National Marine Fisheries Service
Endangered Species Act Section 7
Biological Opinion

Title	Biological Opinion on a National Science Foundation-funded seismic survey by the Scripps Institution of Oceanography in the South Atlantic Ocean, and Issuance of an Incidental Harassment Authorization pursuant to section 101(a)(5)(D) of the Marine Mammal Protection Act by the Permits and Conservation Division, National Marine Fisheries Service
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1 INTRODUCTION

The Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 et seq.) establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat they depend on. Section 7(a)(2) of the ESA requires Federal agencies to insure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Federal agencies must do so in consultation with the National Marine Fisheries Service (NMFS) for threatened or endangered species (ESA-listed), or designated critical habitat that may be affected by the action that are under NMFS jurisdiction (50 C.F.R. §402.14(a)). If a Federal action agency determines that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS concur with that determination for species under NMFS jurisdiction, consultation concludes informally (50 C.F.R. §402.14(b)).

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, NMFS provides an opinion stating whether the Federal agency's action is likely to jeopardize ESA-listed species or destroy or adversely modify designated critical habitat. If NMFS determines that the action is likely to jeopardize listed species or destroy or adversely modify critical habitat, NMFS provides a reasonable and prudent alternative that allows the action to proceed in compliance with section 7(a)(2) of the ESA. If an incidental take is expected, section 7(b)(4) requires NMFS to provide an incidental take statement that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts and terms and conditions to implement the reasonable and prudent measures.

The action agencies for this consultation are the National Science Foundation and the NMFS' Permits and Conservation Division. Two federal actions are considered in this biological opinion. The first is the National Science Foundation funded collaborative research project, led by the Scripps Institution of Oceanography, to conduct a seismic survey in the northwest Atlantic Ocean in June and July 2018. The second is the NMFS' Permits and Conservation Division's proposal to issue an incidental harassment authorization (IHA) authorizing non-lethal "takes" from Level B harassment (as defined by the Marine Mammal Protection Act [MMPA]) of marine mammals incidental to the planned seismic survey, pursuant to section 101 (a)(5)(D) of the MMPA, 16 U.S.C. § 1371 (a)(5)(D).

Updates to the regulations governing interagency consultation (50 CFR part 402) were effective on October 28, 2019 [84 FR 44976]. This consultation was pending at that time, and we are applying the updated regulations to the consultation. As the preamble to the final rule adopting the regulations noted, "[t]his final rule does not lower or raise the bar on section 7 consultations, and it does not alter what is required or analyzed during a consultation. Instead, it improves clarity and consistency, streamlines consultations, and codifies existing practice." We have reviewed the information and analyses relied upon to complete this biological opinion in light of the updated regulations and conclude the opinion is fully consistent with the updated regulations.

This document represents the NMFS ESA Interagency Cooperation Division's opinion on the effects of these actions on threatened and endangered species that have been designated for those species (see Table 4 and Table 6). A complete record of this consultation is on file at the NMFS Office of Protected Resources in Silver Spring, Maryland.

1.1 Background

The National Science Foundation is proposing to fund a seismic survey in the South Atlantic Ocean to take place on or about November 3, 2019, to December 5, 2019. In conjunction with this action, the NMFS' Permits and Conservation Division would issue an IHA under the MMPA for marine mammal takes that could occur during the National Science Foundation sponsored seismic survey. Both the National Science Foundation and the Permits and Conservation Division have conducted similar actions in the past that have been the subject of ESA section 7 consultations.

1.2 Consultation History

This opinion is based on information provided in the National Science Foundation's draft environmental analysis prepared under Executive Order 12114 (*Environmental Effects Abroad of Major Federal Actions*), MMPA incidental harassment authorization application, a notice for a proposed incidental harassment authorization prepared pursuant to the MMPA, monitoring reports from similar activities, published and unpublished scientific information on endangered and threatened species and their surrogates, scientific and commercial information such as reports from government agencies and the peer-reviewed literature, biological opinions on similar activities, and other sources of information. Our communication with the National Science Foundation and NMFS' Permits and Conservation Division regarding this consultation is summarized as follows:

- On January 30, 2019, the National Science Foundation requested a list of ESA-listed species and designated critical habitat that may occur in the proposed action area in the South Atlantic Ocean as well as recommended data sources for marine mammal and sea turtle abundances and densities in the action area.
- On February 22, 2019, we responded to the National Science Foundation request and provided a list of ESA-listed species and designated critical habitat that may occur in the action area in the South Atlantic Ocean as well as recommended data sources for marine mammal and sea turtle abundances and densities in the action area.

- On April 15, 2019, the National Science Foundation sent a spreadsheet containing proposed marine mammal density estimates to us and NMFS' Permits and Conservation Division. We reviewed the spreadsheet and provided comments to the National Science Foundation on April 17, 2019.
- On April 26, 2018, we received a request from the National Science Foundation for ESA section 7 consultation for a proposed seismic survey to be undertaken in the South Atlantic Ocean from November 2019 to December 2019. The National Science Foundation provided a letter and draft Environmental Analysis pursuant to the National Environmental Protection Act, which includes information necessary for a biological assessment, in support of the request. We provided comments on the draft environmental analysis on May 8, 2019.
- On May 10, 2019, the National Science Foundation provided responses to our comments on the environmental analysis and we were able to conclude there was sufficient information to initiate formal consultation. We provided the National Science Foundation with an initiation letter on May 21, 2019.
- On June 8, 2019, the National Science Foundation submitted a revised Environmental Analysis to NMFS' ESA Interagency Cooperation Division. An additional draft of the Environmental Analysis was submitted on July 8, 2019.
- On September 6, 2019, we received a request for formal consultation pursuant to section 7 of the ESA from the NMFS Permits and Conservation Division to authorize the incidental harassment of marine mammal species during the National Science Foundation's seismic survey on the Research Vessel *Thomas G. Thompson (R/V Thompson*) in the South Atlantic Ocean. The consultation request package included an initiation memorandum, incidental harassment authorization application, draft *Federal Register* notice of a proposed incidental harassment authorization, and draft incidental harassment authorization.
- On September 6, 2019, we determined there was sufficient information to initiate formal consultation. We provided NMFS Permits and Conservation Division with an initiation letter on September 12, 2019.
- On September 30, 2019, NMFS Permits and Conservation Division published a notice of a proposed incidental harassment authorization in the *Federal Register* soliciting public comment on their intent to issue an incidental harassment authorization for the National Science Foundation's low-energy marine seismic survey on the R/V *Thompson* in the South Atlantic Ocean.

2 THE ASSESSMENT FRAMEWORK

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species; or adversely modify or destroy their designated critical habitat.

"Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of an ESA-listed species in the wild by reducing the reproduction, numbers, or distribution of that species." 50 C.F.R. §402.02.

"Destruction or adverse modification" means a direct or indirect alteration that appreciably diminishes the value of designated critical habitat for the conservation of an ESA-listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features (50 C.F.R. §402.02). An ESA section 7 assessment involves the following steps:

Description of the Proposed Action (Section 3): We describe the proposed action and those aspects (or stressors) of the proposed action that may have direct or indirect effects on the physical, chemical, and biotic environment.

Action Area (Section 4): We describe the action area with the spatial extent of those stressors.

Potential Stressors (Section 5): We identify the stressors that could occur as a result of the proposed action and affect ESA-listed species and designated critical habitat.

Species and Critical Habitat Not Likely to be Adversely Affected (Section 6): We identify the ESA-listed species and designated critical habitat that are not likely to be adversely affected by the stressors produced by the proposed action.

Species Likely to be Adversely Affected (Section 7): During the ESA section 7 consultation process, we identify the ESA-listed species and designated critical habitat that are likely to co-occur with the stressors produced by the proposed action in space and time and evaluate the status of those species and habitat.

Status of Species Likely to be Adversely Affected (Section 8): We examine the species that may be adversely affected by the proposed action. We evaluate the status of ESA-listed species rangewide.

*Environmental Baseline (*Section 9): We describe the environmental baseline in the action area including: past and present impacts of federal, state, or private actions and other human activities in the action area; anticipated impacts of proposed federal projects that have already undergone formal or early section 7 consultation, and impacts of state or private actions that are contemporaneous with the consultation in process.

Effects of the Action (Section 10): We identify the number, age (or life stage), and gender of ESA-listed individuals that are likely to be exposed to the stressors and the populations or sub-populations to which those individuals belong. We also consider whether the action "may affect" designated critical habitat. This is our exposure analysis. We evaluate the available evidence to determine how individuals of those ESA-listed species are likely to respond given their probable exposure. This is our response analysis. We assess the consequences of these responses of individuals that are likely to be exposed to the populations those individuals represent, and the species those populations comprise. This is our risk analysis.

Integration and Synthesis (Section 11): In this section, we integrate the analyses in the opinion to summarize the consequences to ESA-listed species and designated critical habitat under NMFS' jurisdiction.

Cumulative Effects (Section 12): Cumulative effects are the effects to ESA-listed species and designated critical habitat of future state or private activities that are reasonably certain to occur within the action area (50 C.F.R. §402.02). Effects from future Federal actions that are unrelated to the proposed action are not considered because they require separate ESA section 7 compliance.

Conclusion (Section 13): With full consideration of the status of the species and the designated critical habitat, we consider the effects of the action within the action area on populations or subpopulations and on essential features of designated critical habitat when added to the environmental baseline and the cumulative effects to determine whether the action could reasonably be expected to:

- Reduce appreciably the likelihood of survival and recovery of ESA-listed species in the wild by reducing its numbers, reproduction, or distribution, and state our conclusion as to whether the action is likely to jeopardize the continued existence of such species; or
- Appreciably diminish the value of designated critical habitat for the conservation of an ESA-listed species, and state our conclusion as to whether the action is likely to destroy or adversely modify designated critical habitat.

If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of ESA-listed species or destroy or adversely modify designated critical habitat, then we must identify reasonable and prudent alternative(s) to the action, if any, or indicate that to the best of our knowledge there are no reasonable and prudent alternatives (50 C.F.R. §402.14).

In addition, we include an incidental take statement (Section 14) that specifies the impact of the take, reasonable and prudent measures to minimize the impact of the take, and terms and conditions to implement the reasonable and prudent measures. ESA section 7 (b)(4); 50 C.F.R. §402.14(i). We also provide discretionary conservation recommendations that may be implemented by the action agency (Section 15) (50 C.F.R. §402.14(j)). Finally, we identify the circumstances in which reinitiation of consultation is required (Section 16) (50 C.F.R. §402.16).

To comply with our obligation to use the best scientific and commercial data available, we collected information identified through searches of *Google Scholar*, and literature cited sections of peer reviewed articles, species listing documentation, and reports published by government and private entities. This opinion is based on our review and analysis of various information sources, including:

- Information submitted by the National Science Foundation, Lamont-Doherty Earth Observatory of Columbia University, and NMFS Permits and Conservation Division;
- Government reports (including NMFS biological opinions and stock assessment reports);
- National Oceanic and Atmospheric Administration (NOAA) technical memorandums;
- Monitoring reports; and
- Peer-reviewed scientific literature.

These resources were used to identify information relevant to the potential stressors and responses of ESA-listed species and designated critical habitat under NMFS' jurisdiction that may be affected by the proposed action to draw conclusions on risks the action may pose to the continued existence of these species and the value of designated critical habitat for the conservation of ESA-listed species.

3 Description of the Proposed Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies.

Two federal actions were evaluated during consultation. The first proposed action for this consultation is the National Science Foundation's proposal to fund researchers from the University of Houston to conduct a low-energy marine seismic survey on the R/V *Thompson* in the South Atlantic Ocean from November to December 2019. The R/V *Thompson* is managed by the University of Washington under a charter agreement with the U.S. Office of Naval Research and will use a portable multi-channel seismic system operated by marine technicians from Scripps Institution of Oceanography. The second proposed action for this consultation is NMFS Permits and Conservation Division's issuance of a proposed incidental harassment authorization authorizing non-lethal "takes" by MMPA Level B harassment (ESA harassment and harm) pursuant to section 101(a)(5)(D) of the MMPA for the National Science Foundation's low-energy marine seismic survey in the South Atlantic Ocean from November to December 2019.

The proposed action includes a two-dimensional seismic survey in International Waters outside of the U.S. Exclusive Economic Zone. The National Science Foundation, as the research funding and action agency, has a mission to "promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense…". The proposed seismic survey will collect data in support of a research proposal that has been reviewed under the National Science Foundation merit review process and identified as a National Science Foundation program priority. It will strive to understand the volcanic and tectonic development of the Walvis Ridge and Rio Grande Rise formed at the Mid-Atlantic Ridge in the South Atlantic Ocean.

The information presented here is based primarily on the draft environmental analysis, incidental harassment authorization application, and *Federal Register* notice of the proposed incidental harassment authorization provided by the National Science Foundation and NMFS Permits and Conservation Division as part of their initiation packages.

3.1 National Science Foundation's and Scripps Institution of Oceanography's Proposed Activities

The National Science Foundation proposes to fund and conduct a seismic survey in the South Atlantic Ocean on the R/V *Thompson*. An airgun array, multi-beam echosounder and sub-bottom profiler will be deployed as an energy source.

3.1.1 Seismic Survey Overview and Objectives

The National Science Foundation was established by Congress with the National Science Foundation Act of 1950 (Public Law 810507, as amended) and is the only federal agency dedicated to the support of fundamental research and education in all scientific and engineering disciplines. The National Science Foundation has a continuing need to fund seismic surveys that enable scientists to collect data essential to understanding the complex Earth processes beneath the ocean floor.

The goal of the proposed project is to understand the volcanic and tectonic development of the Walvis Ridge and Rio Grande Rise, which are two large igneous provinces thought to have formed together at the Mid-Atlantic Ridge during the Late Cretaceous period. Multi-channel seismic profiling would occur over a rift in Rio Grande Rise and at several sites over Walvis Ridge, to image the sedimentary column and upper igneous basement. Most data would be collected over a feature called Valdivia Bank, an oceanic plateau feature in eastern the Walvis Ridge. Data collected would also be used to inform potential future site locations for International Ocean Discovery Program Expedition 391 (which is not part of the Proposed Action and will undergo separate environmental review). The Proposed Action has implications for addressing important societally relevant questions on ocean basin development and earthquake hazards. In addition to providing a critical data set for the potential future International Ocean Discovery Program project and the volcanic and tectonic development, the low-energy seismic activities during the study would support National Science Foundation's need to foster a better understanding of Earth processes. The Proposed Action has been identified as a National Science Foundation program priority.

Researchers from the University of Houston propose to conduct low-energy seismic surveys to understand the volcanic and tectonic development of the Walvis Ridge and Rio Grande Rise in the South Atlantic Ocean. The majority of the study would take place on R/V *Thompson* in the Southeast Atlantic Ocean; however, one proposed survey area is located in offshore waters of the Southwest Atlantic Ocean (See Figure 1). To achieve the program's goals, the Principal

Investigators, Drs. W.W. Sager and H.-W. Zhou, propose to collect low-energy, high-resolution multi-channel seismic profiles. The seismic survey would commence by likely departing from Montevideo, Uruguay, on or about November 3, 2019, and would arrive in Walvis Bay, Namibia, on or about December 5, 2019. If the arrival port is Cape Town instead of Walvis Bay, an additional two days would be required for transit. Some deviation in timing could also result from unforeseen events such as weather or logistical issues. Seismic operations would occur for approximately 14 days; 16 days are allotted to transit to and from the project area and between survey areas, and equipment deployment and recovery is expected to take approximately three days.

The procedures proposed to be used for the seismic surveys would be similar to those used during previous National Science Foundation-funded research seismic surveys and would use conventional seismic methodology. As previously stated, the surveys would involve one source vessel, the R/V *Thompson* which is operated by the University of Washington under a charter agreement with the U.S. Office of Naval Research. During the proposed survey, marine technicians from Scripps Institution of Oceanography would deploy from up to two 45 cubic inch (in^3) generator-injector (GI) airguns as an energy source with a maximum volume of approximately 90 in^3. The receiving system would consist of one hydrophone streamer, 200 to 1600 meters in length. 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 multi-channel seismic surveys within five areas to improve our understanding of volcanic and tectonic development of the oceanic ridges and to enable the selection and analysis of potential future International Ocean Discovery Program drill-sites. Two types of surveys would be implemented with the airgun array operated in different modes:

(1) High-Quality Surveys: This type of survey will be used to collect the highest-quality seismic reflection data. Two GI airguns would be deployed with the ship travelling at 5 knots; and a 400, 800, or 1600 meter steamer would be used to collect reflected seismic energy. The two GI airguns would be spaced two meters apart. Approximately ten days or 70 percent of survey effort would occur at a speed of 5 knots.

(2) Reconnaissance Surveys: This type of survey will be used to collect reconnaissance seismic reflection data or when weather is too poor to safely use a ≥400-meter steamer, one or two GI airguns would be deployed with the ship travelling at eight knots and a 200-meter steamer would be used to collect reflected seismic energy. If two GI airguns are deployed, they would be towed 8 meters apart. Approximately 4 days or 30 percent of survey effort would occur at a speed of 8 knots.

Reconnaissance Surveys are planned for three survey areas (Gough, Tristan, Central) and High-Quality Surveys are planned to take place along the proposed seismic transect lines in the main survey area (Valdivia Bank) and the Libra Massif survey area (See Figure 1). However, Reconnaissance Surveys may replace High-Quality Surveys depending on weather conditions and timing (e.g., ten percent of survey effort at Valdivia Bank is expected to consist of Reconnaissance Surveys). Reconnaissance Survey operations are quicker and less impacted by adverse weather conditions, while the High-Quality Survey operations yield more resolved imagery and sediment velocity values. Seismic data would be collected first as a single profile over the rift in Libra Massif, the most southeastern edifice of Rio Grande Rise. After crossing the Atlantic, data would be collected over three seamounts (Gough, Tristan, Central) in the "Guyot Province" of Walvis Ridge. Approximately 24 hours of seismic profiling is proposed at each location, before moving on to the Valdivia Bank survey area, where most survey effort (75 percent) would occur.

At the proposed survey areas, approximately 2715 kilometers of seismic data would be collected. Although representative lines for the proposed South Atlantic survey areas are depicted in Figure 1, the line locations for all survey areas are preliminary and could be refined in light of information from data collected during the study. All data acquisition in the Tristan survey area would occur in water >1000 meters deep; all other survey areas have effort in intermediate (100 to 1000 meters) and deep (>1000 meters) water. Most of the survey effort (97 percent) would occur in water >1000 meters 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 shutdown or track deviation in compliance with IHA requirements. Due to this, the National Science Foundation increased its number of operation days by 25 percent in its exposure analysis (See Section 10).

A hull-mounted multibeam echosounder and a sub-bottom profiler would also be operated from the R/V *Thompson* continuously throughout the seismic survey, but not during transits to and from the project area. All planned data acquisition and sampling activities would be conducted by Scripps Institution of Oceanography and the University of Washington 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.

3.1.2 Source Vessel Specifications

The R/V *Thompson* is owned by the Office of Naval Research and is operated under a Charter Party agreement by the School of Oceanography at the University of Washington as part of the University National Oceanographic Laboratories System. The R/V *Thompson* has a length of 83.5 meters, a beam of 16 meters, and a full load draft of 5.8 meters. It is equipped with twin 360 degree azimuth stern thrusters each powered by 3000 horsepower direct current (DC) motors and a water-jet bow thruster powered by a 1100 horsepower DC motor. The motors are driven by three 2250 horsepower, 1500 kilowatt main propulsion generators. An operation speed of 9 to 15 kilometers per hour (approximately five to eight knots) would be used during seismic acquisition. When not towing seismic survey gear, the R/V *Thompson* cruises at 22 kilometers per hour (12 knots) and has a maximum speed of 26.9 kilometers per hour (14.5 knots). It has a normal operating range of approximately 24,400 kilometers.

The R/V *Thompson* would also serve as the platform from which vessel-based protected species visual observers would watch for marine species before and during airgun operations. Other details of the R/V *Thompson* are listed in Table 1 below.

Table 1. R/V Thomas Vessel Specifications

Vessel Owner	U.S. Navy
Operator	University of Washington
Flag	United States of America
Launch Date	July 8, 1991
Gross Tonnage	3250 Long Tons
Compressors for Airguns	3 x Stark Industries D-100, 100 Standard cubic feet per minute (SCFM) at 2000 pounds per square inch (psi)
Accommodation Capacity	60 including 36 scientists

3.1.3 Description of Airgun Array and Acoustic Receiver

The R/V *Thompson* is proposed to 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 meters behind the R/V *Thompson*, two-meters (during five knot High-Quality Surveys) or eight meter (eight knot Reconnaissance Surveys) apart, side by side, at a depth of two to four meters. High-Quality Surveys with the two-meter airgun separation configuration would use a streamer up to 1600 meters long, whereas the Reconnaissance Surveys with the eight-meter airgun separation configuration would use a 200-meter streamer. Seismic pulses would be emitted at intervals of 25 meters for the High-Quality Surveys using the two-meter GI airgun separation and at 50 meters for the Reconnaissance Surveys using the eight-meter airgun separation.

Table 2. Specifications of the source airgun array to be used by the R/V Thompson during the proposed seismic survey in the South Atlantic Ocean.

Source Airgun Array Specifications	
Energy Source – Number of Airguns	Two GI guns of 45 in^3
Source Output (Downward) of 18 and 36 Airgun Array	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)
Tow Depth	2–4 m

Air Discharge Volume of 18 and 36 Airgun Array	Approximately 90 in^3
Dominant Frequency Components	0–188 Hz
Pulse Duration	32 milliseconds
Shot Interval	High-Quality Survey: 25 meters (9.7192 seconds) Reconnaissance: 50 meters (12.149 seconds)

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 (approximately 20 degrees) when a short streamer is towed compared with a turning rate of approximately five degrees when a longer streamer (1600 meter) is towed. Thus, the maneuverability of the vessel would be limited during operations.

The source levels were 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 meter 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 one meter 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 literature and thus would be for an airgun-type source. A measured received sound pressure level (SPL) of 160 dB re 1 μPa_{rms} in the far field would typically correspond to approximately 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 (McCauley et al. 1998b; McCauley et al. 2000d). 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.

