.	N.A.	N.A.
Dwarf sperm whale	N.A.		N.A.	N.A.	HF	13958	681	N.A.	N.A.	N.A.	N.A.
Arnoux's beaked whale	0.01138		0.01138	599300	MF	13958	9	159	159	0	<0.01
Cuvier's beaked whale	0.00055		0.00055	599300	MF	13958	9	8	8	0	<0.01
Southern bottlenose whale	0.00791		0.00791	599300	MF	13958	9	110	110	0	<0.01
Shepherd's beaked whale	0.00627		0.00627	N.A.	MF	13958	9	88	88	0	N.A.
Blainville's beaked whale	0.00132	0.04	0.00005	N.A.	MF	13958	9	1	1	0	N.A.
Gray's beaked whale	0.00189		0.00189	599300	MF	13958	9	26	26	0	<0.01
Hector's beaked whale	0.00132	0.16	0.00021	N.A.	MF	13958	9	3	3	0	N.A.
True's beaked whale	0.00132	0.04	0.00005	N.A.	MF	13958	9	1	1	0	N.A.
Strap-toothed beaked whale	0.00132	0.44	0.00058	599300	MF	13958	9	8	8	0	<0.01
Andrew's beaked whale	0.00132	0.12	0.00016	N.A.	MF	13958	9	2	2	0	N.A.
Spade-toothed beaked whale	0.00132	0.04	0.00005	N.A.	MF	13958	9	1	1	0	N.A.
Risso's dolphin	0.00436		0.00436	18250	MF	13958	9	61	61	0	0.3
Rough-toothed dolphin	0.00595		0.00595	N.A.	MF	13958	9	83	83	0	N.A.
Common bottlenose dolphin	0.05091		0.05091	77532	MF	13958	9	711	711	0	0.9
Pantropical spotted dolphin	0.00377		0.00377	3333	MF	13958	9	53	53	0	1.6
Atlantic spotted dolphin	0.22517		0.22517	44715	MF	13958	9	3143	3143	0	7.0
Spinner dolphin	0.01498		0.01498	N.A.	MF	13958	9	209	209	0	N.A.
Clymene dolphin	0.01162		0.01162	N.A.	MF	13958	9	162	162	0	N.A.
Striped dolphin	0.00719		0.00719	54807	MF	13958	9	100	100	0	0.2
Short-beaked common dolphin	0.71717		0.71717	70184	MF	13958	9	10010	10004	6	14.3
Fraser's dolphin	N.A.		N.A.	N.A.	MF	13958	9	N.A.	N.A.	N.A.	N.A.
Dusky dolphin <1000 m	0.12867		0.12867	7252	MF	7981	9	1027	1026	1	14.2
Dusky dolphin >1000 m	0.12867	0.01	0.00129	7252	MF	5977		8	8		0.1
Hourglass dolphin	0.14871		0.14871	150000	HF	13958	681	2076	1975	101	1.4
Peale's dolphin	0.03014		0.03014	20000	HF	13958	681	421	400	21	2.1
Southern right whale dolphin	0.00616		0.00616	N.A.	MF	13958	9	86	86	0	N.A.
Commerson's dolphin <100 m	0.06763		0.06763	21000	HF	761	681	51	5	46	0.2
Commerson's dolphin >100 m	0.06763	0.10	0.00676	21000	HF	13198		89	89		0.4
Killer whale	0.01538		0.01538	25000	MF	13958	9	215	215	0	0.9
Short-finned pilot whale	0.00209		0.00209	200000	MF	13958	9	29	29	0	<0.01
Long-finned pilot whale	0.21456		0.21456	200000	MF	13958	9	2995	2993	2	1.5
False killer whale	N.A.		N.A.	N.A.	MF	13958	9	N.A.	N.A.	N.A.	N.A.
Spectacled porpoise <100 m	0.00150		0.00150	N.A.	HF	761	681	1	0	1	N.A.
Spectacled porpoise >100 m	0.00150	0.10	0.00015	N.A.	HF	13198		2	2		N.A.
Pinnipeds											
Antarctic fur seal	0.01693	0.01	0.00017	45000000	OW	13958	4	2	2	0	<0.01
South American fur seal	0.01693	0.97	0.01642	99000	OW	13958	4	229	229	0	0.2
Subantarctic fur seal	0.01693	0.02	0.00034	400000	OW	13958	4	5	5	0	<0.01
Crabeater seal	0.64865	0.01	0.00649	5000000	PW	13958	92	91	90	1	<0.01
Leopard seal	0.01622	0.10	0.00162	222000	PW	13958	92	23	23	0	<0.01
Southern elephant seal	0.00155		0.00155	750000	PW	13958	92	22	22	0	<0.01
South American sea lion	0.00249		0.00249	445000	OW	13958	4	35	35	0	<0.01

APPENDIX D: ENSONIFIED AREAS FOR MARINE MAMMAL TAKE CALCULATIONS

Survey Type	Criteria	Daily Ensonified Area (km^2)	Total Survey Days	25% increase	Total Ensonified Area	Relevant Isopleth (m)
5-kt survey	160dB - all depths	299.56	16	1.25	5991.12	
5-kt survey	160 dB - shallow	18.80	16	1.25	376.04	539
5-kt survey	160 dB - intermediate	147.32	16	1.25	2946.34	809
5-kt survey	160-dB - deep	133.44	16	1.25	2668.74	1295
5-kt survey	LFCetacean - Level A	2.89	16	1.25	57.72	6.5
5-kt survey	MFCetacean - Level A	0.44	16	1.25	8.88	1
5-kt survey	HFCetacean - Level A	15.37	16	1.25	307.34	34.6
5-kt survey	Phocids - Level A	2.44	16	1.25	48.84	5.5
5-kt survey	Otariids - Level A	0.22	16	1.25	4.44	0.5
8-kt survey	160dB - all depths	531.15	12	1.25	7967.19	
8-kt survey	160 dB - shallow	25.64	12	1.25	384.60	578
8-kt survey	160 dB - intermediate	284.93	12	1.25	4273.97	867
8-kt survey	160-dB - deep	220.58	12	1.25	3308.63	1400
8-kt survey	LFCetacean - Level A	2.22	12	1.25	33.29	3.1
8-kt survey	MFCetacean - Level A	0	12	1.25	0	0
8-kt survey	HFCetacean - Level A	24.93	12	1.25	374	34.8
8-kt survey	Phocids - Level A	2.86	12	1.25	42.96	4
8-kt survey	Otariids - Level A	0	12	1.25	0	0

Criteria	Total Ensonified Area (km^2) (all survey days; all survey speeds)
160dB - all depths combined	13958.31
160 dB - shallow	760.64
160 dB - intermediate water	7220.31
160 dB - deep water	5977.37
LFCetacean - Level A	91.01
MFCetacean - Level A	8.88
HFCetacean - Level A	681.29
Phocids - Level A	91.80
Otariids - Level A	4.44