3.1.4 Multibeam Echosounder and Sub-bottom Profiler

Along with the airgun operations, two additional acoustical data acquisition systems would be operated during the seismic survey. The ocean floor would be mapped with the Kongsberg EM300 multi-beam echosounder and a Knudsen 3260 sub-bottom profiler. The multi-beam

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

echosounder and sub-bottom profiler sound sources will operate simultaneously with the airgun array, but not during transit to and from the seismic survey area.

3.1.4.1 Multi-Beam Echosounder

The ocean floor would be mapped with the Kongsberg EM 302 multibeam echosounder. The EM 302 nominal sonar frequency is 30 kilohertz with an angular coverage sector of up to 140 degrees and 864 soundings per ping. The achievable swath width on a flat bottom would normally be up to six times the water depth and the transmitting beam width is one degree fore-aft. The maximum sound source level is 214 dB re: 1µPa . Maximum intensity is encountered in a thin wedge extending below the ship with an angular coverage of about 140 degrees (intensity decreases from nadir). For shallow waters a pulse length of 0.7 milliseconds is used, for intermediate waters a pulse length of two milliseconds is used, and the normal pulse length for waters deeper than about 1000 meters is five milliseconds

3.1.4.2 Sub-bottom Profiler

The ocean floor will also be mapped with the Knudsen 3260 sub-bottom profiler. The sub-bottom profiler is normally operated to provide information about the near sea floor sedimentary features and the bottom topography that is mapped simultaneously by the multi-beam echosounder. The beam is transmitted as a 27-degree cone, which is directed downward by a 3.5-kilohertz transducer in the hull of the R/V *Thompson*. The nominal power output is 10 kilowatts, but the actual maximum radiated power is 3 kilowatts or 222 dB re: 1 µPa at 1 meter (rms). The ping duration is up to 64 milliseconds, and the ping interval is one second. A common mode of operation is to broadcast five pulses at one-second intervals followed by a five-second pause. The sub-bottom profiler is capable of reaching depths of 10,000 meters (32,808.4 feet).

3.1.5 Mitigation and Monitoring

The National Science Foundation and Scripps Institution of Oceanography are obligated to enact mitigation measures to have their action result in the least practicable adverse impact on marine mammal species or stocks and to reduce or avoid the likelihood of adverse effects to ESA-listed marine species or adverse effects on their designated critical habitats. Monitoring is used to observe or check the progress of the mitigation over time and to ensure that any mitigation measures implemented to reduce or avoid adverse effects on ESA-listed species are successful.

NMFS Permits and Conservation Division and ESA Interagency Conservation Division will require mitigation and monitoring measures that the National Science Foundation and Scripps Institution of Oceanography will implement. These mitigation and monitoring measures are listed below. These mitigation and monitoring measures are required during the seismic survey to reduce potential for injury or harassment to MMPA and ESA protected marine mammals. Additional detail for each mitigation and monitoring measure is described in subsequent sections of this opinion:

- Proposed exclusion and buffer zones;

- Power-down procedures;
- Shutdown procedures;
- Ramp-up procedures;
- Visual monitoring by NMFS-approved protected species observers;
- Vessel strike avoidance measures; and
- Additional mitigation measures considered.

We discuss the proposed exclusion and buffer zones in more detail in the next section (see below). Additional details for the other mitigation and monitoring measures (e.g., power-down, shutdown, and ramp-up procedures can be found in the NMFS Permits and Conservation Division *Federal Register* notice of proposed incidental harassment authorization and request for comments on proposed incidental authorization and possible renewal (84 FR 51886 to 51928) and Appendix A (Section 18.1).

3.1.5.1 Proposed Exclusion and Buffer Zones-Ensonified Area

The NMFS Permits and Conservation Division will require, and the National Science Foundation and Scripps Institution of Oceanography will implement exclusion zones around the R/V *Thompson* to minimize any potential adverse effects of sound from the airgun array on MMPA and ESA-listed species. The exclusion zones are areas within which occurrence of a marine mammal or sea turtles triggers a power-down or shutdown of the airgun array, to reduce exposure of marine mammals and sea turtles to sound levels expected to have adverse effects on the species and habitats. These exclusion zones are based upon modeled sound levels at various distances from the R/V *Thompson*, and correspond to the respective species sound threshold that corresponds with ESA harm (e.g., injury) and harassment.

Ensonified Area

Direct acoustic measurements have not been reported for the two 45 in^3 GI airgun array that will be used during the proposed survey. Due to this, Lamont-Doherty Earth Observatory's acoustic model results was used to determine the 160 dB re: 1 μPa (rms) and 175 dB re: 1 μPa (rms)[2] radius for the two 45 in^3 GI airgun array in deep water (>1000 meters) down to a maximum water depth of 2000 meters. The radii for intermediate water depths (100–1000 meters) were derived from the deep-water ones by applying a correction factor of 1.5. Received sound levels were predicted by Lamont-Doherty Earth Observatory's model (Diebold et al. 2010), which uses ray tracing for the direct wave traveling from the airgun array to the receiver and its associated source ghost (i.e., reflection at the air-water interface in the vicinity of the airgun array), in a constant-velocity half-space (infinite homogeneous ocean layer, unbounded by a seafloor). In 2003, empirical data concerning 190, 180, and 160 dB re: 1 μPa (rms) distances were acquired

[2] 160 dB re: 1 μPa (rms) is the MMPA Level B behavioral harassment threshold and 175 dB re: 1 μPa (rms) sea turtle behavioral harassment threshold based on U.S. Navy, 2017. Criteria and thresholds for U.S. Navy acoustic and explosive effects analysis (Phase III). In: Technical Report. Space and Naval Warfare Systems Command, U.S Navy, Department of Defence, San Diego, California..

during the acoustic calibration study of the R/V *Maurice Ewing*'s airgun array in a variety of configurations in the northern Gulf of Mexico (Tolstoy 2004). In addition, propagation measurements of pulses from the R/V *Marcus G. Langseth*'s 36 airgun array at a tow depth of 6 meters (19.7 feet) have been reported in deep water (approximately 1,600 meters [5,249.3 feet]), intermediate water depth on the slope (approximately 600 to 1,100 meters [1,968.5 to 3,608.9 feet]), and shallow water (approximately 50 meters [164 feet]) in the Gulf of Mexico in 2007 through 2008 (Tolstoy et al. 2009; Diebold et al. 2010). Results of the propagation measurements (Tolstoy et al. 2009) showed that radii around the airguns for various received levels varied with water depth. However, the depth of the airgun array was different in the Gulf of Mexico calibration study 6 meters [19.7 feet]) from in the proposed seismic survey activities (10 to 12 meters [32.8 to 39.4 feet]). Because propagation varies with airgun array depth, correction factors have been applied to the distances reported by Tolstoy et al. (2009).

Predicted distances to ESA harm (MMPA Level A harassment) isopleths, which vary based on marine mammal hearing groups, were calculated based on modeling performed by Lamont-Doherty Earth Observatory using the NUCLEUS software program and the NMFS User Spreadsheet (https://www.fisheries.noaa.gov/action/user-manual-optional-spreadsheet-tool-2018-acoustic-technical-guidance). Distances for ESA harm (MMPA Level A harassment) and ESA harassment of cetaceans (MMPA Level B harassment) and sea turtles are presented in Table 5, Table 10, and Table 11. In addition, a detailed description for why MMPA thresholds were used for ESA harm and harassment of marine mammals is presented in Section 10.3.

Establishment of Proposed Exclusion and Buffer Zones

As previously stated, the National Science Foundation and Scripps Institution of Oceanography's proposed action and NMFS Permits and Conservation Division's proposed incidental harassment authorization requires monitoring and mitigation measures that includes the use of proposed exclusion and buffer zones, power-down procedures, shutdown procedures, ramp-up procedures, visual monitoring with NMFS-approved protected species observers, vessel strike avoidance measures, and additional mitigation measures considered in the presence of ESA-listed cetaceans to minimize or avoid exposure. The NMFS-approved protected species observers will use a 100 meter (328 foot) exclusion zone for marine mammals. If marine mammals are detected in or about to enter the exclusion zone, the airgun array will be shutdown (i.e., shut off) immediately. An additional measure extends the exclusion zone to a 500 meter (1,640 feet) zone for southern right whales and aggregations of six or more large whales. The NMFS Permits and Conservation Division's proposed incidental harassment authorization contains additional mitigation measures (including ramp-up procedures) to minimize or avoid exposure that are described in Appendix A (see Section 18).

3.2 National Marine Fisheries Service's Proposed Activities

The National Science Foundation and Lamont-Doherty Earth Observatory's requested authorization from the NMFS Permits and Conservation Division to take a small number of 48 marine mammal species by MMPA Level B harassment. Neither the National Science

Foundation, Scripps Institution of Oceanography, nor NMFS Permits and Conservation Division expects serious injury or mortality to result from the proposed activities, therefore, the NMFS permits and Conservation Division proposes to issue an incidental harassment authorization for the proposed action. The incidental harassment authorization will be valid for a period of one year from the date of issuance. The NMFS Permits and Conservation Division proposes to issue the incidental harassment authorization on or before November 3, 2019, so that the National Science Foundation and Scripps Institution of Oceanography will have the incidental harassment authorization prior to the start of the proposed seismic survey activities.

On September 30, 2019, NMFS Permits and Conservation published a notice of a proposed incidental harassment authorization and request for comments on a proposed incidental harassment authorization and possible renewal in the *Federal Register* (84 FR 51886 to 51928). The public comment period will close on October, 30 2019. Appendix A (see Section 18) contains the proposed incidental harassment authorization. The text in Appendix A was taken directly from the proposed incidental harassment authorization provided to us in the consultation initiation package.

The incidental harassment authorization will authorize the incidental harassment of the following threatened and endangered species: southern right whale (*Eubalaena australis*), blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), sei whale (*Balaenoptera borealis*), and sperm whale (*Physeter macrocephalus*). The proposed incidental harassment authorization identifies requirements that the National Science Foundation must comply with as part of its authorization. The NMFS Permits and Conservation Division does not expect the National Science Foundation-funded seismic survey to exceed one year and do not expect subsequent MMPA incidental harassment authorizations will be issued for this particular specified activity. Nevertheless, NMFS Permits and Conservation Division recognizes that delays to the activity have the potential to occur and as a result, may issue a one-year renewal to the incidental harassment authorization. This is discussed below.

On a case-by-case basis, NMFS Permits and Conservation Division may issue a one-year incidental harassment authorization renewal with an expedited 15-day public comment period when (1) another year of identical or nearly identical activities is planned or (2) the activities will not be completed by the time the incidental harassment authorization expires and a second incident harassment authorization will allow for completion of the activities beyond the original dates and duration, provided all of the following conditions are met:

- A request for renewal is received no later than 60 days prior to expiration of the current incidental harassment authorization;
- The request for renewal must include the following: (1) an explanation that the activities to be conducted under the proposed renewal are identical to the activities analyzed under the initial incidental harassment authorization, are a subset of the activities, or include changes so minor (e.g., reduction in pile size) that changes do not affect the previous analyses, mitigation and monitoring requirements, or take estimates (with the exception

of reducing the type or amount of take because only a subset of the initially analyzed activities remain to be completed under the renewal); and (2) a preliminary monitoring report showing the results of the required monitoring to date and an explanation showing that the monitoring results do not indicate impacts of a scale or nature not previously analyzed or authorized.

- Upon review of the request for renewal, the status of the affected species or stocks, and any other pertinent information, NMFS Permits and Conservation Division determines that there are not more than minor changes in the activities, the mitigation and monitoring measures will remain the same and appropriate, and the findings in the initial incidental harassment authorization remain valid.

4 ACTION AREA

Action area means all areas affected directly, or indirectly, by the Federal action, and not just the immediate area involved in the action (50 C.F.R. §402.02).

As stated in Section 3.1.1, the R/V *Thompson* would likely depart from Buenos Aires, Argentina on or about November 5, 2019 and would arrive in Walvis Bay, Namibia, on or about December 7, 2019. If the arrival port is Cape Town instead of Walvis Bay, an additional two days would be required for transit. During the seismic survey, the majority of the proposed action will take place in the Southeast Atlantic Ocean between approximately 33.2 degrees to 21 degrees south and one degree west to eight degrees east (see Figure 1). A small survey area is proposed for the Southwest Atlantic Ocean between approximately 33.2 degrees to 34.3 degrees south and 30.8 degrees to 31.8 degrees west (see Figure 1). Seismic acquisition would occur in five survey areas including Libra Massif in the Southwest Atlantic and Valdivia Bank, Gough, Tristan, and Central survey areas in the Southeast Atlantic; representative survey tracklines are shown in Figure 1. However, some deviation in actual tracklines 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 seismic surveys would be conducted in International Waters ranging in depth from approximately 500 to 5700 meters.

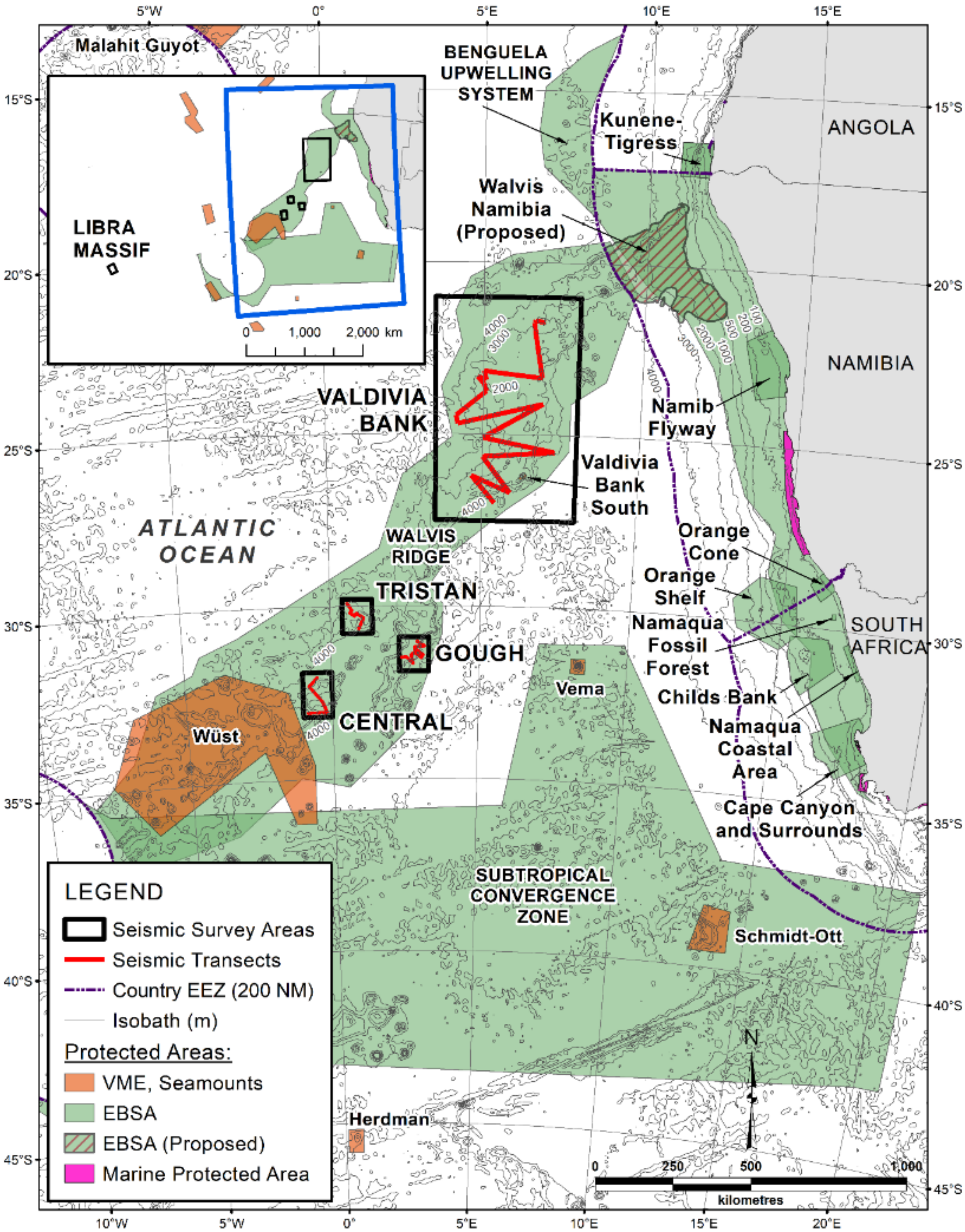

Figure 1. Survey areas for the proposed low-energy seismic surveys in the South Atlantic Ocean, November–December 2019, Vulnerable Marine Ecosystem (VME) Closed Areas, Ecologically or Biologically Sensitive Marine Areas (EBSAs), and Marine Protected Areas.

5 POTENTIAL STRESSORS

The proposed action involves multiple activities, each of which can create stressors. Stressors are any physical, chemical, or biological entity that may directly or indirectly induce a response either in an ESA-listed species or their designated critical habitat. During consultation, we deconstructed the proposed action to identify stressors that are reasonably certain to result from the proposed activities. These can be categorized as pollution (e.g., fuel, oil, trash), vessel strikes, acoustic and visual disturbance (research vessel, multi-beam echosounder, sub-bottom profiler, and seismic airgun array), and entanglement in towed seismic equipment (hydrophone streamers). Below we provide detailed information on the effects of these potential stressors. Furthermore, the proposed action includes several mitigation measures described in Section 3.1.5 that are designed to minimize effects that may result from these potential stressors. While we consider all of these measures important and expect them to be effective in minimizing the effects of potential stressors, they do not completely eliminate the identified stressors. Nevertheless, we treat them as part of the proposed action and fully consider them when evaluating the effects of the proposed action (Section 3.1). Table 3 depicts our effects analysis by stressor for each ESA-listed species considered in this consultation.

Table 3. ESA-listed species that may be affected by the proposed action and effects determination by stressor for ESA-listed species expected to be encountered during the proposed surveys in the South Atlantic Ocean during September to October 2019.

ESA-listed Species in the action area	Overall Determination	Potential Stressors					
		Pollution	Vessel Strike	Vessel noise, visual disturbance	Acoustic Sources		Gear Entanglement
					Echosounder, Sub Bottom profiler	Seismic airguns	
Cetaceans							
Blue Whale	LAA	*NLAA*	*NLAA*	*NLAA*	*NLAA*	LAA	*NLAA*
Fin Whale	LAA	*NLAA*	*NLAA*	*NLAA*	*NLAA*	LAA	*NLAA*
Sei Whale	LAA	*NLAA*	*NLAA*	*NLAA*	*NLAA*	LAA	*NLAA*
Southern Right Whale	LAA	*NLAA*	*NLAA*	*NLAA*	*NLAA*	LAA	*NLAA*
Sperm Whale	LAA	*NLAA*	*NLAA*	*NLAA*	*NLAA*	LAA	*NLAA*
Sea Turtles							
Leatherback Sea Turtle	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*

South Atlantic DPS of Green Sea Turtle	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*
South Atlantic Ocean DPS of Loggerhead Sea Turtle	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*
Hawksbill Sea Turtle	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*
Olive Ridley Sea Turtle	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*
Fishes (Elasmobranchs)							
Scalloped Hammerhead	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*
Oceanic Whitetip Shark	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*
Giant Manta Ray	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*	*NLAA*

NLAA – Not likely to adversely affect; LAA – Likely to adversely affect; DPS – Distinct Population Segment

5.1 Pollution

The operation of the R/V *Thompson* as a result of the proposed action may result in pollution from exhaust, fuel, oil, trash, and other debris. Air and water quality are the basis of a healthy environment for all species. Emissions pollute the air, which could be harmful to air-breathing organisms and lead to ocean pollution (Duce et al. 1991; Chance et al. 2015). Emissions also cause increased greenhouse gases (carbon dioxide, methane, nitrous oxide, and other fluorinated gases) that can deplete the ozone, affect natural earth cycles, and ultimately contribute to climate change (see https://www.epa.gov/ghgemissions/overview-greenhouse-gases for additional information). The release of marine debris such as paper, plastic, wood, glass, and metal associated with vessel operations can also have adverse effects on marine species most commonly through entanglement or ingestion (Gall and Thompson 2015). While lethal and non-lethal effects to air breathing marine animals such sea turtles, birds, and marine mammals are well documented, marine debris also adversely affects marine fish (Gall and Thompson 2015).

The National Science Foundation proposes to include guidance on the handling and disposal of marine trash and debris during the seismic survey. While this is expected to reduce the amount of pollution that may result from the proposed action, pollution remains a potential stressor.

The research vessel used during the National Science Foundation-funded seismic survey has spill-prevention plans, which will allow a rapid response to a spill in the event one occurred. The potential of pollution from fuel or oil leakages is extremely unlikely. An oil or fuel leak will likely pose a significant risk to the research vessel and its crew and actions to correct a leak should occur immediately to the fullest extent possible. In the event that a leak should occur, the amount of fuel or oil onboard the R/V *Thompson* is unlikely to cause widespread, high-dose contamination (excluding the remote possibility of severe damage to the research vessel) that will impact ESA-listed species directly or pose hazards to their food sources.

5.2 Vessel Strikes

Seismic surveys necessarily involve vessel traffic within the marine environment, and the transit of any research vessel in waters inhabited by ESA-listed species carries the risk of a vessel strike. Vessel strikes are known to adversely affect ESA-listed marine mammals, sea turtles, and fishes (Laist et al. 2001; NMFS and USFWS 2008; Brown and Murphy 2010; Work et al. 2010). The probability of a vessel collision depends on the number, size, and speed of vessels, as well as the distribution, abundance, and behavior of the species (Laist et al. 2001; Jensen and Silber 2004; Hazel et al. 2007; Vanderlaan and Taggart 2007; Conn and Silber 2013b). If an animal is struck by a research vessel, it may experience minor, non-lethal injuries, serious injuries, or death.

Vessel traffic associated with the proposed action carries the risk of vessel strikes of ESA-listed species. In general, the probability of a vessel collision and the associated response depends, in part, on size and speed of the vessel. The R/V *Thompson* has a length of 83.5 meters (274 feet) and the operating speed during seismic data acquisition is typically approximately 9.3 to 14.8 kilometers per hour (five to eight knots). When not towing seismic survey gear, the R/V *Thompson* typically transits at 22 kilometers per hour (12 knots).

Several conservation measures proposed by the NMFS Permits and Conservation Division and/or National Science Foundation and Scripps Institution of Oceanography will minimize the risk of vessel strikes (i.e. the use of visual observers). In addition, the overall level of vessel activity associated with the proposed action is low relative to the large size of the action area, further reducing the likelihood of a vessel strike of an ESA-listed species. Nevertheless, vessel strikes remain a potential stressor associated with the proposed action.

5.3 Acoustic Noise from Airgun Array, Vessel Noise, and Visual Disturbance

The proposed action will produce a variety of different sounds including those associated with vessel operations, multi-beam echosounders, sub-bottom profilers, and airgun arrays that may produce an acoustic disturbance or otherwise affect ESA-listed species. It will also involve the presence of vessels (and associated equipment) that produce a visual disturbance that may affect ESA-listed marine mammals, sea turtles, and fishes.

The research vessel associated with the proposed action may cause visual or auditory disturbances to ESA-listed species that spend time near the surface, such as marine mammals, sea turtles, and fishes, which may generally disrupt their behavior. Studies have shown that vessel operations can result in changes in the behavior of marine mammals, sea turtles, and fishes (Patenaude et al. 2002; Richter et al. 2003; Hazel et al. 2007; Smultea et al. 2008; Holt et al. 2009; Luksenburg and Parsons 2009; Noren et al. 2009). In many cases, particularly when responses are observed at great distances, it is thought that animals are likely responding to sound more than the visual presence of vessels (Evans et al. 1992; Blane and Jaakson 1994a;

Evans et al. 1994). Nonetheless, it is generally not possible to distinguish responses to the visual presences of vessels from those to the sounds associated with those vessels. Moreover, at close distances animals may not even differentiate between visual and acoustic disturbances created by vessels and simply respond to the combined disturbance.

Unlike vessels, which produce sound as a byproduct of their operations, multi-beam echosounders, sub-bottom profilers, and airgun arrays are designed to actively produce sound, and as such, the characteristics of these sound sources are deliberate and under control. Assessing whether these sounds may adversely affect ESA-listed species involves understanding the characteristics of the acoustic sources, the species that may be present near the sound, and the effects that sound may have on the physiology and behavior of those species. Although it is known that sound is important for marine mammal communication, navigation, and foraging (NRC 2003b; NRC 2005), there are many unknowns in assessing impacts of sound, such as the potential interaction of different effects and the significance of responses by marine mammals to sound exposures (Nowacek et al. 2007; Southall et al. 2007). For other ESA-listed species such as sea turtles and fishes effects from anthropogenic sound are much less is known and are difficult to assess (Popper et al. 2014; Nelms et al. 2016). Nonetheless, depending on the circumstances, exposure to anthropogenic sounds may result in auditory injury, changes in hearing ability, masking of important sounds, behavioral responses, as well as other physical and physiological responses.

Several of the mitigation measures associated with the proposed action such as ramp-up and shutdown procedures associated with the seismic survey protocols are specifically designed to minimize effects that may result from active acoustic sources used during the seismic survey activities (i.e., sounds from the seismic airgun array). In addition, while not specifically designed to do so, several aspects of the proposed vessel strike avoidance measures will minimize effects on species associated with vessel disturbance. However, even with these mitigation measures, visual and acoustic disturbances are considered a potential stressor.

The research vessel may cause auditory disturbance to ESA-listed marine mammals, sea turtles, and fishes, and more generally disrupt their behavior. In addition to the active sound sources mentioned above, we expect the R/V *Thompson* will add to the local noise environment in the action area due to the vessel's propulsion and other noise characteristics of the research vessel's machinery.

Sounds emitted by large vessels can be characterized as low-frequency, continuous, or tonal, and sound pressure levels at a source will vary according to speed, burden, capacity, and length (Richardson et al. 1995a; Kipple and Gabriele 2007; Mckenna et al. 2012). Source levels for 593 container ship transits were estimated from long-term acoustic recording received levels in the Santa Barbara shipping channel, and a simple transmission loss model using Automatic Identification System data for source-receiver range (McKenna et al. 2013). Vessel noise levels could vary five to ten decibels depending on transit conditions. Given the sound propagation of low frequency sounds, a large vessel in this sound range can be heard 139 to 463 kilometers

(75.1 to 250 nautical miles) away (Polefka 2004). Hatch et al. (2008) measured commercial ship underwater noise levels and reported average source level estimates (71 to 141 Hertz, re: 1 µPa [rms] ± standard error) for individual vessels ranged from 158 ± 2 dB (research vessel) to 186 ± 2 dB (oil tanker). McKenna et al (2012) in a study off Southern California documented different acoustic levels and spectral shapes observed from different modern vessel-types.

Very little research exists on sea turtle responses to vessel noise disturbance. Currently, there is nothing in the available literature specifically aimed at studying and quantifying sea turtle response to vessel noise. However, a study examining vessel strike risk to green sea turtles suggests that sea turtles may habituate to vessel sound and may be more likely to respond to the sight of a vessel rather than the sound of a vessel, although both may play a role in prompting reactions (Hazel et al. 2007). Regardless of the specific stressor associated with vessels to which sea turtles are responding, they only appear to show responses (i.e., avoidance behavior) at approximately 10 meters (32.8 feet) or closer (Hazel et al. 2007). Therefore, the noise from vessels is not likely to affect sea turtles from further distances, and disturbance may only occur if a sea turtle hears a vessel nearby or sees it as it approaches. These responses appear limited to non-injurious, minor changes in behavior based on the limited information available on sea turtle response to vessel noise.

All ESA-listed fish species considered in this opinion can detect vessel noise due to its low-frequency content and their hearing capabilities. Therefore, ESA-listed fishes could be exposed to a range of vessel noises, depending on the source and context of the exposure. Because of the characteristics of vessel noise, sound produced from seismic research vessels are unlikely to result in direct injury, hearing impairment, or other trauma to fishes. Moreover, in the near field, fish are likely able to detect water motion via their lateral line as well as visually locate an oncoming vessel. In these cases, most fishes located in close proximity that detect the vessel either visually, via sound and motion in the water would be capable of avoiding the vessel or move away from the area affected by vessel sound. Thus, fish are more likely to react to vessel noise at close range than to vessel noise emanating from a greater distance away. These reactions may include physiological stress responses, or avoidance behaviors.

5.4 Multi-Beam Echosounder and Sub-Bottom Profiler

The multi-beam echosounder and sub-bottom profiler are two active acoustic systems that will operate during the proposed seismic survey on the R/V *Thompson*. As described above in Section 3.1.4, a multi-beam echosounder and sub-bottom profiler would be operated continuously during the proposed surveys, but not during transit to and from the survey areas.

The multi-beam echosounder and sub-bottom profiler have the potential to expose ESA-species. The multi-beam echosounder and sub-bottom profiler operate at generally higher frequencies than airgun array operations (10 to 13.5 [usually 12] kilohertz for the multi-beam echosounder and 3.5 kilohertz for the sub-bottom profiler). As such, the frequencies from these devices will attenuate more rapidly than those from airgun array sound sources. For these reasons, ESA-listed species will likely experience higher levels of sound from the airgun array well before sounds of equal amplitude from the multi-beam echosounder and sub-bottom profiler since these other sound sources will drop off faster than the airgun arrays. In addition, the multi-beam echosounder and sub-bottom profiler are expected to affect a smaller ensonified area within the larger sound field produced by the airgun array and are not expected to be of sufficient duration that will lead to the onset of a temporary threshold shift (TTS) in hearing or permanent threshold shift (PTS) for an animal. Therefore, sounds from the airgun are expected to effectively cancel out sounds produced by the multi-beam each

Each ping emitted by the multi-beam echosounder consists of eight (in water >1,000 meters deep) or four (<1,000 meters) successive fan-shaped transmissions, each ensonifying a sector that extends 1degree fore–aft. Given the movement and speed of the vessel, the intermittent and narrow downward-directed nature of the sounds emitted by the multi-beam echosounder would result in no more than one or two brief ping exposures of any individual cetacean, if any exposure were to occur.

5.5 Gear Entanglement

The towed seismic equipment associated with the proposed seismic survey activities may pose a risk of entanglement to ESA-listed species. Entanglement can result in death or injury of marine mammals, sea turtles, and fishes (Moore et al. 2009b; Moore et al. 2009a; Deakos and H. 2011; Van Der Hoop et al. 2013a; Van der Hoop et al. 2013b; Duncan et al. 2017). Marine mammal, sea turtle, and fish entanglement, or bycatch, is a global problem that every year results in the death of hundreds of thousands of animals worldwide. Entangled marine mammals and sea turtles may drown or starve due to being restricted by gear, suffer physical trauma and systemic infections, and/or be hit by vessels due to an inability to avoid them. For smaller animals like sea turtles, death is usually quick, due to drowning. However, large whales can typically pull gear, or parts of it, off the ocean floor, and are generally not in immediate risk of drowning. Nonetheless, depending on the entanglement, towing gear for long periods may prevent a whale from being able to feed, migrate, or reproduce (Van der Hoop et al. 2017; Lysiak et al. 2018).

6 Species Not Likely to be Adversely Affected

This section identifies the ESA-listed species under NMFS jurisdiction that may occur within the action area (as described in Table 4 below) and may be affected, but are not likely to be adversely affected by the proposed action. NMFS uses two criteria to identify the ESA-listed species or designated critical habitat that are not likely to be adversely affected by the proposed action, as well as the effects of activities that are interrelated to or interdependent with the Federal agency’s proposed action. The first criterion is exposure, or some reasonable expectation of a co-occurrence, between one or more potential stressors associated with the proposed activities and ESA-listed species or designated critical habitat. If we conclude that an ESA-listed species is not likely to be exposed to the proposed activities, we must also conclude that the species is not likely to be adversely affected by those activities.

The second criterion is the probability of a response given exposure. ESA-listed species or designated critical habitat that are exposed to a potential stressor but is likely to be unaffected by the exposure is also not likely to be adversely affected by the proposed action. We applied these criteria to the ESA-listed species in Table 4 and we summarize our results below.

An action warrants a "may affect, not likely to adversely affect" finding when its effects are wholly *beneficial, insignificant* or *discountable*. *Beneficial* effects have an immediate positive effect without any adverse effects to the species or habitat. Beneficial effects are usually discussed when the project has a clear link to the ESA-listed species or its specific habitat needs and consultation is required because the species may be affected.

Insignificant effects relate to the size or severity of the impact and include those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. Insignificant is the appropriate effect conclusion when plausible effects are going to happen, but will not rise to the level of constituting an adverse effect. That means the ESA-listed species may be expected to be affected, but not harmed or harassed.

Discountable effects are those that are extremely unlikely to occur. For an effect to be discountable, there must be a plausible adverse effect (i.e., a credible effect that could result from the action and that would be an adverse effect if it did impact a listed species), but it is very unlikely to occur.

In this section, we evaluate effects to several ESA-listed species that may be affected, but are not likely to be adversely affected, by the proposed action. The species potentially occurring within the action area that may be affected, but are not likely to be adversely affected, are listed in Table 4, along with their regulatory status, designated critical habitat, and recovery plan.

Table 4. Endangered Species Act-listed threatened and endangered species potentially occurring in the action area that may be affected, but are not likely to be adversely affected.

Species	ESA Status	Critical Habitat	Recovery Plan
	Sea Turtles		
Green Sea Turtle (*Chelonia mydas*) – South Atlantic DPS	T – 81 FR 20057	-- --	-- --
Hawksbill Sea Turtle (*Eretmochelys imbricata)*	E – 35 FR 8491	63 FR 46693	57 FR 38818
Leatherback Sea Turtle (*Dermochelys coriacea*)	E – 35 FR 8491	44 FR 17710 and 77 FR 4170	10/1991 – U.S. Caribbean, Atlantic, and Gulf of Mexico 63 FR 28359 05/1998 – U.S. Pacific

Species	ESA Status	Critical Habitat	Recovery Plan
Loggerhead Sea Turtle (*Caretta caretta*) – South Atlantic Ocean DPS	T – 76 FR 58868	-- --	-- --
Olive Ridley Sea Turtle (*Lepidochelys olivacea*)	T – 43 FR 32800	-- --	-- --
Fishes			
Giant Manta Ray (*Manta birostris*)	T – 83 FR 2916	-- --	-- --
Oceanic Whitetip Shark (*Carcharhinus longimanus*)	T – 83 FR 4153	-- --	9/2018- Outline
Scalloped Hammerhead Shark (*Sphyrna lewini*) – Eastern Atlantic DPS	E – 79 FR 38213	-- --	-- --

6.1 Endangered Species Act-Listed Sea Turtles

ESA-listed sea turtles (South Atlantic DPS of green sea turtle, hawksbill sea turtle, leatherback sea turtle, South Atlantic Ocean DPS of loggerhead, and olive ridley sea turtles) can occur in the action area and may be affected by the stressors associated with the National Science Foundation and Scripps Institution of Oceanography's proposed seismic survey activities (See Section 5). While the aforementioned sea turtles can be found in pelagic habitats within the proposed action area, it is unlikely that ESA-listed sea turtles will be adversely affected by stressors associated with the proposed action. Each the stressors associated with the proposed action, along with our determination on their impacts to ESA-listed sea turtles within the action area, are discussed below.

Pollution

As stated in Section 5, the National Science Foundation and Scripps Institution of Oceanography proposes to include guidance on the handling and disposal of marine trash and debris during the seismic survey. In addition to this, the potential for an oil or fuel spill to emanate from the R/V *Thompson* during the proposed activities is small. Since the possibility for oil or fuel leakage is extremely unlikely to occur, we find that the risk from this potential stressor on ESA-listed sea turtles in the action area is discountable.

Vessel Strike

Vessel strike risks for sea turtles is less known compared to other taxa groups (i.e., marine mammals), but it is considered an important injury and mortality risk within the action area (Lutcavage et al. 1997). Based on behavioral observations of sea turtle avoidance of small vessels, green turtles may be susceptible to vessel strikes at speeds as low as 3.7 kilometers per hour (2 knots) (Hazel et al. 2007). If an animal is struck by a vessel, responses can include death, serious injury, and/or minor, non-lethal injuries, with the associated response depending on the size and speed of the vessel, among other factors (Laist et al. 2001; Jensen and Silber 2004; Vanderlaan and Taggart 2007; Conn and Silber 2013a).

As discussed in Section 5, the R/V *Thompson* will have an operating speed of five to eight knots per hour during seismic data acquisition. When not towing seismic survey gear, the R/V *Thompson* typically transits at 12 knots per hour. While vessel strikes of sea turtles from seismic survey activities are possible, we are not aware of any definitive case of a sea turtle being struck by a vessel associated with seismic surveys. In addition, the R/V *Thompson* will be traveling at generally low speeds, reducing the probability of a vessel strike (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). Furthermore, adherence to observation and avoidance procedures is also expected to avoid vessel strikes. With all factors considered, we have concluded the potential for vessel strike from the research vessel is highly improbable. As a result of vessel strike being extremely unlikely to occur, we find that the risk from this potential stressor on ESA-listed sea turtles in the action area is discountable.

Gear Entanglement

Towed gear from the seismic survey activities for this project pose a risk of entanglement to ESA-listed sea turtles. The towed hydrophone streamer could come in direct contact with ESA-listed species and sea turtle entanglements have occurred in towed gear from seismic survey vessels. For example, a National Science Foundation-funded seismic survey off the coast of Costa Rica during 2011 recovered a dead olive ridley turtle (*Lepidochelys olivacea*) in the foil of towed seismic equipment, and thus it was unclear whether the sea turtle became lodged in the foil pre- or post mortem (Spring 2011). However, for the activities proposed for this project, entanglement is considered highly unlikely due to the towed hydrophone streamer design as well as observations of sea turtles investigating the towed hydrophone streamer and not becoming entangled in regions of high sea turtle density (Holst et al. 2005b; Holst et al. 2005a; Hauser 2008; Holst and Smultea 2008a). To the best of our knowledge, sea turtles do not occur in high densities in the action area during the proposed survey (Huang 2015).

As discussed, towed seismic equipment associated with the proposed seismic survey activities may pose a risk of entanglement to ESA-listed species. Although the towed hydrophone streamer or passive acoustic monitoring array could come in direct contact with an ESA-listed species, entanglements are highly unlikely due to the taut cables of the towed streamer. Based upon extensive deployment of this type of equipment with no reported entanglement and the nature of the gear that is likely to prevent it from occurring, we find the probability of adverse impacts to ESA-listed sea turtles from this stressor to be discountable.

Vessel Noise

The contribution of vessel noise by the R/V *Thompson* is likely small in the overall regional sound field. The R/V *Thompson*’s passage past a sea turtle will be brief and not likely to be significant in affecting any individual’s ability to feed, reproduce, or avoid predators. In addition, the R/V *Thompson* will travel at slow speeds, reducing the amount of noise produced by the propulsions system (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). The distance between the research vessel and observed sea turtles, per avoidance protocols, will also minimize the potential for acoustic disturbance from engine noise. Because the potential acoustic interference from engine noise is expected to be nearly undetectable or so minor that it cannot be meaningfully evaluated, we find that the risk from this potential stressor on ESA-listed sea turtles is insignificant.

Multibeam Echosounder and Sub-bottom Profiler

Due to the lower source levels of the sub-bottom profiler relative to the *Thompson's* airgun array (maximum Source Level of 222 dB re 1 μPa for the sub-bottom profiler, versus a minimum of 230.9 dB re 1 μPa for the two airguns (LGL 2019), sounds from the sub-bottom profiler are expected to be effectively subsumed by sounds from the airgun array. In addition, sea turtles do not possess a hearing range that includes frequencies emitted by the multi-beam echosounder (10.5 to 13 [usually 12] kilohertz) and sub-bottom profiler (3.5 kilohertz). Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hertz to 2 kilohertz, with a range of maximum sensitivity between 100 and 800 Hertz (Ridgway et al. 1969; Lenhardt 1994; Bartol et al. 1999; Lenhardt 2002; Moein Bartol and Ketten 2006). Therefore, ESA-listed sea turtles are not expected to detect these sounds even if they are exposed and are not expected to respond to them. Based on this we find the effects of these acoustic stressors, (noise from the multibeam echosounder and sub-bottom profiler) on ESA-listed sea turtles in the action area, to be insignificant.

Acoustic Noise from Airgun Array

It is unlikely that ESA-listed sea turtles in the action area will be affected by acoustic disturbance from seismic airguns during the time of the proposed survey. Huang (2015) collected 18,142 bycatch observations and 47.1 million hooks from large-scale Taiwanese longline vessels in the Atlantic Ocean from June 2002 to December 2013. Overall, the data showed that ESA-listed sea turtles located in the Southeastern and Southwestern Atlantic Ocean were found in more tropical locations, closer to the equator (i.e. Gabon) during the months of the proposed action (i.e., November to December) (See Figures 4 through 7 of Huang 2015). As shown in Huang (2015), only one instance of sea turtle bycatch occurred in the South Atlantic during the months of October to December over the course of a 13-year study period. The one instance of bycatch was of a leatherback sea turtle that occurred in the central South Atlantic, outside of the proposed action area.

In addition to the data above, the National Science Foundation and United States Geological Survey's PEIS for marine seismic research (NSF and USGS 2011) concluded that due to implementation of the proposed monitoring and mitigation measures, no significant impacts of seismic airgun operations are likely to affect sea turtle populations and any effects are likely to be limited to short-term behavioral disturbance and short-term localized avoidance of an area of unknown size near the active airguns. This is supported by reviewing the distances for ESA-harassment of sea turtles calculated for the proposed National Science Foundation-funded survey. As shown in Table 5 below, using Navy thresholds for behavioral harassment of sea turtles (U.S. Navy 2017), the National Science Foundation estimated the largest behavioral harassment zone for sea turtles will be 155 and 142 meters from the sound source while the proposed survey occurs in depths of 100 meters to 1,000 meters. Furthermore, while the survey occurs in depths that are greater than 1,000 meters, the behavioral harassment zone is truncated to a distance of 95 and 103 meters. Given that 97 percent of the survey will occur in depths greater than 1,000 meters and most (70 percent) of the survey will be configured with a two-meter airgun separation, the 100 meter exclusion zone for sea turtles implemented by the National Science Foundation and Scripps Institution of Oceanography will cover most of the entire sea turtle behavioral harassment zone for a majority of the survey effort. This, combined with the short duration of the total survey and the low abundance of ESA-listed sea turtles in the action area during the time of the proposed survey make the possibility of ESA-listed sea turtle exposure to sound levels resulting from behavioral harassment discountable. Therefore, we have determined that South Atlantic DPS green sea turtle, hawksbill sea turtle, leatherback sea turtle, South Atlantic Ocean DPS of loggerhead sea turtle, and olive ridley sea turtles are not likely to be adversely affected by the proposed action. As a result, these species will not be carried forward in this consultation.

Table 5. Predicted distances to the 175-dB rms sound levels that could be received from two 45-in3 GI guns (at a tow depth of 4 m) that would be used during the seismic surveys in the South Atlantic Ocean during November−December 2019 (model results provided by L-DEO). The 175-dB rms criterion applies to all sea turtles.

Airgun Configuration	Water Depth (m)	Predicted Distances (meters) to Various Received Sound Levels
		175 dB re 1 μPa_{rms}(Behavioral)
Two 45-in^3 GI guns / 2 meter gun separation	>1000	95[1]
	100–1000	142[2]
Two 45-in^3 GI guns / 8 meter gun separation	>1000	103[1]
	100–1000	155[2]

[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.

6.2 ESA-Listed Elasmobranchs

ESA-listed elasmobranchs (giant manta rays, oceanic whitetip sharks, and scalloped hammerheads) can occur in the action area and may be affected by the stressors associated with the National Science Foundation and Scripps Institution of Oceanography’s proposed seismic survey activities (See Section 5). While the aforementioned ESA-listed elasmobranchs can be found in pelagic habitats within the proposed action area, it is unlikely that stressors associated with the proposed action will adversely affect these species. Each of these stressors, along with our determination on their impacts to ESA-listed elasmobranchs within the action area, are discussed below.

Pollution

As stated in Section 5, the National Science Foundation and Scripps Institution of Oceanography proposes to include guidance on the handling and disposal of marine trash and debris during the seismic survey. In addition to this, the potential for an oil or fuel spill to emanate from the R/V *Thompson* during the proposed activities is small. Since the possibility for oil or fuel leakage is extremely unlikely to occur, we find that the risk from this potential stressor on ESA-listed elasmobranchs in the action area is discountable.

Vessel Strike

Each of the ESA-listed fish species considered in this opinion are thought to spend at least some time in the upper portions of the water column where they may be susceptible to vessel strike. Despite these species' utilization of the upper portion of the water column for at least some of their life history, in most cases, we would anticipate the ESA-listed fishes considered in this opinion would be able to detect vessels or other in-water devices and avoid them. Fish are able to use a combination of sensory cues to detect approaching vessels, such as sight, hearing, and their lateral line (for nearby changes in water motion). A study on fish behavioral responses to vessels showed that most adults exhibit avoidance responses to engine noise, sonar, depth finders, and fish finders (Jørgensen et al. 2004), reducing the potential for vessel strikes. Misund (1997) found that fish ahead of a ship showed avoidance reactions at ranges of 50 to 350 meters (160 to 490 feet). When the vessel passed over them, some fish responded with sudden escape responses that movement away from the vessel laterally or through downward compression of the school. In an early study conducted by Chapman and Hawkins (1973), the authors observed avoidance responses of herring from the low-frequency sounds of large vessels or accelerating small vessels. Avoidance responses quickly ended within ten seconds after the vessel departed. Conversely, Rostad (2006) observed that some fish are attracted to different types of vessels (e.g., research vessels, commercial vessels) of varying sizes, noise levels, and habitat locations.

As discussed in Section 5, the R/V *Thompson* will have an operating speed acquisition of five to eight knots during seismic data acquisition. When not towing seismic survey gear, the R/V *Thompson* typically transits at 22 kilometers per hour (12 knots). While vessel strikes of elasmobranchs from seismic survey activities are possible, we are not aware of any definitive case of an elasmobranch being struck by a vessel associated with seismic surveys. In addition, the R/V *Thompson* will be traveling at generally low speeds, reducing probability of a vessel strike (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). With all factors considered, we have concluded the potential for vessel strike from the research vessel is highly improbable. As a result of vessel strike being extremely unlikely to occur, we find that the risk from this potential stressor on ESA-listed elasmobranchs in the action area is discountable.

Gear Entanglement

As discussed, towed seismic equipment associated with the proposed seismic survey activities may pose a risk of entanglement to ESA-listed species. In addition to marine mammals and sea turtles, some of the ESA-listed fish species in the action area are more susceptible to entanglement in derelict fishing gear and other marine debris, compared to other fish groups. For example, the shape of the body of some elasmobranchs such as manta rays, increase their risk of entanglement compared to fishes with smoother, more streamlined bodies. Nevertheless, for most of the pelagic species of ESA-listed fish species including oceanic whitetip sharks, the risk of entanglement is unlikely given their body shape and ability to avoid materials that could entangle them in the water column.

Although the towed hydrophone streamer or passive acoustic monitoring array could come in direct contact with an ESA-listed elasmobranchs, entanglements are highly unlikely due to the taut cables of the towed streamer. Based upon extensive deployment of this type of equipment with no reported entanglement and the nature of the gear that is likely to prevent it from occurring, we find the probability of adverse impacts to ESA-listed elasmobranchs from this stressor to be discountable.

Vessel Noise

The contribution of vessel noise by the R/V *Thompson* is likely small in the overall regional sound field. The R/V *Thompson*'s passage past an elasmobranch will be brief and not likely to be significant in impacting any individual's ability to feed, reproduce, or avoid predators. In addition, the R/V *Thompson* will travel at slow speeds, reducing the amount of noise produced by the propulsions system (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). Because the potential acoustic interference from engine noise is expected to be nearly undetectable or so minor that it cannot be meaningfully evaluated, we find that the risk from this potential stressor on ESA-listed elasmobranchs is insignificant.

Multibeam Echosounder, Sub-bottom Profiler and Airgun Array

The ESA-listed elasmobranchs discussed in this opinion occupy tropical and subtropical oceanic waters. Giant manta rays are found at depths less than 10 meters (32.8 feet) during the day (Carlson and Gulak 2012; Miller et al. 2014; Miller 2016; Young 2016). Oceanic whitetip sharks can be found at the ocean surface (28.2 percent of their time at depths less than 25 meters [82 feet]) but frequently stay between 25.5 and 50 meters (83.7 to 164 feet) deep or more (Carlson and Gulak 2012; Young 2016). Scalloped hammerheads occur over continental and insular shelves, as well as adjacent deep waters, but are seldom found in waters cooler than 22 degrees Celsius (Miller et al. 2014), which is greater than the water temperature found in the action area (Sayre et al. 2014). It ranges from the intertidal and surface to depths of up to 450-512 meters, with occasional dives to even deeper waters. It has also been documented entering enclosed bays and estuaries (Miller et al. 2014). We expect that giant manta rays, oceanic whitetip sharks, and scalloped hammerhead sharks will, for the most part, be at depths or water temperatures where there will be minimal risk of exposure to noise generated by the multibeam echosounder, sub-bottom profiler and airgun array used during the National Science Foundation and Scripps Institution of Oceanography's proposed seismic survey activities.

Elasmobranchs, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Hastings and Popper 2005; Popper and Schilt 2009). Data for elasmobranch fishes suggest they are capable of detecting sounds from approximately 20 Hertz to 1 kilohertz with the highest sensitivity to sounds at lower ranges (Myrberg Jr. 2001; Yan 2003; Casper 2006; Casper and Mann 2009; Casper et al. 2012; Ladich and Fay 2013). However, unlike fish with swim bladders, elasmobranchs do not have swim bladders (or any other air-filled cavity), and thus are considered unable to detect sound pressure (Casper et al. 2012). Particle motion is presumably the only sound stimulus that can be detected by elasmobranchs (Casper et al. 2012). Given their assumed hearing range, elasmobranchs are anticipated to be able to detect the low frequency sound from an airgun array if exposed. However, the duration and intensity of low-frequency acoustic stressors will likely minimize the effect this stressor has on elasmobranchs. Furthermore, although some elasmobranchs have been known to respond to anthropogenic sound, in general elasmobranchs are not considered particularly sensitive to sound produced by airguns (Casper et al. 2012).

There have been no studies examining the direct effects of exposure to specific anthropogenic sound sources in any species of elasmobranchs (Casper et al. 2012). However, several elasmobranch species, including the oceanic silky shark (*Carcharhinus falciformis*) and coastal lemon shark (*Negaprion brevirostris*), have been observed withdrawing from pulsed low-frequency sounds played from an underwater speaker (Myrberg et al. 1978; Klimley and Myrberg 1979). Lemon sharks exhibited withdrawal responses to pulsed low to mid-frequency sounds (500 Hertz to 4 kilohertz) raised 18 dB re: 1 µPa at an onset rate of 96 dB re: 1 µPa per second to a peak amplitude of 123 dB re: 1 µPa received level from a continuous level, just masking broadband ambient noise (Klimley and Myrberg 1979). In the same study, lemon sharks withdrew from artificial sounds that included ten pulses per second and 15 to 7.5 decreasing pulses per second.

In contrast, other elasmobranch species are attracted to pulsing low frequency sounds. Myrberg (2001) stated that sharks have demonstrated highest sensitivity to low frequency sound (40 to 800 Hertz). Free-ranging sharks are attracted to sounds possessing specific characteristics including irregular pulsed, broadband frequencies below 80 Hertz and transmitted suddenly without an increase in intensity, thus resembling struggling fish.

These signals, some "pulsed," are not substantially different from the airgun array signals. Myrberg et al. (1978) reported that a silky shark withdrew 10 meters (33 feet) from a speaker broadcasting a 150 to 600 Hertz sound with a sudden onset and peak source level of 154 dB re: 1 µPa. These sharks avoided a pulsed low frequency attractive sound when its sound level was abruptly increased by more than 20 dB re: 1 µPa. Other factors enhancing withdrawal were sudden changes in the spectral or temporal qualities of the transmitted sound. The pelagic oceanic whitetip (*Carcharhinus longimanus*) also showed a withdrawal response during limited tests, but less so than other species (Myrberg et al. 1978). These results do not rule out that such sounds may have been harmful to the fish after habituation; the tests were not designed to examine that point.

Popper et al. (2014) concluded that the relative risk of fishes with no swim bladders exhibiting a behavioral response to low-frequency active sonar was low, regardless of the distance from the sound source. The authors did not find any data on masking by sonar in fishes, but concluded that if it were to occur, masking will result in a narrow range of frequencies being masked (Popper et al. 2014). Popper et al. (2014) also concluded that the risk of mortality, mortal injury, or recoverable injury for fish with no swim bladders exposed to low frequency active sonar was low, regardless of the distance from the sound source. Although low frequency active sonar is a different type of sound source from seismic airguns (i.e., low frequency active sonar is a continuous source whereas seismic airguns are impulsive), both sources have overlapping frequency ranges, therefore similar effects to fishes after exposure to the sound sources may occur.

A recent study on the behavioral responses of sharks to sensory deterrent devices tested the sharks' attraction to bait while being exposed to auditory and visual stimuli. Ryan et al. (2017) used a strobe light and sound sources within a range thought to be audible to sharks (20 to 2,000 Hertz) on captive Port Jackson (*Heterodontus portusjacksoni*) and epaulette (*Hemiscyllium ocelltum*) sharks, and wild great white sharks (*Carcharodon carcharius*). The strobe lights along (and the lights with sound) reduced the number of times bait was taken by Port Jackson and epaulette sharks. The strobe lights along did not change white shark behavior, but the sound and the strobe light together led to great white sharks spending less time near bait. Sound alone did not have an effect on great white shark behavior (Ryan et al. 2017). As expressed above, the sound sources used in this study are different than the airguns used in the proposed action, but are still somewhat similar as they are both fairly low frequency sounds.

The precise expected response of ESA-listed elasmobranchs to low-frequency acoustic energy is not completely understood due to a lack of sufficient experimental and observational data for these species. However, given the signal type and level of exposure to the low frequency signals used in seismic survey activities, we do not expect adverse effects (including significant behavioral responses, TTS, injury, or mortality). The most likely response of ESA-listed elasmobranchs exposed to sound from seismic survey activities, if any, will be minor temporary changes in their behavior including increased swimming rate, avoidance of the sound source, or changes in orientation to the sound source, none of which rise to the level of take. In addition, as discussed, there is a low chance that giant manta rays, oceanic whitetip sharks, and scalloped hammerheads will occur in the action area during the time of the survey.

Therefore, the potential effect of noise from the multibeam echosounder, sub-bottom profiler, and airguns used during the survey on ESA-listed elasmobranch species (giant manta ray, oceanic whitetip shark, and scalloped hammerhead) is insignificant. We conclude that the proposed seismic survey activities in the action area are not likely to adversely affect ESA-listed elasmobranch species (giant manta ray, oceanic whitetip shark, and scalloped hammerhead) and these species will not be discussed further in this opinion.

7 SPECIES LIKELY TO BE ADVERSELY AFFECTED

This section identifies the ESA-listed species that occur within the action area (Figure 1) that are likely to be adversely affected by the proposed action. These species are listed in Table 6, along with their regulatory status and recovery plan. As shown in Table 6, the only species that are likely to be adversely affected by the proposed action are ESA-listed cetaceans. The determinations for the effects of stressors that are not likely to adversely affect ESA-listed cetaceans during the proposed seismic survey are discussed below. Other stressors are discussed in more detail in Section 10.

Pollution

As stated in Section 5, the National Science Foundation and Scripps Institution of Oceanography proposes to include guidance on the handling and disposal of marine trash and debris during the seismic survey. In addition to this, the potential for an oil or fuel spill to emanate from the R/V *Thompson* during the proposed activities is small. Since the possibility for oil or fuel leakage is extremely unlikely to occur, we find that the risk from this potential stressor on ESA-listed cetaceans in the action area is discountable.

Vessel Strike

Our expectation of vessel strike for a marine mammal is small due to the hundreds of thousands of kilometers the R/V *Thompson* has traveled without a vessel strike, the general expected movement of marine mammals away from or parallel to the *Thompson*, as well as the generally slow movement of the *Thompson* during most of its travels (Holst and Smultea 2008b; Hauser and Holst 2009; Holst 2010). The R/V *Thompson* will have an operating speed acquisition of five to eight knots during seismic data acquisition. When not towing seismic survey gear, the R/V *Thompson* typically transits at 22 kilometers per hour (12 knots). In addition, there has been no history of marine mammal vessel strikes with the R/V *Thompson* over the last two decades. With all factors considered, we have concluded the potential for vessel strike from the research vessel is highly improbable. As a result of vessel strike being extremely unlikely to occur, we find that the risk from this potential stressor on ESA-listed cetaceans in the action area is discountable.

Gear Entanglement

As discussed, towed seismic equipment associated with the proposed seismic survey activities may pose a risk of entanglement to ESA-listed species. Although the towed hydrophone streamer or passive acoustic monitoring array could come in direct contact with an ESA-listed cetacean, entanglements are highly unlikely. The towed hydrophone streamer is rigid and as such is not expected to encircle, wrap around, or in any other way entangle any of the cetaceans considered during this consultation. For these reasons, we expect the taut cables will prevent entanglement of ESA-listed species. Furthermore, mysticetes and possibly sperm whales (the only cetaceans considered in this opinion) are expected to avoid areas where the airgun array is actively being used, meaning they will also likely avoid towed gear. Instances of such entanglement events with ESA-listed marine mammals are unknown to us. Based upon extensive deployment of this type of equipment with no reported entanglement and the nature of the gear that is likely to prevent it from occurring, we find the probability of adverse impacts to ESA-listed cetaceans from this stressor to be discountable.

Vessel Noise

Numerous studies of interactions between surface vessels and cetaceans have demonstrated that free-ranging cetaceans engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel or an interaction between the two (Bryant et al. 1984; Bauer 1986; Watkins 1986a; Corkeron 1995; Wursig et al. 1998; Bejder et al. 1999; Au and Green 2000; Félix 2001; Nowacek et al. 2001; Erbe 2002b; Magalhaes et al. 2002; Williams et al. 2002; Lusseau 2003; Richter et al. 2003; Goodwin and Cotton 2004; Scheidat et al. 2004; Amaral and Carlson 2005; Simmonds 2005a; Bain et al. 2006; Lemon et al. 2006; Lusseau 2006; Bejder and Lusseau. 2008; Bejder et al. 2009). However, several authors suggest that the noise generated during motion is probably an important factor (Evans et al. 1992; Blane and Jaakson 1994b; Evans et al. 1994). These studies suggest that the behavioral responses of cetaceans to surface vessels are similar to their behavioral responses to predators. With this said, the overall contribution of vessel noise by the R/V *Thompson* is likely small in the overall regional sound field of the action area. The R/V *Thompson*'s passage past ESA-listed cetaceans will be brief, at a distance of at least 100 meters, and not likely to be significant in impacting any individual's ability to feed, reproduce, or avoid predators. In addition, the R/V *Thompson* will travel at slow speeds, reducing the amount of noise produced by the propulsion system (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). Because the potential acoustic interference from engine noise is expected to be nearly undetectable or so minor that it cannot be meaningfully evaluated, we find that the risk from this potential stressor on ESA-listed cetaceans is insignificant.

Table 6. Threatened and endangered species that may be affected by the National Science Foundation and Scripps Institution of Oceanography's proposed marine seismic survey in the South Atlantic Ocean.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus)*	E – 35 FR 18319	-- --	07/1998
Fin Whale (*Balaenoptera physalus)*	E – 35 FR 18319	-- --	75 FR 47538
Sei Whale (*Balaenoptera borealis*)	E – 35 FR 18319	-- --	12/2011
Southern Right Whale (*Eubalaena australis*)	E – 35 FR 8491	-- --	-- --

Species	ESA Status	Critical Habitat	Recovery Plan
Sperm Whale (*Physeter macrocephalus*)	E – 35 FR 18319	-- --	75 FR 81584 12/2010

8 Status of Species Likely to be Adversely Affected

This section identifies and examines the status of each species that is expected to be adversely affected by the proposed action. The status includes the existing level of risk that the ESA-listed species face, based on parameters considered in documents such as recovery plans, status reviews, and ESA-listing decisions. The species' status section helps to inform the description of the species' current "reproduction, numbers, or distribution," which is part of the jeopardy determination as described in 50 C.F.R. §402.02. More detailed information on the status and trends of these ESA-listed species, and their biology and ecology can be found in the listing regulations and critical habitat designations published in the *Federal Register*, status reviews, recovery plans, and on this NMFS websites: http://www.nmfs.noaa.gov/pr/species/index.htm, among others. No designated or proposed critical habitat exists in the action area, therefore only the status of species likely to be adversely affected by the proposed action will be discussed in this section.

One factor affecting the rangewide status of cetaceans at large is climate change. Climate change will be discussed in the *Environmental Baseline* section (Section 9).

8.1 Blue Whale

The blue whale is a widely distributed baleen whale found in all major oceans (Figure 2).

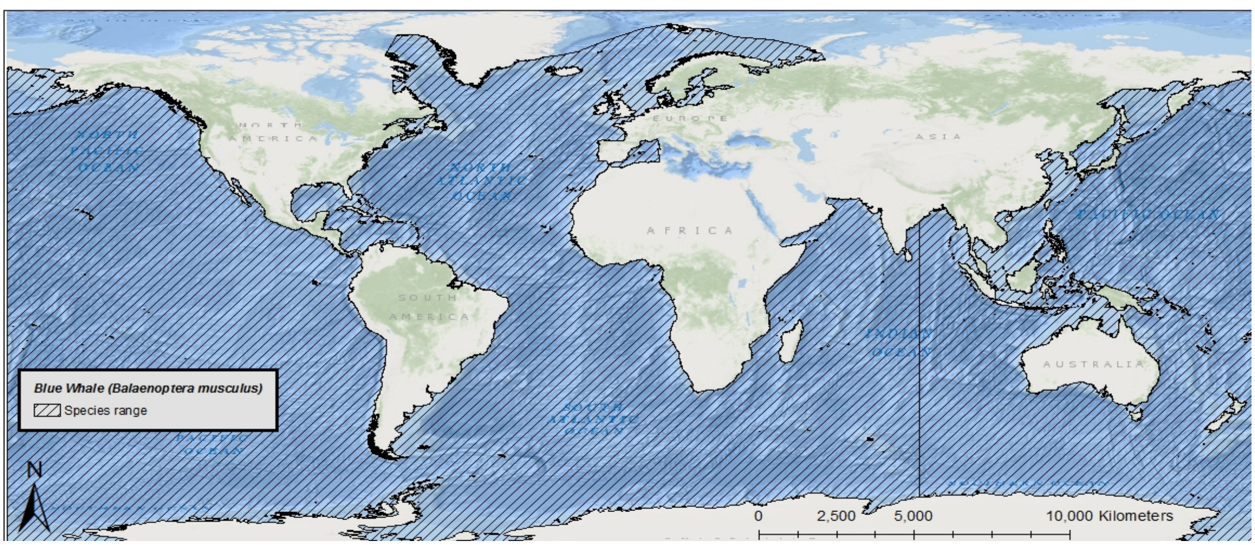

Figure 2. Map identifying the range of the endangered blue whale.

Blue whales are the largest animal on earth and distinguishable from other whales by a long-body and comparatively slender shape, a broad, flat "rostrum" when viewed from above, proportionally smaller dorsal fin, and a mottled gray color that appears light blue when seen through the water. Most experts recognize at least three subspecies of blue whale, *B. m. musculus*, which occurs in the Northern Hemisphere, *B. m. intermedia*, which occurs in the Southern Ocean, and *B. m. brevicauda*, a pygmy species found in the Indian Ocean and South Pacific Ocean. The blue whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 1998), recent stock assessment reports (Carretta et al. 2017; Hayes et al. 2017; Muto et al. 2017), and status review (COSEWIC 2002) were used to summarize the life history, population dynamics, and status of the species as follows.

8.1.1 Life History

The average life span of blue whales is 80 to 90 years. They have a gestation period of ten to 12 months, and calves nurse for six to seven months. Blue whales reach sexual maturity between five and 15 years of age with an average calving interval of two to three years. They winter at low latitudes, where they mate, calve and nurse, and summer at high latitudes, where they feed. Blue whales forage almost exclusively on krill and can eat approximately 3,600 kilograms (7,936.6 pounds) daily. Feeding aggregations are often found at the continental shelf edge, where upwelling produces concentrations of krill at depths of 90 to 120 meters (295.3 to 393.7 feet).

8.1.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the blue whale.

The global, pre-exploitation estimate for blue whales is approximately 181,200 (IWC 2007b). Current estimates indicate approximately 5,000 to 12,000 blue whales globally (IWC 2007b). Blue whales are separated into populations by ocean basin in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere. There are three stocks of blue whales designated in United States waters: the Eastern North Pacific Ocean (current best estimate N=1,647, N_{min}=1,551) (VanBlaricom et al. 1993), Central North Pacific Ocean (N=81, N_{min}=38), and Western North Atlantic Ocean (N=400 to 600, N_{min}=440). In the Southern Hemisphere, the latest abundance estimate for Antarctic blue whales is 2,280 individuals in 1997/1998 (95 percent confidence intervals 1,160 to 4,500 (Branch 2007). While no rangewide estimate for pygmy blue whales exists (Thomas et al. 2016), the latest estimate for pygmy blue whales off the west coast of Australia is 662 to 1,559 individuals based on passive acoustic monitoring (McCauley and Jenner 2010), or 712 to 1,754 individuals based on photographic mark-recapture (Jenner 2008).

Current estimates indicate a growth rate of just under three percent per year for the eastern North Pacific stock (Calambokidis 2009). An overall population growth rate for the species or growth rates for the two other individual U.S. stocks are not available at this time. In the Southern Hemisphere, population growth estimates are available only for Antarctic blue whales, which estimate a population growth rate of 8.2 percent per year (95 percent confidence interval 1.6 to 14.8 percent) (Branch 2007).

Little genetic data exist on blue whales globally. Data from Australia indicates that at least populations in this region experienced a recent genetic bottleneck, likely the result of commercial whaling, although genetic diversity levels appear to be similar to other, non-threatened mammal species (Attard et al. 2010). Consistent with this, data from Antarctica also demonstrate this bottleneck but high haplotype diversity, which may be a consequence of the recent timing of the bottleneck and blue whales long lifespan (Sremba et al. 2012). Data on genetic diversity of blue whales in the Northern Hemisphere are currently unavailable. However, genetic diversity information for similar cetacean population sizes can be applied. Stocks that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Stocks that have a total population of 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Stock population at low densities (less than 100) are more likely to suffer from the 'Allee' effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density.

In general, distribution is driven largely by food requirements; blue whales are more likely to occur in waters with dense concentrations of their primary food source, krill. While they can be found in coastal waters, they are thought to prefer waters further offshore. In the North Atlantic Ocean, the blue whale range extends from the subtropics to the Greenland Sea. They are most frequently sighted in waters of eastern Canada with a majority of sightings taking place in the Gulf of St. Lawrence. In the North Pacific Ocean, blue whales range from Kamchatka to southern Japan in the west and from the Gulf of Alaska and California to Costa Rica in the east. They primarily occur off the Aleutian Islands and the Bering Sea. In the northern Indian Ocean, there is a "resident" population of blue whales with sightings being reported from the Gulf of Aden, Persian Gulf, Arabian Sea, and across the Bay of Bengal to Burma and the Strait of Malacca. In the Southern Hemisphere, distributions of subspecies *(B. m. intermedia* and *B. m. brevicauda*) can be segregated. The subspecies *B. m. intermedia* occurs in relatively high latitudes south of the "Antarctic Convergence" (located between 48 and 61 degrees South latitude) and close to the ice edge. The subspecies *B. m. brevicauda* is typically distributed north of the Antarctic Convergence.

8.1.3 Vocalization and Hearing

Blue whale vocalizations tend to be long (greater than 20 seconds), low frequency (less than 100 Hertz) signals (Thomson and Richardson 1995a), with a range of 12 to 400 Hertz and dominant energy in the infrasonic range of 12 to 25 Hertz (McDonald et al. 1995; Ketten 1998; Mcdonald et al. 2001; Mellinger and Clark 2003). Vocalizations are predominantly songs and calls.

Calls are short-duration sounds (two to five seconds) that are transient and frequency-modulated, having a higher frequency range and shorter duration than song units and often sweep down in frequency (20 to 80 Hertz), with seasonally variable occurrence. Blue whale calls have high acoustic energy, with reports of source levels ranging from 180 to 195 dB re: 1 μPa at 1 meter

(Cummings and Thompson 1971; Aburto et al. 1997; Ketten 1998; Mcdonald et al. 2001; Clark and Gagnon 2004; Berchok et al. 2006; Samaran et al. 2010). Calling rates of blue whales tend to vary based on feeding behavior. For example, blue whales make seasonal migrations to areas of high productivity to feed, and vocalize less at the feeding grounds then during migration (Burtenshaw et al. 2004). Stafford et al. (2005) recorded the highest calling rates when blue whale prey was closest to the surface during its vertical migration. Wiggins et al. (2005) reported the same trend of reduced vocalization during daytime foraging followed by an increase at dusk as prey moved up into the water column and dispersed. Oleson et al. (2007c) reported higher calling rates in shallow diving (less than 30 meters [98.4 feet] whales), while deeper diving whales (greater than 50 meters [154 feet]) were likely feeding and calling less.

Although general characteristics of blue whale calls are shared in distinct regions (Thompson et al. 1996; Mcdonald et al. 2001; Mellinger and Clark 2003; Rankin et al. 2005), some variability appears to exist among different geographic areas (Rivers 1997). Sounds in the North Atlantic Ocean have been confirmed to have different characteristics (i.e., frequency, duration, and repetition) than those recorded in other parts of the world (Mellinger and Clark 2003; Berchok et al. 2006; Samaran et al. 2010). Clear differences in call structure suggestive of separate populations for the western and eastern regions of the North Pacific Ocean have also been reported (Stafford et al. 2001); however, some overlap in calls from the geographically distinct regions have been observed, indicating that the whales may have the ability to mimic calls (Stafford and Moore 2005). In Southern California, blue whales produce three known call types: Type A, B, and D. B calls are stereotypic of blue whale population found in the eastern North Pacific (McDonald et al. 2006b) and are produced exclusively by males and associated with mating behavior (Oleson et al. 2007a). These calls have long durations (20 seconds) and low frequencies (10 to 100 Hertz); they are produced either as repetitive sequences (song) or as singular calls. The B call has a set of harmonic tonals, and may be paired with a pulsed Type A call. D calls are produced in highest numbers during the late spring and early summer and in diminished numbers during the fall, when A-B songs dominate blue whale calling (Oleson et al. 2007c; Hildebrand et al. 2011; Hildebrand et al. 2012).

Blue whale songs consist of repetitively patterned vocalizations produced over time spans of minutes to hours or even days (Cummings and Thompson 1971; Mcdonald et al. 2001). The songs are divided into pulsed/tonal units, which are continuous segments of sound, and phrases, repeated in combinations of one to five units (Payne and Mcvay 1971; Mellinger and Clark 2003). Songs can be detected for hundreds, and even thousands of kilometers (Stafford et al. 1998), and have only been attributed to males (Mcdonald et al. 2001; Oleson et al. 2007a). Worldwide, songs are showing a downward shift in frequency (McDonald et al. 2009). For example, a comparison of recording from November 2003 and November 1964 and 1965 reveals a long-term shift in the frequency of blue whale calling near San Nicolas Island. In 2003, the spectral energy peak was 16 Hertz compared to approximately 22.5 Hertz in 1964 and 1965, illustrating a more than 30 percent shift in call frequency over four decades (McDonald et al. 2006b). McDonald et al. (2009) observed a 31 percent downward frequency shift in blue whale calls off the coast of California, and also noted lower frequencies in seven of the world's ten known blue whale songs originating in the Atlantic, Pacific, Southern, and Indian Oceans. Many possible explanations for the shifts exist but none have emerged as the probable cause.

As with other baleen whale vocalizations, blue whale vocalization function is unknown, although numerous hypotheses exist (maintaining spacing between individuals, recognition, socialization, navigation, contextual information transmission, and location of prey resources) (Payne and Webb. 1971; Thompson et al. 1992; Edds-Walton 1997; Oleson et al. 2007b). Intense bouts of long, patterned sounds are common from fall through spring in low latitudes, but these also occur less frequently while in summer high-latitude feeding areas. Short, rapid sequences of 30 to 90 Hertz calls are associated with socialization and may be displays by males based upon call seasonality and structure. The low frequency sounds produced by blue whales can, in theory, travel long distances, and it is possible that such long distance communication occurs (Payne and Webb. 1971; Edds-Walton 1997). The long-range sounds may also be used for echolocation in orientation or navigation (Tyack 1999).

Direct studies of blue whale hearing have not been conducted, but it is assumed that blue whales can hear the same frequencies that they produce (low frequency) and are likely most sensitive to this frequency range (Richardson et al. 1995b; Ketten 1997). Based on vocalizations and anatomy, blue whales are assumed to predominantly hear low-frequency sounds below 400 Hertz (Croll et al. 2001; Stafford and Moore 2005; Oleson et al. 2007c). In terms of functional hearing capability, blue whales belong to the low frequency group, which have a hearing range of 7 Hertz to 35 kilohertz (NOAA 2018).

8.1.4 Status

The blue whale is endangered as a result of past commercial whaling. In the North Atlantic Ocean, at least 11,000 blue whales were killed from the late 19th to mid-20th centuries. In the North Pacific Ocean, at least 9,500 whales were killed between 1910 and 1965. Commercial whaling no longer occurs, but blue whales are affected by anthropogenic noise, threatened by ship strikes, entanglement in fishing gear, pollution, harassment due to whale watching, and reduced prey abundance and habitat degradation due to climate change. Because populations appear to be increasing in size, the species appears to be somewhat resilient to current threats; however, the species has not recovered to pre-exploitation levels.

8.1.5 Critical Habitat

No critical habitat has been designated for the blue whale.

8.1.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover blue whale populations. These threats will be discussed in further detail in the *Environmental Baseline* section (Section 9) of this opinion. See the 1998 Final Recovery Plan for the Blue Whale for complete downlisting/delisting criteria for each of the following recovery plan goals:

1. Determine stock structure of blue whale populations occurring in U.S. waters and elsewhere.
2. Estimate the size and monitor trends in abundance of blue whale populations.
3. Identify and protect habitat essential to the survival and recovery of blue whale populations.
4. Reduce or eliminate human-caused injury and mortality of blue whales.
5. Minimize detrimental effects of directed vessel interactions with blue whales.
6. Maximize efforts to acquire scientific information from dead stranded, and entangled blue whales.
7. Coordinate state, federal, and international efforts to implement recovery actions for blue whales.
8. Establish criteria for deciding whether to delist or downlist blue whales.

8.2 Fin Whale

The fin whale is a large, widely distributed baleen whale found in all major oceans and comprised of three subspecies: *B. p. physalus* in the Northern Hemisphere, and *B. p. quoyi* and *B. p. patachaonica* (a pygmy form) in the Southern Hemisphere (Figure 3).

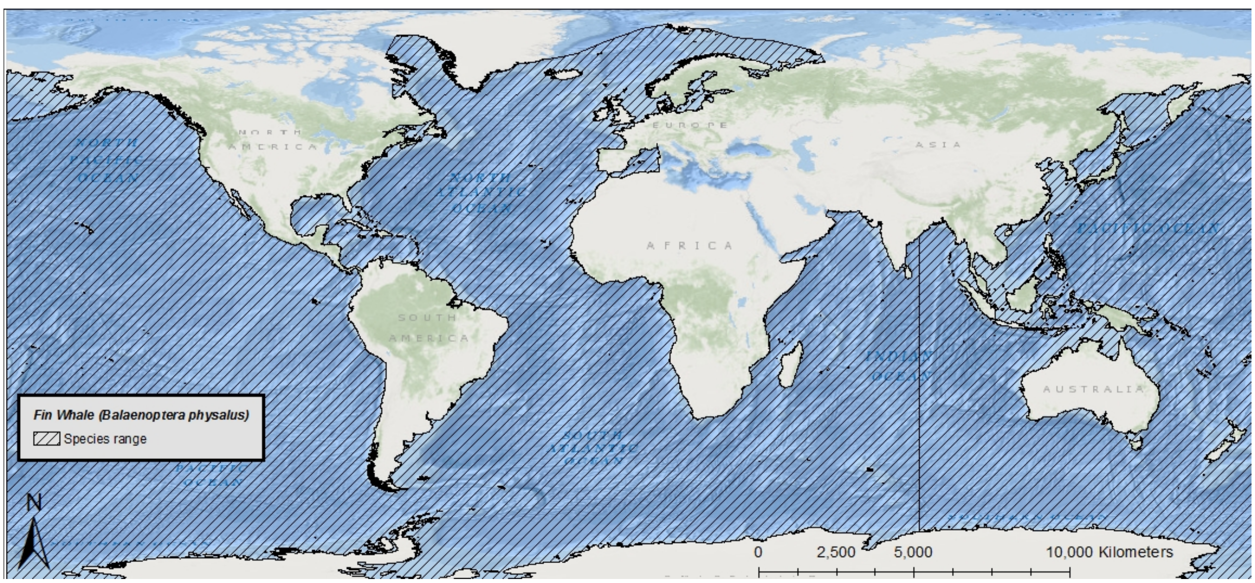

Figure 3. Map identifying the range of the endangered fin whale

Fin whales are distinguishable from other whales by a sleek, streamlined body, with a V-shaped head, a tall falcate dorsal fin, and a distinctive color pattern of a black or dark brownish-gray body and sides with a white ventral surface. The lower jaw is gray or black on the left side and creamy white on the right side. The fin whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 2010b), recent stock assessment reports (Carretta et al. 2017; Hayes et al. 2017; Muto et al. 2017), and status review (NMFS 2011a) were used to summarize the life history, population dynamics and status of the species as follows.

8.2.1 Life History

Fin whales can live, on average, 80 to 90 years. They have a gestation period of less than one year, and calves nurse for six to seven months. Sexual maturity is reached between six and ten years of age with an average calving interval of two to three years. They mostly inhabit deep, offshore waters of all major oceans. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed, although some fin whales appear to be residential to certain areas. Fin whales eat pelagic crustaceans (mainly euphausiids or krill) and schooling fish such as capelin, herring, and sand lice.

8.2.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the fin whale.

The pre-exploitation estimate for the fin whale population in the North Pacific Ocean was 42,000 to 45,000 (Ohsumi and Wada 1974). In the North Atlantic Ocean, at least 55,000 fin whales were killed between 1910 and 1989. Approximately 704,000 fin whales were killed in the Southern Hemisphere from 1904 to 1975. Of the three to seven stocks in the North Atlantic Ocean (approximately 50,000 individuals), one occurs in United States waters, where the best estimate of abundance is 1,618 individuals (N_{min}=1,234); however, this may be an underrepresentation as the entire range of stock was not surveyed (Palka 2012). There are three stocks in United States Pacific Ocean waters: Northeast Pacific [minimum 1,368 individuals], Hawaii (approximately 58 individuals [N_{min}=27]) and California/Oregon/Washington (approximately 9,029 [N_{min}=8,127] individuals) (Nadeem et al. 2016). The International Whaling Commission also recognizes the China Sea stock of fin whales, found in the Northwest Pacific Ocean, which currently lacks an abundance estimate (Reilly et al. 2013). Abundance data for the Southern Hemisphere stock are limited; however, there were assumed to be somewhat more than 15,000 in 1983 (Thomas et al. 2016).

Current estimates indicate approximately 10,000 fin whales in United States Pacific Ocean waters, with an annual growth rate of 4.8 percent in the Northeast Pacific stock and a stable population abundance in the California/Oregon/Washington stock (Nadeem et al. 2016). Overall, population growth rates and total abundance estimates for the Hawaii stock, China Sea stock, western North Atlantic stock, and Southern Hemisphere fin whales are not available at this time.

Archer et al. (2013) recently examined the genetic structure and diversity of fin whales globally. Full sequencing of the mitochondrial DNA genome for 154 fin whales sampled in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere, resulted in 136 haplotypes, none of which were shared among ocean basins suggesting differentiation at least at this geographic scale. However, North Atlantic Ocean fin whales appear to be more closely related to the Southern Hemisphere population, as compared to fin whales in the North Pacific Ocean, which may indicate a revision of the subspecies delineations is warranted. Generally speaking, haplotype diversity was found to be high both within oceans basins, and across. Such high genetic diversity and lack of differentiation within ocean basins may indicate that despite some populations having small abundance estimates, the species may persist long-term and be somewhat protected from substantial environmental variance and catastrophes.

There are over 100,000 fin whales worldwide, occurring primarily in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere where they appear to be reproductively isolated. The availability of prey, sand lice in particular, is thought to have had a strong influence on the distribution and movements of fin whales.

8.2.3 Vocalization and Hearing

Fin whales produce a variety of low frequency sounds in the 10 to 200 Hertz range (Watkins 1981; Watkins et al. 1987; Edds 1988; Thompson et al. 1992). Typical vocalizations are long, patterned pulses of short duration (0.5 to two seconds) in the 18 to 35 Hertz range, but only males are known to produce these (Patterson and Hamilton 1964; Clark et al. 2002). The most typically recorded call is a 20 Hertz pulse lasting about one second, and reaching source levels of 189 ±4 dB re: 1 μPa at 1 meter (Watkins 1981; Watkins et al. 1987; Edds 1988; Richardson et al. 1995b; Charif et al. 2002; Clark et al. 2002; Sirovic et al. 2007). These pulses frequently occur in long sequenced patterns, are down swept (e.g., 23 to 18 Hertz), and can be repeated over the course of many hours (Watkins et al. 1987).

In temperate waters, intense bouts of these patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clark and Charif 1998). Richardson et al. (1995b) reported this call occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns in winter. The seasonality and stereotype nature of these vocal sequences suggest that they are male reproductive displays (Watkins 1981; Watkins et al. 1987); a notion further supported by data linking these vocalizations to male fin whales only (Croll et al. 2002).

In Southern California, the 20 Hertz pulses are the dominant fin whale call type associated both with call-counter-call between multiple animals and with singing (U.S. Navy 2010; U.S. Navy 2012b). An additional fin whale sound, the 40 Hertz call described by Watkins (1981), was also frequently recorded, although these calls are not as common as the 20 Hertz fin whale pulses. Seasonality of the 40 Hertz calls differed from the 20 Hertz calls, since 40 Hertz calls were more prominent in the spring, as observed at other sites across the northeast Pacific Ocean (Sirovic et al. 2012). Source levels of Eastern Pacific Ocean fin whale 20 Hertz calls has been reported as 189 ± 5.8 dB re: 1 μPa at 1 meter (Weirathmueller et al. 2013). Some researchers have also recorded moans of 14 to 118 Hertz, with a dominant frequency of 20 Hertz, tonal vocalizations of 34 to 150 Hertz, and songs of 17 to 25 Hertz (Watkins 1981; Edds 1988; Cummings and Thompson 1994).

In general, source levels for fin whale vocalizations are 140 to 200 dB re: 1 μPa at 1 meter (as compiled by Erbe 2002b; see also Clark and Gagnon 2004). The source depth of calling fin whales has been reported to be about 50 meters (164 feet) (Watkins et al. 1987). Although acoustic recordings of fin whales from many diverse regions show close adherence to the typical 20-Hertz bandwidth and sequencing when performing these vocalizations, there have been slight differences in the pulse patterns, indicative of some geographic variation (Watkins et al. 1987; Thompson et al. 1992).

Although their function is still in doubt, low frequency fin whale vocalizations travel over long distances and may aid in long distance communication (Payne and Webb. 1971; Edds-Walton 1997). During the breeding season, fin whales produce pulses in a regular repeating pattern, which have been proposed to be mating displays similar to those of humpback whales (Croll et al. 2002). These vocal bouts last for a day or longer (Tyack 1999). Also, it has been suggested that some fin whale sounds may function for long range echolocation of large-scale geographic targets such as seamounts, which might be used for orientation and navigation (Tyack 1999).

Direct studies of fin whale hearing have not been conducted, but it is assumed that fin whales can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Richardson et al. 1995b; Ketten 1997). This suggests fin whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than mid- to high-frequencies (Ketten 1997). In a study using computer tomography scans of a calf fin whale skull, Cranford and Krysl (2015) found sensitivity to a broad range of frequencies between 10 Hertz and 12 kilohertz and a maximum sensitivity to sounds in the 1 to 2 kilohertz range. In terms of functional hearing capability, fin whales belong to the low-frequency group, which have a hearing range of 7 Hertz to 35 kilohertz (NOAA 2018).

8.2.4 Status

The fin whale is endangered as a result of past commercial whaling. Prior to commercial whaling, hundreds of thousands of fin whales existed. Fin whales may be killed under "aboriginal subsistence whaling" in Greenland, under Japan's scientific whaling program, and Iceland's formal objection to the International Whaling Commission's ban on commercial whaling. Additional threats include ship strikes, reduced prey availability due to overfishing or climate change, and noise. The species' overall large population size may provide some resilience to current threats, but trends are largely unknown.

8.2.5 Critical Habitat

No critical habitat has been designated for the fin whale.

8.2.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover fin whale populations. These threats will be discussed in further detail in the *Environmental Baseline* section (Section 9) of this opinion. See the 2010 Final Recovery Plan for the fin whale for complete downlisting/delisting criteria for both of the following recovery goals:

1. Achieve sufficient and viable population in all ocean basins.
2. Ensure significant threats are addressed.

8.3 Sei Whale

The sei whale is a widely distributed baleen whale found in all major oceans (Figure 4).

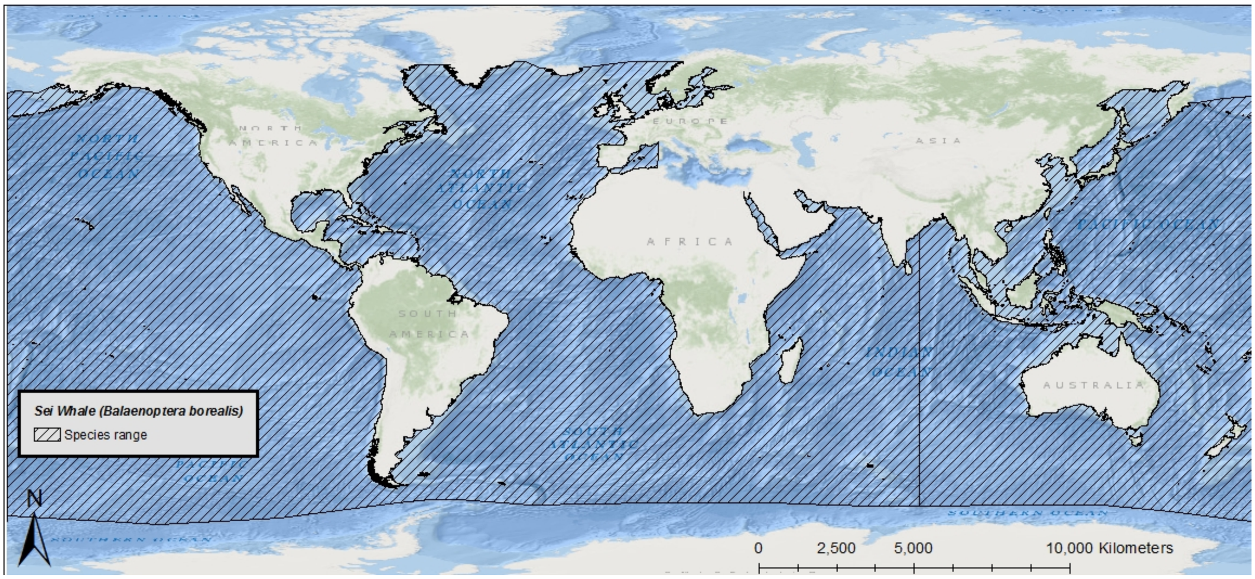

Figure 4. Map identifying the range of the endangered sei whale.

Sei whales are distinguishable from other whales by a long, sleek body that is dark bluish-gray to black in color and pale underneath, and a single ridge located on their rostrum. The sei whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 2011b), recent stock assessment reports (Carretta et al. 2017; Hayes et al. 2017; Muto et al. 2017), and status review (NMFS 2012) were used to summarize the life history, population dynamics, and status of the species as follows.

8.3.1 Life History

Sei whales can live, on average, between 50 and 70 years. They have a gestation period of ten to 12 months, and calves nurse for six to nine months. Sexual maturity is reached between six and 12 years of age with an average calving interval of two to three years. Sei whales mostly inhabit continental shelf and slope waters far from the coastline. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed on a range of prey types, including: plankton (copepods and krill) small schooling fishes, and cephalopods.

8.3.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the sei whale.

Two subspecies of sei whale are recognized, *B. b. borealis* in the Northern Hemisphere and *B. b. schlegellii* in the Southern Hemisphere. There are no estimates of pre-exploitation abundance for the North Atlantic Ocean. Models indicate that total abundance declined from 42,000 to 8,600 individuals between 1963 and 1974 in the North Pacific Ocean. More recently, the North Pacific Ocean population was estimated to be 29,632 (95 percent confidence intervals 18,576 to 47,267) between 2010 and 2012 (IWC 2016; Thomas et al. 2016). In the Southern Hemisphere, pre-exploitation abundance is estimated at 65,000 whales, with recent abundance estimated at 9,800 to 12,000 whales. Three relatively small stocks occur in U.S. waters: Nova Scotia (N=357, N_{min}=236), Hawaii (N=178, N_{min}=93), and Eastern North Pacific (N=519, N_{min}=374). Population growth rates for sei whales are not available at this time as there are little to no systematic survey efforts to study sei whales.

Based on genetic analyses, there appears to be some differentiation between sei whale populations in different ocean basins. An early study of allozyme variation at 45 loci found some genetic differences between Southern Ocean and the North Pacific sei whales (Wada and Numachi 1991). However, more recent analyses of mtDNA control region variation show no significant differentiation between Southern Ocean and the North Pacific sei whales, though both appear to be genetically distinct from sei whales in the North Atlantic (Baker and Clapham 2004; Huijser et al. 2018). Within ocean basin, there appears to be intermediate to high genetic diversity and little genetic differentiation despite there being different managed stocks (Danielsdottir et al. 1991; Kanda et al. 2006; Kanda et al. 2011; Kanda et al. 2013; Kanda et al. 2015; Huijser et al. 2018).

Sei whales are distributed worldwide, occurring in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere.

8.3.3 Vocalization and Hearing

Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100 to 600 Hertz range with 1.5 second duration and tonal and upsweep calls in the 200 to 600 Hertz range of one to three second durations (McDonald et al. 2005). Vocalizations from the North Atlantic Ocean consisted of paired sequences (0.5 to 0.8 seconds, separated by 0.4 to 1.0 seconds) of 10 to 20 short (4 milliseconds) frequency modulated sweeps between 1.5 to 3.5 kilohertz (Thomson and Richardson 1995b). Source levels of 189 ±5.8 dB re: 1 μPa at 1 meter have been established for sei whales in the northeastern Pacific Ocean (Weirathmueller 2013).

Direct studies of sei whale hearing have not been conducted, but it is assumed that they can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Richardson et al. 1995b; Ketten 1997). This suggests sei whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than mid- to high-frequencies (Ketten 1997). In terms of functional hearing capability, sei whales belong to the low-frequency group, which have a hearing range of 7 Hertz to 35 kilohertz (NOAA 2018).

8.3.4 Status

The sei whale is endangered as a result of past commercial whaling. Now, only a few individuals are taken each year by Japan; however, Iceland has expressed an interest in targeting sei whales. Current threats include ship strikes, fisheries interactions (including entanglement), climate change (habitat loss and reduced prey availability), and anthropogenic sound. Given the species' overall abundance, they may be somewhat resilient to current threats. However, trends are largely unknown, especially for individual stocks, many of which have relatively low abundance estimates.

8.3.5 Critical Habitat

No critical habitat has been designated for the sei whale.

8.3.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover sei whale populations. These threats will be discussed in further detail in the *Environmental Baseline* section (Section 9) of this opinion. See the 2011 Final Recovery Plan for the sei whale for complete downlisting/delisting criteria for both of the following recovery goals:

1. Achieve sufficient and viable populations in all ocean basins.
2. Ensure significant threats are addressed.

8.4 Southern Right Whale

Southern right whales are a large baleen whale species distributed in the Southern Hemisphere worldwide from 20 to 60 degrees South (Figure 5).

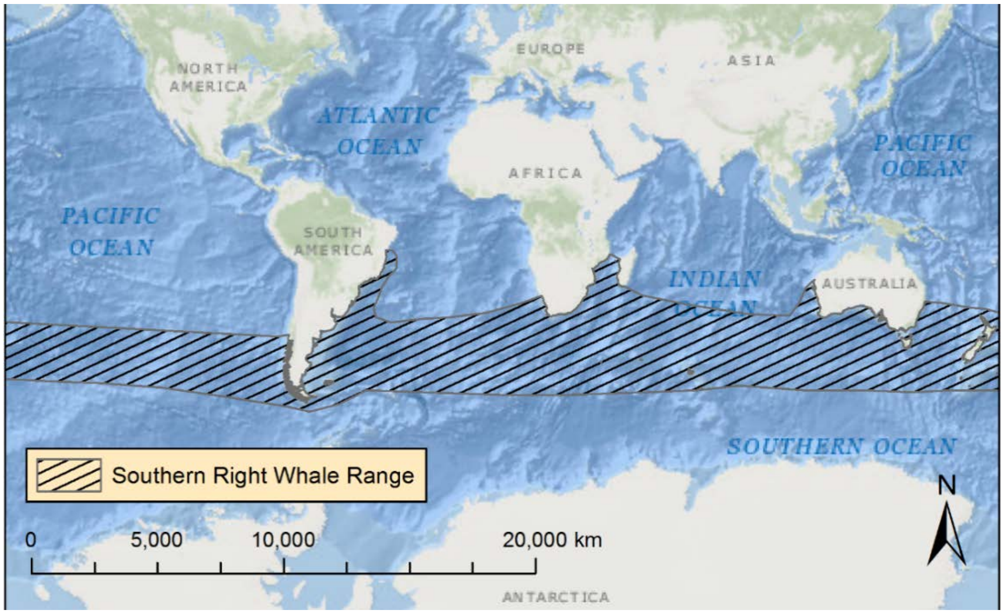

Figure 5. Map identifying the range of the endangered Southern right whale.

Southern right whales have a stocky, black body lacking a dorsal fin and a large head covered in callosities. They range in length between 13 to 17 meters (43 to 56 ft), and weigh up to 54,431 kg (120,000 lb). The Southern right whale was listed as endangered under the Endangered Species Preservation Act on June 2, 1970, and this listing was carried over when the ESA was enacted (Table 4).

We used information available in the 2015 Status Review (NMFS 2015a) and the International Whaling Commission's 2012 Report on the Assessment of Southern Right Whales (IWC 2012b) to summarize the life history, population dynamics, and status of this species, as follows.

8.4.1 Life History

The lifespan of Southern right whales is currently unknown but likely similar to North Pacific and North Atlantic right whales, who are believed to live to around 50 years old. Females usually give birth to their first calf between eight and ten years old and gestation takes approximately one year. Offspring wean at approximately one year of age, and females reproduce every three to four years. Southern right whales feed during austral summer in high latitude feeding grounds in the Southern Ocean, where they use their baleen to "skim" copepods and krill from the water. Mating likely occurs in winter in the low latitude breeding and calving grounds.

8.4.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Southern right whale.

In 2010, there were an estimated 15,000 Southern right whales worldwide; this is over twice the species estimate of 7,000 in 1997. The population structure for southern right whales is uncertain, but some separation to the population level exists. Breeding populations can be delineated based on geographic region: South Africa, Argentina, Brazil, Peru and Chile, Australia, and New Zealand. Population estimates for all of the breeding populations are not available. There are about 3,500 southern right whales in the Australia breeding population, about 4,000 in Argentina, 4,100 in South Africa, and 2,169 in New Zealand. Other smaller southern right whale populations occur off Tristan da Cunha, South Georgia, Namibia, Mozambique and Uruguay, but not much is known about the population abundance of these groups.

The Australia, South Africa and Argentina breeding stocks of southern right whales are increasing at an estimated seven percent annually. The Brazil breeding population is increasing, while the status of the Peru and Chile breeding population is unknown (NMFS 2015a). The New Zealand breeding population is showing signs of recovery; recent population modeling estimates the population growth rate at 5.6 percent (Davidson 2016). Juveniles in New Zealand show high apparent annual survival rates, between 0.87 and 0.95 percent (Carroll et al. 2016).

Mitochondrial DNA analysis of Southern right whales indicates at least 37 unique haplotypes and greater genetic diversity in the South Atlantic Ocean than in the Indo-Pacific (Patenaude et al. 2007). Females exhibit high site fidelity to calving grounds, restricting gene flow and establishing geographic breeding populations. Recent genetic testing reveals the possibility that individuals from different ocean basins are mixing on the Antarctic feeding grounds (Kanda et al. 2014).

Southern right whales are found in the Southern Hemisphere from temperate to polar waters, favoring shallow waters less than twenty meters deep. Southern right whales migrate between winter breeding areas in coastal waters of the South Atlantic, Pacific, and Indian Oceans from May to December and offshore summer (January to April) foraging locations in the Subtropical and Antarctic Convergence zones (Figure 5).

8.4.3 Vocalization and Hearing

Data on Southern right whale vocalizations indicates that they exhibit similar acoustic behavior to other right whales (Clark 1982; Matthews et al. 2001a). Right whales vocalize to communicate over long distances and for social interaction, including communication apparently informing others of prey path presence (Biedron et al. 2005; Tyson and Nowacek 2005). Vocalization patterns amongst all right whale species are generally similar, with six major call types: scream, gunshot, blow, up call, warble, and down call (McDonald and Moore 2002; Parks and Tyack 2005). A large majority of vocalizations occur in the 300 to 600 Hertz range with up and down sweeping modulations (Vanderlaan et al. 2003). Vocalizations below 200 Hertz and above 900 Hertz were rare and calls tend to be clustered, with periods of silence between clusters (Vanderlaan et al. 2003). Gunshot bouts last 1.5 hours on average and up to seven hours (Parks et al. 2012a). Blows are associated with ventilation and are generally inaudible underwater (Parks and Clark 2007). Up calls are 100 to 400 Hertz (Gillespie and Leaper 2001). Gunshots appear to be largely or exclusively male vocalization (Parks et al. 2005b).

Smaller groups vocalize more than larger groups and vocalization is more frequent at night (Matthews et al. 2001b). Moans are usually produced within 10 meters (33 feet) of the surface (Matthews et al. 2001b). Up calls were detected year-round in Massachusetts Bay except July and August and peaking in April (Mussoline et al. 2012). Individuals remaining in the Gulf of Maine through winter continue to call, showing a strong diel pattern of up call and gunshot vocalizations from November through January possibly associated with mating (Bort et al. 2011; Morano et al. 2012; Mussoline et al. 2012). Estimated source levels of gunshots in non-surface active groups are 201 decibels re: 1 μPa peak-to-peak (Hotchkin et al. 2011). While in surface active groups, females produce scream calls and males produce up calls and gunshot calls as threats to other males; calves (at least female calves) produce warble sounds similar top their mothers' screams (Parks et al. 2003; Parks and Tyack 2005). Source levels for these calls in surface active groups range from 137 to 162 decibels re: 1 μPa-meter (root mean square), except for gunshots, which are 174 to 192 decibels re: 1 μPa-meter (root mean square) (Parks and Tyack 2005). Up calls may also be used to reunite mothers with calves (Parks and Clark 2007). Atlantic right whales shift calling frequencies, particularly of up calls, as well as increase call amplitude over both long and short term periods due to exposure to vessel noise (Parks et al. 2005a; Parks et al. 2006; Parks and Clark 2007; Parks et al. 2007a; Parks et al. 2010; Parks et al. 2011; Parks et al. 2012b), particularly the peak frequency (Parks et al. 2009). North Atlantic right whales respond to anthropogenic sound designed to alert whales to vessel presence by surfacing (Nowacek et al. 2003; Nowacek et al. 2004).

There is no direct data on the hearing range of Southern right whales. However, based on anatomical modeling, the hearing range for North Atlantic right whales is predicted to be from 10 Hertz to 22 kilohertz with functional ranges probably between 15 Hertz to 18 kilohertz (Parks et al. 2007b).

8.4.4 Status

Southern right whales underwent severe decline due to whaling during the 18th and 19th centuries (NMFS 2015a). In general, Southern right whale populations appear to be increasing at a robust rate. Nonetheless, the current population estimate (15,000) is still much less than the estimated 60,000 pre-whaling estimate (NHT 2005). Southern right whales are currently subject to many of the same anthropogenic threats other large whales face. In the Southern Hemisphere, southern right whales are by far the most vessel struck cetacean, with at least 56 reported instances (48 confirmed and eight unconfirmed) ; nearly four-fold higher than the second most struck large whale (Van Waerebeek et al. 2007). Additional threats include declines in water quality, pollutant exposure and near shore habitat degradation from development. Reproductive success is influenced by krill availability on the feeding grounds; therefore, climatic shifts that change krill abundance may hinder the recovery of Southern right whales (Seyboth et al. 2016). Because populations appear to be increasing in size, the species appears to be somewhat resilient to current threats, but it has not recovered to pre-exploitation abundance.

8.4.5 Critical Habitat

No critical habitat has been designated for the Southern right whale.

8.4.6 Recovery Goals

NMFS has not prepared a Recovery Plan for the Southern right whale. In general, ESA-listed species which occur entirely outside U.S. jurisdiction are not likely to benefit from recovery plans (55 FR 24296; June 15, 1990).

8.5 Sperm Whale

The sperm whale is a widely distributed species found in all major oceans (Figure 6).

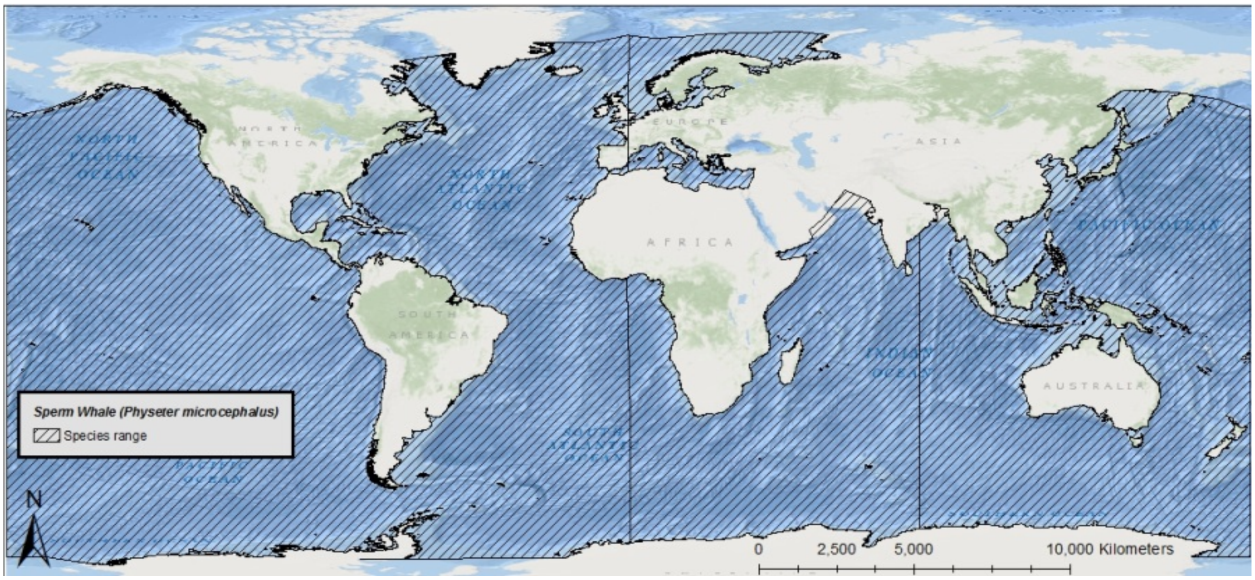

Figure 6. Map identifying the range of the endangered sperm whale.

Sperm whales are the largest toothed whale, distinguishable from other whales by its extremely large heard, which takes up to 25 to 35 percent of its total body length, and a single blowhole asymmetrically situated on the left side of the head near the tip. The sperm whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 2010a), recent stock assessment reports (Carretta et al. 2017; Hayes et al. 2017; Muto et al. 2017), and status review (NMFS 2015b) were used to summarize the life history, population dynamics, and status of the species as follows.

8.5.1 Life History

The average lifespan of sperm whales is estimated to be at least 50 years (Whitehead 2009). They have a gestation period of one to one and a half years, and calves nurse for approximately two years. Sexual maturity is reached between seven and 13 years of age for females with an average calving interval for four to six years. Male sperm whales reach full sexual maturity in their twenties. Sperm whales mostly inhabit areas with a water depth of 600 meters (1,968 feet) or more, and are uncommon in waters less than 300 meters (984 feet) deep. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed primarily on squid; other prey includes octopus and demersal fish (including teleosts and elasmobranchs).

8.5.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the sperm whale.

The sperm whale is the most abundant of the large whale species, with total abundance estimates between 200,000 and 1,500,000. The most recent estimate indicated a global population of between 300,000 and 450,000 individuals (Whitehead 2009). The higher estimates may be approaching population sizes prior to commercial whaling. There are no reliable estimates for sperm whale abundance across the entire Atlantic Ocean. However, estimates are available for two to three U.S. stocks in the Atlantic Ocean, the Northern Gulf of Mexico stock, estimated to consists of 763 individuals (N_{min}=560) and the North Atlantic stock, underestimated to consist of 2,288 individuals (N_{min}=1,815). There are insufficient data to estimate abundance for the Puerto Rico and U.S. Virgin Islands stock. In the northeast Pacific Ocean, the abundance of sperm whales was estimated to be between 26,300 and 32,100 in 1997. In the northeast Pacific Ocean, the abundance of sperm whales was estimated to be between 26,300 and 32,100 in 1997. In the eastern tropical Pacific Ocean, the abundance of sperm whales was estimated to be 22,700 (95 percent confidence intervals 14,800 to 34,600) in 1993. Population estimates are also available for two to three U.S. stocks that occur in the Pacific Ocean, the California/Oregon/Washington stock, estimated to consist of 2,106 individuals (N_{min}=1,332), and the Hawaii stock, estimated to consist of 3,354 individuals (N_{min}=2,539). There are insufficient data to estimate the population abundance of the North Pacific stock. We are aware of no reliable abundance estimates specifically for sperm whales in the South Pacific Ocean, and there is insufficient data to evaluate trends in abundance and growth rates of sperm whale populations at this time. There is insufficient data to evaluate trends in abundance and growth rates of sperm whales at this time.

Ocean-wide genetic studies indicate sperm whales have low genetic diversity, suggesting a recent bottleneck, but strong differentiation between matrilineal related groups (Lyrholm and Gyllensten 1998). Consistent with this, two studies of sperm whales in the Pacific Ocean indicate low genetic diversity (Mesnick et al. 2011; Rendell et al. 2012). Furthermore, sperm whales from the Gulf of Mexico, the western North Atlantic Ocean, the North Sea, and the Mediterranean Sea all have been shown to have low levels of genetic diversity (Engelhaupt et al. 2009). As none of the stocks for which data are available have high levels of genetic diversity, the species may be at some risk to inbreeding and 'Allee' effects, although the extent to which is currently unknown. Sperm whales have a global distribution and can be found in relatively deep waters in all ocean basins. While both males and females can be found in latitudes less than 40°, only adult males venture into the higher latitudes near the poles.

8.5.3 Vocalization and Hearing

Sound production and reception by sperm whales are better understood than in most cetaceans. Recordings of sperm whale vocalizations reveal that they produce a variety of sounds, such as clicks, gunshots, chirps, creaks, short trumpets, pips, squeals, and clangs (Goold 1999). Sperm whales typically produce short duration repetitive broadband clicks with frequencies below 100 Hertz to greater than 30 kilohertz (Watkins 1977) and dominant frequencies between 1 to 6 kilohertz and 10 to 16 kilohertz. Another class of sound, "squeals," are produced with frequencies of 100 Hertz to 20 kilohertz (e.g., Weir et al. 2007). The source levels of clicks can reach 236 dB re: 1 µPa at 1 meter, although lower source level energy has been suggested at around 171 dB re: 1 µPa at 1 meter (Weilgart and Whitehead 1993; Goold and Jones 1995; Weilgart and Whitehead 1997b; Mohl et al. 2003). Most of the energy in sperm whale clicks is concentrated at around 2 to 4 kilohertz and 10 to 16 kilohertz (Weilgart and Whitehead 1993; Goold and Jones 1995). The clicks of neonate sperm whales are very different from typical clicks of adults in that they are of low directionality, long duration, and low frequency (between 300 Hertz and 1.7 kilohertz) with estimated source levels between 140 to 162 dB re: 1 µPa at 1 meter (Madsen et al. 2003). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Norris and Harvey 1972).

Long, repeated clicks are associated with feeding and echolocation (Whitehead and Weilgart 1991; Weilgart and Whitehead 1993; Goold and Jones 1995; Weilgart and Whitehead 1997b; Miller et al. 2004). Creaks (rapid sets of clicks) are heard most frequently when sperm whales are foraging and engaged in the deepest portion of their dives, with inter-click intervals and source levels being altered during these behaviors (Miller et al. 2004; Laplanche et al. 2005). Clicks are also used during social behavior and intragroup interactions (Weilgart and Whitehead 1993). When sperm whales are socializing, they tend to repeat series of group-distinctive clicks (codas), which follow a precise rhythm and may last for hours (Watkins and Schevill 1977). Codas are shared between individuals in a social unit and are considered to be primarily for intragroup communication (Weilgart and Whitehead 1997b; Rendell and Whitehead 2004). Research in the South Pacific Ocean suggests that in breeding areas the majority of codas are produced by mature females (Marcoux et al. 2006). Coda repertoires have also been found to vary geographically and are categorized as dialects (Weilgart and Whitehead 1997b; Pavan et al. 2000). For example, significant differences in coda repertoire have been observed between sperm whales in the Caribbean Sea and those in the Pacific Ocean (Weilgart and Whitehead 1997b). Three coda types used by male sperm whales have recently been described from data collected over multiple years: these codas are associated with dive cycles, socializing, and alarm (Frantzis and Alexiadou 2008).

Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder and Ridgway 1990). From this whale, responses support a hearing range of 2.5 to 60 kilohertz and highest sensitivity to frequencies between 5 to

20 kilohertz. Other hearing information consists of indirect data. For example, the anatomy of the sperm whale's inner and middle ear indicates an ability to best hear high-frequency to ultrasonic hearing (Ketten 1992). The sperm whale may also possess better low-frequency hearing than other odontocetes, although not as low as many baleen whales (Ketten 1992). Reactions to anthropogenic sounds can provide indirect evidence of hearing capability, and several studies have made note of changes seen in sperm whale behavior in conjunction with these sounds. For example, sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins and Schevill 1975a; Watkins et al. 1985). In the Caribbean Sea, Watkins et al. (1985) observed that sperm whales exposed to 3.25 to 8.4 kilohertz pulses (presumed to be from submarine sonar) interrupted their activities and left the area. Similar reactions were observed from artificial sound generated by banging on a boat hull (Watkins et al. 1985). André et al. (1997) reported that foraging whales exposed to a 10 kilohertz pulsed signal did not ultimately exhibit any general avoidance reactions: when resting at the surface in a compact group, sperm whales initially reacted strongly, and then ignored the signal completely. Thode et al. (2007) observed that the acoustic signal from the cavitation of a fishing vessel's propeller (110 dB re: 1 μPa^2-s between 250 Hertz and one kilohertz) interrupted sperm whale acoustic activity and resulted in the animals converging on the vessel. Sperm whales have also been observed to stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999). Nonetheless, sperm whales are considered to be part of the mid-frequency marine mammal hearing group, with a hearing range between 150 Hertz and 160 kilohertz (NOAA 2018).

8.5.4 Status

The sperm whale is endangered as a result of past commercial whaling. Although the aggregate abundance worldwide is probably at least several hundred thousand individuals, the extent of depletion and degree of recovery of populations are uncertain. Commercial whaling is no longer allowed, however, illegal hunting may occur at biologically unsustainable levels. Continued threats to sperm whale populations include ship strikes, entanglement in fishing gear, competition for resources due to overfishing, population, loss of prey and habitat due to climate change, and noise. The species' large population size shows that it is somewhat resilient to current threats.

8.5.5 Critical Habitat

No critical habitat has been designated for the sperm whale.

8.5.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover sperm whale populations. These threats will be discussed in further detail in the *Environmental*

Baseline section (Section 9) of this opinion. See the 2010 Final Recovery Plan for the sperm whale for complete downlisting/delisting criteria for both of the following recovery goals:

1. Achieve sufficient and viable populations in all ocean basins.
2. Ensure significant threats are addressed.

9 ENVIRONMENTAL BASELINE

The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 C.F.R. §402.02).

A number of human activities have contributed to the status of populations of ESA-listed cetaceans in the action area. Some human activities are ongoing and appear to continue to affect marine mammal populations in the action area for this consultation. Some of these activities, most notably commercial whaling, occurred extensively in the past and continue at low levels that no longer appear to significantly affect marine mammal populations, although the effects of past reductions in numbers persist today. The following discussion summarizes the impacts, which include climate change, oceanic temperature regimes, whaling and subsistence harvest, vessel strike, whale watching, fisheries (fisheries interactions and aquaculture), pollution (marine debris, pesticides and contaminants, and hydrocarbons), deep sea-bed mining, aquatic nuisance species, disease, anthropogenic sound (vessel sound and commercial shipping, aircraft, seismic surveys, and marine construction), military activities, and scientific research activities.

9.1 Climate Change

The Atlantic Ocean appears to be warming faster than all other ocean basins except perhaps the southern oceans (Cheng et al. 2017). This is particularly evident in areas of the South Atlantic near the proposed action area. Based on satellite imagery, sea surface temperature (SST) off Angola has increased over the past three decades, with average rates between 0.23 °C and 0.8 °C per decade depending on the satellite data source used (See Figure 7). This is higher than the global average and southern Angola is specifically recognized as one of 24 ocean warming hotspots (Hobday and Pecl 2014). This warming is scattered with warm and cool periods which have generally become more pronounced in the south (which lies near the action area along the northern Namibian coast); particularly cool events (Jarre et al. 2015). These cool events seem to be caused by internal waves of tropical origin rather than an increase of winds that are favorable to upwelling (Lingen and Hampton 2018). There is evidence from satellite imagery of increased phytoplankton production off southern Angola in some years since 2002 (Jarre et al. 2015), but this observation should be treated with caution due to limitations of satellite imagery as a measure of chlorophyll concentration in southern Angolan waters. Current zooplankton assemblies off Angola are not consistent enough to provide a coherent time series of trends in zooplankton biomass and community structure, particularly for the subtropical system. A more definite climatic threat near the action area is considered to be sea level rise (estimated at about 0.6 mm per year during the 1990s (Hardman-Mountford et al. 2003) aggravated by rising sea surface temperature, and increased flooding from higher rainfall in the interior.

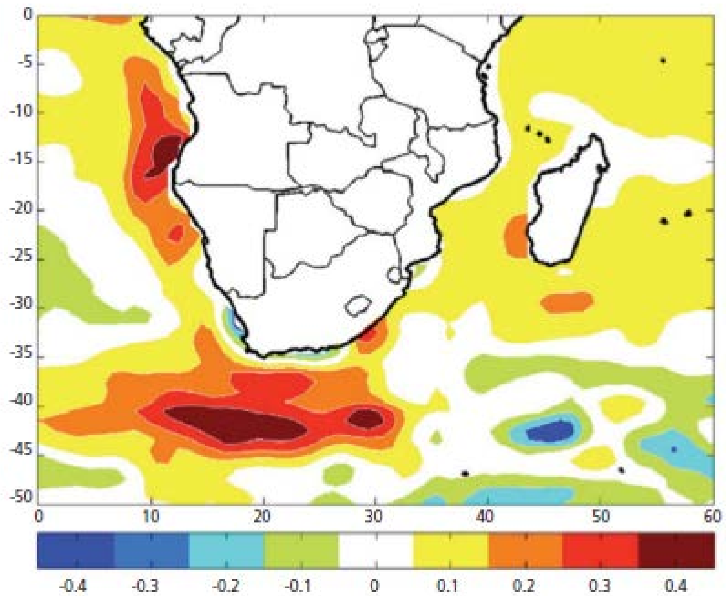

Figure 7. Linear trend of 1° x 1° resolution Reynolds Sea Surface Temperature in degrees Celsius per decade from 1982 to 2012 (Blamey et al., 2015 as cited in Lingen and Hampton 2018)

Climate change has the potential to impact species abundance, geographic distribution, migration patterns, and susceptibility to disease and contaminants, as well as the timing of seasonal activities and community composition and structure (MacLeod et al. 2005; Robinson et al. 2005; Kintisch 2006; Learmonth et al. 2006a; McMahon and Hays 2006; Evans and Bjørge 2013; IPCC 2014). Though predicting the precise consequences of climate change on highly mobile marine species is difficult (Simmonds and Isaac 2007a), recent research has indicated a range of consequences already occurring.

Changes in the marine ecosystem caused by global climate change (e.g., ocean acidification, salinity, oceanic currents, dissolved oxygen levels, nutrient distribution) could influence the distribution and abundance of lower trophic levels (e.g., phytoplankton, zooplankton, submerged aquatic vegetation, crustaceans, mollusks, and forage fish), ultimately affecting primary foraging areas of ESA-listed species including cetaceans. Marine species ranges are expected to shift as they align their distributions to match their physiological tolerances under changing environmental conditions (Doney et al. 2012). Hazen et al. (2012) examined top predator distribution and diversity in the Pacific Ocean in light of rising sea surface temperatures using a database of electronic tags and output from a global climate model. They predicted up to a 35 percent change in core habitat area for some key marine predators in the Pacific Ocean, with some species predicted to experience gains in available core habitat and some predicted to experience losses. Notably, blue whales were predicted to experience losses in available core habitat (McMahon and Hays 2006). The authors noted this is already occurring in the Atlantic Ocean. MacLeod (2009) estimated, based upon expected shifts in water temperature, 88 percent of cetaceans will be affected by climate change, with 47 percent predicted to experience unfavorable conditions (e.g., range contraction).

Similarly, climate-related changes in important prey species populations are likely to affect predator populations. For example, blue whales, as predators that specialize in eating krill, are likely to change their distribution in response to changes in the distribution of krill (Payne et al. 1986); (Payne et al. 1990); (Clapham et al. 1999). (Pecl and Jackson 2008) predicted climate change will likely result in squid that hatch out smaller and earlier, undergo faster growth over shorter life-spans, and mature younger at a smaller size. This could have negative consequences for species such as sperm whales, whose diets can be dominated by cephalopods. For ESA-listed species that undergo long migrations, if either prey availability or habitat suitability is disrupted by changing ocean temperatures regimes, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott 2009).

This review provides some examples of impacts to ESA-listed species and their habitats that may occur as the result of climate change. While it is difficult to accurately predict the consequences of climate change to a particular species or habitat, a range of consequences are expected that are likely to change the status of the species and the condition of their habitats, and may be exacerbated by additional threats in the action area.

9.2 Oceanic Temperature Regimes

Oceanographic conditions in the Atlantic and Pacific Oceans can be altered due to periodic shifts in atmospheric patterns. These climatic events can alter habitat conditions and prey distribution for ESA-listed species in the action areas (Beamish 1993; Mantua et al. 1997; Hare and Mantua 2001); (Benson and Trites 2002; Stabeno et al. 2004; Mundy and Cooney 2005). For example, decade-scale climatic regime shifts have been related to changes in zooplankton in the North Atlantic Ocean (Fromentin and Planque 1996), and decadal trends in the North Atlantic oscillation (Hurrell 1995) can affect the position of the Gulf Stream (Taylor et al. 1998) and other circulation patterns in the North Atlantic Ocean that act as migratory pathways for various marine species, especially fish.

The Angola-Benguela front is a near-surface oceanic frontal zone where the southward-flowing Angola Current meets the northward flowing Benguela Current (See Figure 8). This frontal zone is known to change in position and intensity across different timescales, and these fluctuations can have a profound impact on the regional South Atlantic near the proposed action area (Sun et al. 2018). High resolution computer simulations of the South Atlantic coupled with multiple oceanic and atmospheric re-analyses have provided strong indications of a southward shift in the position and intensification in the strength of the Angola/Benguela Front since 1980, related to a southward shift in the position of the South Atlantic subtropical anticyclone (Sun et al. 2018). Periodic, southward intrusions of warm, salty, nutrient-poor and low oxygen water onto the Namibian shelf with an associated poignant southward movement of the Angola/Benguela Front, known as Benguela Niños, have occurred roughly once a decade, most notably in 1994/95 when the intrusion was particularly extensive and protracted, and most recently in 2010/11 (Rouault et al. 2017). These have a noticeable impact on the environment and fishery resources of the northern and central Namibian coast and species not adapted to these abnormal conditions may die off or migrate. Both pelagic and demersal fish species showed mortalities and/or southward or offshore displacements associated with the 1994/95 event (Lingen and Hampton 2018). In the past three decades, sea surface temperature off the coast of northern Namibia has increased in all months of the year by between 0.2 degrees Celsius and 0.5 degrees Celsius per decade depending on season, but south of about Walvis Bay there has been no general change in sea surface temperature over this period (See Figure 7).

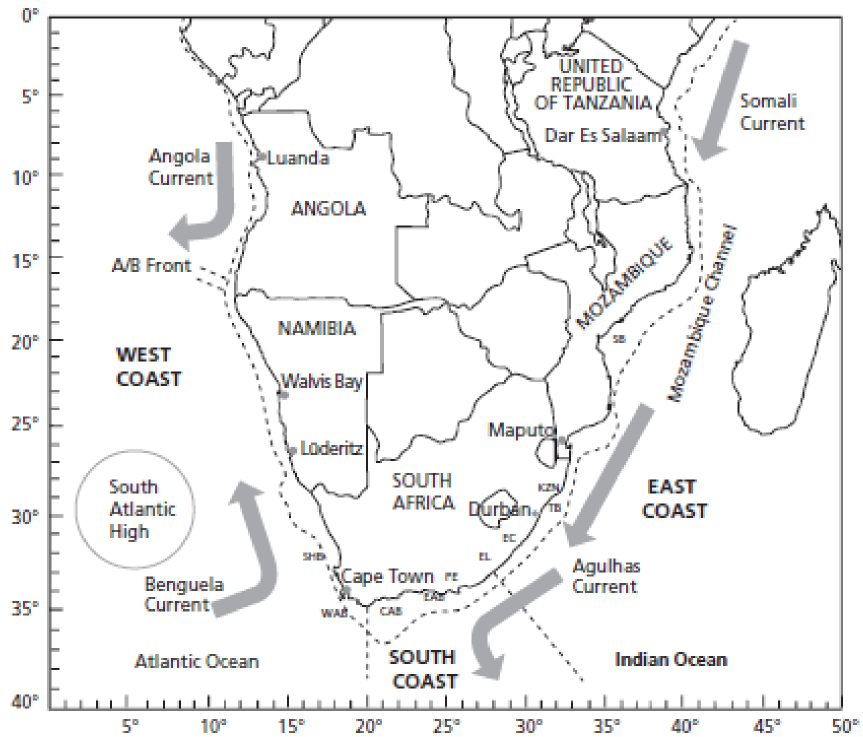

Figure 8. Map showing Angola-Benguela Front (Hardman-Mountford et al. 2003)

Longer-term trends in climate change and/or variability have the potential to alter habitat conditions suitable for ESA-listed species in the action area on a much longer time scale. For example, from 1906 through 2006, global surface temperatures have risen 0.74 degrees Celsius and this trend is continuing at an accelerating pace. Twelve of the warmest years on record since 1850 have occurred since 1995 (Poloczanska et al. 2009). Possible effects of this trend in climate change and/or variability for ESA-listed marine species in the action area include the alteration of community composition and structure, changes to migration patterns or community structure, changes to species abundance, increased susceptibility to disease and contaminants, altered timing of breeding and nesting, and increased stress levels (MacLeod et al. 2005; Robinson et al. 2005; Kintisch 2006; Learmonth et al. 2006b; McMahon and Hays 2006). Climate change can influence reproductive success by altering sperm whale fertility with females having lower rates of conception following periods of unusually warm sear surface temperature (Whitehead et al. 1997). However, gaps in information and the complexity of climatic interactions complicate the ability to predict the effects that climate change and/or variability may have to these species from year to year in the action area (Kintisch 2006; Simmonds and Isaac 2007b).

9.3 Whaling and Subsistence Harvesting

From 1864 to 1985, at least 2.4 million baleen whales and sperm whales were killed (Gambell 1999). The large number of baleen whales harvested during the 1930s and 1940s has been shown to correspond to increased cortisol levels in earplugs collected from baleen whales, suggesting that anthropogenic activities, such as those associated with whaling, may contribute to increased stress levels in whales (Trumble et al. 2018). Prior to current prohibitions on whaling most large whale species were significantly depleted to the extent it was necessary to list them as endangered under the Endangered Species Preservation Act of 1966. In 1982, the International Whaling Commission issued a moratorium on commercial whaling beginning in 1986. There is currently no legal commercial whaling by International Whaling Commission Member Nations party to the moratorium; however, whales are still killed commercially by countries that field objections to the moratorium (i.e., Iceland and Norway). Presently three types of whaling take place: (1) aboriginal subsistence whaling to support the needs of indigenous people; (2) special permit whaling; and (3) commercial whaling conducted either under objection or reservation to the moratorium. The reported catch and catch limits of large whale species from aboriginal subsistence whaling, special permit whaling, and commercial whaling can be found on the International Whaling Commission's website at: https://iwc.int/whaling.

Large whale population numbers in the action area have historically been impacted by early commercial exploitation, and some stocks were already reduced by 1864 (the beginning of the era of modern commercial whaling using harpoon guns as opposed to harpoons simply thrown by men). Near the proposed action area, southern right whales off Namibia were severely depleted by early 19th century whaling, with a decline of more than 95 percent, and rarely featured in modern whaling catches in the 1920s (Roux et al. 2015b). According to Currie et al. (2008), along the Namibian coast, the breeding population was probably eradicated through overexploitation before the species was granted protection in 1935. More than 3700 whales were killed out of Walvis Bay alone between 1788 and 1803 and the last recorded catch in the region was in 1913 in southern Angola. The historical breeding range included Walvis Bay, Conception Bay, Spencer Bay, Lüderitz Bay, Elizabeth Bay and the Sperrgebiet coast. Since then, sightings of this species have been extremely rare with only three sightings documented between 1971 and 1980. Subsequent monitoring has shown that the species has been present in its former historical range but in extremely low numbers (with only 28 sightings involving 45 individuals between 1991 and 1999).

Most current whaling activities occur outside of the action area. Regardless, prior exploitation is likely to have altered population structure and social cohesion of all whale species within the action area, such that effects on abundance and recruitment continued for years after harvesting has ceased. ESA-listed whale mortalities since 1986 resulting from these activities can be seen below in Table 7 (IWC 2017b; IWC 2017c; IWC 2017a).

Table 7. Endangered Species Act-listed cetacean mortalities as the result of whaling since 1985.

Species	Commercial Whaling	Scientific Research	Subsistence
Blue Whale	-- --	-- --	-- --
Fin Whale	706	310	385
Sei Whale	-- --	1,563	3
Sperm Whale	388	56	-- --
Southern Right Whale	-- --	-- --	-- --

DPS=Distinct Population Segment

Many of the whaling numbers reported represent minimum catches, as illegal or underreported catches are not included. For example, recently uncovered Union of Soviet Socialists Republics catch records indicate extensive illegal whaling activity between 1948 and 1979 (Ivashchenko et al. 2014). Additionally, despite the moratorium on large-scale commercial whaling, catch of some of these species still occurs whether it be under objection of the International Whaling Commission, for aboriginal subsistence purposes, or under International Whaling Commission scientific permit 1985 through 2013. Some of the whales killed in these fisheries are likely part of the same population of whales occurring within the action area for this consultation.

Historically, commercial whaling caused all of the large whale species to decline to the point where they faced extinction risks high enough to list them as endangered species. Since the end of large-scale commercial whaling, the primary threat to the species has been eliminated. Many whale species have not yet fully recovered from those historic declines. Scientists cannot determine if those initial declines continue to influence current populations of most large whale species in the Atlantic Ocean. For example, the North Atlantic right whale (*Eubalaena glacialis*) has not recovered from the effects of commercial whaling and continue to face very high risks of extinction because of their small population sizes and low population growth rates. In contrast, populations of species such as southern right whales have increased substantially from post-whaling population levels and appear to be recovering despite the impacts of vessel strikes, interactions with fishing gear, and increased levels of ambient sound.

9.4 Vessel Strike

Vessels have the potential to affect animals through strikes, sound, and disturbance associated with their physical presence. Responses to vessel interactions include interruption of vital behaviors and social groups, separation of mothers and young, and abandonment of resting areas (Mann et al. 2000; Samuels et al. 2000; Boren et al. 2001; Constantine 2001; Nowacek 2001). Whale watching, a profitable and rapidly growing business with more than nine million participants in 80 countries and territories, may increase these types of disturbance and negatively affect the species (Hoyt 2001).

Vessel strikes are considered a serious and widespread threat to ESA-listed cetaceans (especially large whales) and are the most well-documented "marine road" interaction with large whales (Pirotta et al. 2019). This threat is increasing as commercial shipping lanes cross important breeding and feeding habitats and as whale populations recover and populate new areas or areas where they were previously extirpated (Swingle et al. 1993; Wiley et al. 1995). In the South Atlantic Ocean, southern right whales are especially susceptible where shipping lanes overlap with suspected breeding and calving areas. For example, in September 2012, a ship strike on a right whale was reported off Rio de Janeiro. Van Waerebeek et al. (2007) claims that Southern right whale populations off South Africa and off eastern South America (Brazil, Uruguay and Argentina) suffer significant mortality claiming that 48 out of the 79 confirmed cases of large cetacean deaths by vessel collision in the southern hemisphere occurred with southern right whales, representing 61 percent of all confirmed reports. Using stranding records of southern right whales in South Africa from 1963-1998, Best et al. (2001) identified ship collisions as a known or possible factor in 20 percent (11 of 55) of recorded deaths. Of these, 55 percent (6 of 11) involved calves or juveniles. In five cases ship strikes were cited as a definite cause of death and in six cases they were considered a possible cause. Two of the five definite ship strikes involved known vessels, a hopper dredge and a ferry. Non-fatal collisions (n=5) involved two motor launches, a six meter inflatable boat, a catamaran whale- watching boat, and a fisheries patrol boat (Best et al ., 2001).

As vessels become faster and more widespread, an increase in vessel interactions with cetaceans is to be expected. All sizes and types of vessels can hit whales, but most lethal and severe injuries are caused by vessels 80 meters (262.5 feet) or longer (Laist et al. 2001). For whales, studies show that the probability of fatal injuries from vessel strikes increases as vessels operate at speeds above 26 kilometers per hour (14 knots) (Laist et al. 2001). Evidence suggests that not all whales killed as a result of vessel strike are detected, particularly in offshore waters, and some detected carcasses are never recovered while those that are recovered may be in advanced stages of decomposition that preclude a definitive cause of death determination (Glass et al. 2010). The vast majority of commercial vessel strike mortalities of cetaceans are likely undetected and unreported, as most are likely never reported. Most animals killed by vessel strike likely end up sinking rather than washing up on shore (Cassoff 2011). Kraus et al. (2005) estimated that 17 percent of vessel strikes are actually detected. Therefore, it is likely that the number of documented cetacean mortalities related to vessel strikes is much lower than the actual number of moralities associated with vessel strikes, especially for less buoyant species such as blue and fin whales (Rockwood et al. 2017).

9.5 Whale Watching

Whale watching is a rapidly-growing business with more than 3,300 operators worldwide, serving 13 million participants in 119 countries and territories (O'Connor et al. 2009). As of 2010, commercial whale watching was a one billion dollar global industry per year (Lambert et al. 2010). Private vessels may partake in this activity as well. NMFS has issued regulations and guidelines relevant to whale watching. As noted previously, many of the cetaceans considered in this opinion are highly migratory, so may also be exposed to whale watching activity occurring outside of the action area.

Although considered by many to be a non-consumptive use of cetaceans with economic, recreational, educational and scientific benefits, whale watching is not without potential negative impacts (reviewed in Parsons 2012). Whale watching has the potential to harass whales by altering feeding, breeding, and social behavior, or even injure them if the vessel gets too close or strikes the animal. Preferred habitats may be abandoned if disturbance levels are too high. Animals may also become more vulnerable to vessel strikes if they habituate to vessel traffic (Swingle et al. 1993; Wiley et al. 1995).

Several studies have examined the short-term effects of whale watching vessels on cetaceans (Watkins 1986b; Corkeron 1995; Au and Green 2000; Felix 2001; Erbe 2002b; Magalhaes et al. 2002; Williams et al. 2002; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005b). A whale's behavioral responses to whale watching vessels depended on the distance of the vessel from the whale, vessel speed, vessel direction, vessel sound, and the number of vessels. In some circumstances, whales do not appear to respond to vessels, but in other circumstances, whales change their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions. Disturbance by whale watch vessels has also been noted to cause newborn calves to separate briefly from their mother's sides, which leads to greater energy expenditures by the calves (NMFS 2006b).

Although numerous short-term behavioral responses to whale watching vessels were documented, little information is available on whether long-term negative effects result from whale watching (NMFS 2006b). Christiansen et al. (2014) estimated that cumulative time minke whales spent with whale watching boats in Iceland to assess the biological significance of whale watching disturbances and found that, though some whales were repeatedly exposed to whale watching boats throughout the feeding season, the estimated cumulative time they spent with boats was very low. Christiansen et al. (2014) suggested that the whale watching industry, in its current state, is likely not having any long-term negative effects on vital rates.

It is difficult to precisely quantify or estimate the magnitude of the risks posed to cetaceans in general from vessel approaches associated with whale watching. Given that the proposed seismic survey activities will not occur within approximately 650 kilometers (404 miles) of land, few (if any) whale watching vessels, if any, will be expected to co-occur with the proposed action's research vessel.

9.6 Fisheries

Fisheries constitute an important and widespread use of the ocean resources throughout the action area. Fisheries can adversely affect fish populations, other species, and habitats. Direct effects of fisheries interactions on cetaceans include entanglement and entrapment, which can lead to fitness consequences or mortality as a result of injury or drowning. Indirect effects include reduced prey availability, including overfishing of targeted species, and destruction of habitat. Use of mobile fishing gear, such as bottom trawls, disturbs the seafloor and reduces structural complexity. Indirect impacts of trawls include increased turbidity, alteration of surface sediment, removal of prey (leading to declines in predator abundance), removal of predators, ghost fishing (i.e., lost fishing gear continuing to ensnare fish and other marine animals), and generation of marine debris. Lost gill nets, purse seines, and long-lines may foul and disrupt bottom habitats and have the potential to entangle or be ingested by cetaceans.

According to Currie et al. (2008), extensive commercial fishing by foreign fleets started in South West African waters in 1947, when 1,000 tons of Sardine were initially caught. This industry developed quickly and by 1953 catches, by more than 100 purse seiners, had increased to 262,000 tons. Throughout 1968, 1.4 million tons were caught. Sardine stocks fell significantly in the late 1960s and early 1970s. Falloffs were ascribed to over-fishing and environmental disturbances in the ecosystem, which also caused stock fluctuations. Sardine biomass in Namibia dwindled to a few thousand tons in 1995/96 following the 1995 Benguela Niño. Since then minimal stocks have contracted to the north of Mercury Island. After the collapse of Sardine, the fishing industry turned to Anchovy but this fishery also collapsed when stocks became severely depleted and after 1996, catches were negligible. (Currie et al. 2008).

As described above, fisheries can also have a profound influence on fish populations. In a study of retrospective data, Jackson et al. (2001) concluded that ecological extinction caused by overfishing precedes all other pervasive human disturbance of coastal ecosystems, including pollution and anthropogenic climatic change. Cetaceans are known to feed on several species of fish that are harvested by humans (Waring et al. 2008). Thus, competition with humans for prey is a potential concern. Reductions in fish populations in the action area, whether natural or human-caused, may affect the survival and recovery of ESA-listed whale species considered in this opinion since the Namibian and South African coast is host to several feeding grounds for large whales (Roux et al. 2015b).

9.6.1 Fisheries Interaction

Globally, 6.4 million tons of fishing gear is lost in the oceans every year (Wilcox et al. 2015). Entrapment and entanglement in fishing gear is a frequently documented source of human-caused mortality in cetaceans (see Dietrich et al. 2007). Materials entangled tightly around a body part may cut into tissues, enable infection, and severely compromise an individual's health (Derraik 2002). Entanglements also make animals more vulnerable to additional threats (e.g., predation and vessel strikes) by restricting agility and swimming speed. The majority of cetaceans that die from entanglement in fishing gear likely sink at sea rather than strand ashore, making it difficult to accurately determine the extent of such mortalities. In excess of 97 percent of entanglement is caused by derelict fishing gear (Baulch and Perry 2014a).

Cetaceans are also known to ingest fishing gear, likely mistaking it for prey, which can lead to fitness consequences and mortality. Necropsies of stranded whales have found that ingestion of net pieces, ropes, and other fishing debris has resulted in gastric impaction and ultimately death (Jacobsen et al. 2010a). As with vessel strikes, entanglement or entrapment in fishing gear likely has the greatest impact on populations of ESA-listed species with the lowest abundance (e.g., Kraus et al. 2016). Nevertheless, all species of cetaceans may face threats from derelict fishing gear.

According to Meÿer et al. (2011), major causes of large whale entanglement near the proposed action area (i.e. South Africa) are static fishing gear, specifically due to the West Coast rock lobster (*Jasus lalandii*) industry, and large-mesh gillnets (shark nets) that are set off the coast to reduce shark attacks. The occurrence of entanglements is temporal with spikes in activity overlapping with the breeding migrations of humpback whales and southern right whales, the two large whale species that are the most predisposed to entanglement. Together, humpback whales (n = 49) and southern right whales (n = 19) comprised 85 percent of the large whales caught in shark nets between 1981 and 2009 (disregarding suspected whale encounters). The other 15 percent consisted of minke whales (n = 10), sperm whales Physeter macrocephalus (n = 1) and Bryde's whales (n = 1). Seasonally, large whales were caught in the shark nets mainly between July and November (Meÿer et al. 2011). Outside of shark netted areas (i.e. offshore of southwest South Africa), there were 96 records of large whale entanglements in fishing gear or associated gear between 1975 and 2009. Of these incidents, 58 involved southern right whales (60 percent) and 16 (17 percent) were humpback whales, with the remaining 22 (23 percent) unidentified. These entanglement events significantly overlap with rock lobster fishing grounds. Gear associated with the West Coast rock lobster industry, namely ropes, ropes with traps attached or ropes with buoys attached, accounted for 74 percent of entanglements for which the gear type was identified in this area (Meÿer et al. 2011). Furthermore, even though rare in shallow depths off the coast of Namibia, there was one recorded entanglement incident from lobster trap ropes in 2006 of a southern right whale (Currie et al. 2008).

In addition to these direct impacts, cetaceans may also be subject to indirect impacts from fisheries. Cetaceans probably consume at least as much fish as is harvested by humans (Kenney et al. 1985). Many cetacean species (particularly fin and humpback whales) are known to feed on species of fish that are harvested by humans (Carretta et al. 2016). Even species that do not directly compete with human fisheries could be indirectly affected by fishing activities through changes in ecosystem dynamics.

9.6.2 Aquaculture

In Namibia, commercial marine aquaculture is currently controlled by oyster and abalone production in Walvis Bay, Swakopmund and Luderitz. Both Pacific oyster (Crassostrea gigas) and European oyster (Ostrea edulis) are grown. Culture methods include baskets suspended from rafts and long lines and onshore raceways, at open sea and ponds (FAO 2015). With inadequate and subsidiary information available on Namibian aquaculture, the total annual production was estimated rather conservatively to be 470 tons in 2013 (FAO 2015).

Aquaculture has the potential to impact protected species via entanglement and/or other interaction with aquaculture gear (i.e., buoys, nets, and lines), introduction or transfer of pathogens, increased vessel traffic and noise, impacts to habitat and benthic organisms, and water quality (Lloyd 2003; Clement 2013; Price and Morris 2013; Price et al. 2017). Current data suggest that interactions and entanglements of ESA-listed cetaceans with aquaculture gear are rare (Price et al. 2017). This may be because worldwide the number and density of aquaculture farms are low, and thus there is a low probability of interactions, or because they pose little risk of ESA-listed cetaceans. Nonetheless, given that in some aquaculture gear, such as that used in longline mussel farming, is similar to gear used in commercial fisheries, aquaculture may impact similar to fisheries and bycatch, as discussed above in Section 9.6.1, respectively.

9.7 Pollution

Within the action area, pollution poses a threat to ESA-listed cetaceans. Pollution can come in the form of marine debris, pesticides, contaminants, and hydrocarbons.

9.7.1 Marine Debris

Marine debris is an ecological threat that is introduced into the marine environment through ocean dumping, littering, or hydrologic transport of these materials from land-based sources (Gallo et al. 2018). Even natural phenomena, such as tsunamis and continental flooding, can cause large amounts of debris to enter the ocean environment (Watters et al. 2010). Marine debris has been discovered to be accumulating in gyres throughout the oceans. Cetaceans often become entangled in marine debris, including fishing gear (Baird et al. 2015). Despite debris removal and outreach to heighten public awareness, marine debris in the environment has not been reduced (NRC 2008) and continues to accumulate in the ocean and along shorelines within the action area.

Marine debris affects marine habitats and marine life worldwide, primarily by entangling or choking individuals that encounter it (Gall and Thompson 2015). Entanglement in marine debris can lead to injury, infection, reduced mobility, increased susceptibility to predation, decreased feeding ability, fitness consequences, and mortality for ESA-listed species in the action area. Entanglement can also result in drowning for air breathing marine species including cetaceans. The ingestion of marine debris has been documented to result in blockage or obstruction of the digestive tract, mouth, and stomach lining of various species and can lead to serious internal injury or mortality (Derraik 2002). In addition to interference with alimentary processes, plastics lodged in the alimentary tract could facilitate the transfer of pollutants into the bodies of whales and dolphins (Derraik 2002). Law et al. (2010) presented a time series of plastic content at the surface of the western North Atlantic Ocean and Caribbean Sea from 1986 through 2008. More than 60 percent of 6,136 surface plankton net tows collected small, buoyant plastic pieces. Data on marine debris in some locations of the action area is largely lacking; therefore, it is difficult to draw conclusions as to the extent of the problem and its impacts on populations of ESA-listed species in the South Atlantic Ocean, but we assume similar effects from marine debris documented within other ocean basins could also occur to species from marine debris.

Cetaceans are also impacted by marine debris, which includes: plastics, glass, metal, polystyrene foam, rubber, and derelict fishing gear (Baulch and Perry 2014b; Li et al. 2016). Over half of cetacean species (including blue, fin, humpback, sei, and sperm whales) are known to ingest marine debris (mostly plastic), with up to 31 percent of individuals in some populations containing marine debris in their guts and being the cause of death for up to 22 percent of individuals found stranded on shorelines (Baulch and Perry 2014a).

Given the limited knowledge about the impacts of marine debris on cetaceans, it is difficult to determine the extent of the threats that marine debris poses to cetaceans. However, marine debris is consistently present and has been found throughout the Earth’s oceans. Fin whales in the Mediterranean Sea are exposed to high densities of microplastics on the feeding grounds, and in turn exposed to a higher oxidative stress because of the presence of plasticizers, an additive in plastics (Fossi et al. 2016). In 2008, two sperm whales stranded along the California coast, with an assortment of fishing related debris (e.g., net scraps, rope) and other plastics inside their stomachs (Jacobsen et al. 2010b). One whale was emaciated, and the other had a ruptured stomach. It was suspected that gastric impactions was the cause of both deaths. Jacobsen et al. (2010b) speculated the debris likely accumulated over many years, possibly in the North Pacific gyre that will carry derelict Asian fishing gear into eastern Pacific Ocean waters. In January and February 2016, 30 sperm whales stranded along the coast of the North Sea (in Germany, the Netherlands, Denmark, France, and Great Britain); of the 22 dissected specimens, nine had marine debris in their gastro-intestinal tracts. Most of it (78 percent) was fishing-related debris (e.g., nets, monofilament line) and the remainder (22 percent) was general debris (plastic bags, plastic buckets, agricultural foils) (Unger et al. 2016).

Plastic debris is a major concern because it degrades slowly and many plastics float. The floating debris is transported by currents throughout the oceans and has been discovered accumulating in oceanic gyres (Law et al. 2010). Additionally, plastic waste in the ocean chemically attracts hydrocarbon pollutants such as polychlorinated biphenyl and dichlorodiphenyltrichloroethane. Cetaceans can mistakenly consume these wastes containing elevated levels of toxins instead of their prey. It is expected cetaceans may be exposed to marine debris over the course of the action although the risk of ingestion or entanglement and the resulting impacts are uncertain at the time of this consultation. Nevertheless, given the documented history of high fishing levels in the action area (as discussed in Section 9.6), it is assumed that cetaceans in the action area have the potential to be exposed to the various forms of marine debris discussed in this section.

9.7.2 Pesticides and Contaminants

Exposure to pollution and contaminants have the potential to cause adverse health effects in marine species. Marine ecosystems receive pollutants from a variety of local, regional, and international sources, and their levels and sources are therefore difficult to identify and monitor (Grant and Ross 2002). Marine pollutants come from multiple municipal, industrial, and household as well as from atmospheric transport (Iwata 1993; Grant and Ross 2002; Garrett 2004; Hartwell 2004). Contaminants may be introduced by rivers, coastal runoff, wind, ocean dumping, dumping of raw sewage by boats and various industrial activities, including offshore oil and gas or mineral exploitation (Grant and Ross 2002; Garrett 2004; Hartwell 2004).

The accumulation of persistent organic pollutants, including polychlorinated-biphenyls, dibenzo-p-dioxins, dibenzofurans and related compounds, through trophic transfer may cause mortality and sub-lethal effects in long-lived higher trophic level animals (Waring et al. 2016), including immune system abnormalities, endocrine disruption, and reproductive effects (Krahn et al. 2007). Persistent organic pollutants may also facilitate disease emergence and lead to the creation of susceptible “reservoirs” for new pathogens in contaminated cetacean populations (Ross 2002). Recent efforts have led to improvements in regional water quality and monitored pesticide levels have declined, although the more persistent chemicals are still detected and are expected to endure for years (Mearns 2001; Grant and Ross 2002).

Numerous factors can affect concentrations of persistent pollutants in cetaceans, such as age, sex and birth order, diet, and habitat use (Mongillo et al. 2012). In cetaceans, pollutant contaminant load for males increases with age, whereas females pass on contaminants to offspring during pregnancy and lactation (Addison and Brodie 1987; Borrell et al. 1995). Pollutants can be transferred from mothers to juveniles at a time when their bodies are undergoing rapid development, putting juveniles at risk of immune and endocrine system dysfunction later in life (Krahn et al. 2009). While exposure to pesticides and other contaminants is likely to continue and occur for cetaceans in the action area through the duration of the project, the level of risk and degree of impact is unknown. Nevertheless, the action area is adjacent to South Africa which is one of the largest importers of pesticides on the African continent (Quinn et al. 2011).

9.7.3 Hydrocarbons

Exposure to hydrocarbons released into the environment via oil spills and other discharges pose risks to ESA-listed cetaceans. Cetaceans are generally able to metabolize and excrete limited amounts of hydrocarbons, but exposure to large amounts of hydrocarbons and chronic exposure over time pose greater risks (Grant and Ross 2002). Acute exposure of cetaceans to petroleum products causes changes in behavior and may directly injure animals (Geraci 1990). For example, the *Deepwater Horizon* oil spill in the Gulf of Mexico in 2010 led to the exposure of tens of thousands of cetaceans to oil, causing reproductive failure, adrenal disease, lung disease, and poor body condition. The *Deepwater Horizon* oil spill in the Gulf of Mexico in 2010 led to the exposure of tens of thousands of cetaceans to oil, causing reproductive failure, adrenal disease, lung disease, and poor body condition.

Near the action area, two large oil spill events have occurred as a result of oil tanker accidents. One of the largest oil spills to occur near the action area was an explosion in 1991 which occurred on board the oil tanker ABT Summer 700 nautical miles off the Angolan coast, spilling its cargo of around 260,000 tons of oil and polluting the coastline (White and C. Molloy 2003). In addition, the capsizing of the *Castillo de Bellver* 70 miles from the Southwest coast of South Africa resulted in 250,000 tons of oil being expelled into the ocean near the action area (White and C. Molloy 2003). Due to each of these incidents occurring far offshore, both of these oil spills resulted in fairly minor impacts to the marine environment compared to other oil spills (White and C. Molloy 2003).

Cetaceans have a thickened epidermis that greatly reduces the likelihood of petroleum toxicity from skin contact with oils (Geraci 1990), but they may inhale these compounds at the water's surface and ingest them while feeding (Matkin and Saulitis 1997). For example, as a result of the *Deepwater Horizon* oil spill, sperm whales could have been exposed to toxic oil components through inhalation, aspiration, ingestion, and dermal exposure. There were 19 observations of 33 sperm whales swimming in *Deepwater Horizon* surface oil or that had oil on their bodies (Diaz 2015 as cited in Deepwater Horizon NRDA Trustees 2016). The effects of oil exposure likely included physical and toxicological damage to organ systems and tissues, reproductive failure, and death. Whales may have experienced multiple routes of exposure at the same time, over intermittent timeframes and at varying rates, doses, and chemical compositions of oil based on observed impacts to bottlenose dolphins. Hydrocarbons also have the potential to impact prey populations, and therefore may affect ESA-listed species indirectly by reducing food availability. We assume this would also be true for animals utilizing habitat in the action area.

9.8 Deep Sea-Bed Mining

According to Currie et al. (2008), extensive diamond mining occurs on land and in the sea on the west coasts of South Africa and Namibia. In this area, many risks are present as a result of mining activities and their effect on the marine environment. For example, sediment plumes and beach accretion threaten inshore reef habitats and kelp beds. The sources of sediment pollution and unnatural sediment plumes in these inshore marine habitats include discharge points from mine treatment plants. Destruction of healthy reef areas during the removal of diamondiferous gravels is also cause for concern. Typically, seabed with a soft sediment or gravel surface is targeted. However, removal of large boulders in order to reach gravel pockets on reefs, not only destroy the benthic life on the boulders, but also sessile benthic life on the immediate surrounding reef area. The damage to benthic life on the reef is further exacerbated long afterwards by the scouring effect of loose boulders moving over the reef area through the effect of swell and bottom surges. The size of the area affected by dumping of overcast material from mining and dredging vessels onto unmined seabed sites adjacent to mined sites may become problematic. In addition, when kelp beds are very dense and mining pipes tend to get entangled, illegal kelp cutting by diamond divers may occur. Kelp-cutting, which has been done by small-scale operators in the past is also thought to be destructive to the kelp bed habitat. These habitats are particularly important for juvenile rock lobsters that shelter at the base of kelp plants, amongst the holdfasts(Currie et al. 2008). In all, the impacts of deep sea-bed mining (i.e. damage to coral reefs and kelp beds) can cause negative impacts to cetaceans in the action area by causing reductions in prey species that occupy coral reefs and kelp bed habitats during larval or juvenile life stages.

9.9 Aquatic Nuisance Species

Aquatic nuisance species are aquatic and terrestrial organisms, introduced into new habitats throughout the U.S. and other areas of the world, that produce harmful impacts on aquatic ecosystems and native species (http://www.anstaskforce.gov). They are also referred to as invasive, alien, or non-indigenous species. Invasive species have been referred to as one of the top four threats to the world's oceans (Raaymakers and Hilliard 2002; Raaymakers 2003; Terdalkar et al. 2005; Pughiuc 2010). Introduction of these species is cited as a major threat to biodiversity, second only to habitat loss (Wilcove et al. 1998). A variety of vectors are thought to have introduced non-native species including, but not limited to aquarium and pet trades, recreation, and ballast water discharges from ocean-going vessels. Common impacts of invasive species are alteration of habitat and nutrient availability, as well as altering species composition and diversity within an ecosystem (Strayer 2010). Shifts in the base of food webs, a common result of the introduction of invasive species, can fundamentally alter predator-prey dynamics up and across food chains (Moncheva and Kamburska 2002), potentially affecting prey availability and habitat suitability for ESA-listed species. They have been implicated in the endangerment of 48 percent of ESA-listed species (Czech and Krausman 1997). Currently, there is little information on the level of aquatic nuisance species and the impacts of these invasive species may have on cetaceans in the action area through the duration of the project. Therefore, the level of risk and degree of impact to ESA-listed cetaceans is unknown.

9.10 Anthropogenic Sound

The ESA-listed cetacean species that occur in the action area are regularly exposed to several sources of anthropogenic sounds. These include, but are not limited to maritime activities, aircraft, seismic surveys (exploration and research), and marine construction (cable-laying, dredging, and pile-driving). These activities occur to varying degrees throughout the year. Cetaceans generate and rely on sound to navigate, hunt, and communicate with other individuals and anthropogenic sound can interfere with these important activities (Nowacek et al. 2007). The ESA-listed cetacean species have the potential to be impacted by either increased levels of anthropogenic-induced background sound or high intensity, short-term anthropogenic sounds.

Anthropogenic sound in the action area may be generated by commercial and recreational vessels, sonar, aircraft, seismic surveys, in-water construction activities, and other human activities. These activities occur to varying degrees throughout the year. The scientific community recognizes the addition of anthropogenic sound to the marine environment as a stressor that can possibly harm marine animals or significantly interfere with their normal activities (NRC 2005). Within the action area, ESA-listed cetaceans considered in this consultation may be impacted by anthropogenic sound in various ways. Once detected, some sounds may produce a behavioral response, including but not limited to, avoidance of impacted habitat areas affected by irritating sounds, changes in diving behavior, or (for cetaceans) changes in vocalization patterns (MMC 2007).

Many researchers have described behavioral responses of cetaceans to sounds produced by vessels, as well as other sound sources such as helicopters and fixed-wing aircraft, and dredging and construction (and Nowacek et al. 2007; reviewed in Gomez et al. 2016). Most observations have been limited to short-term behavioral responses, which included avoidance behavior and temporary cessation of feeding, resting, or social interactions; however, in terrestrial species habitat abandonment can lead to more long-term effects, which may have implications at the population level (Barber et al. 2010). Masking may also occur, in which an animal may not be able to detect, interpret, and/or respond to biologically relevant sounds. Masking can reduce the range of communication, particularly long-range communication, such as that for blue and fin whales. This can have a variety of implications for an animal's fitness including, but not limited to, predator avoidance and the ability to reproduce successfully (MMC 2007). Recent scientific evidence suggests that cetaceans, including several baleen whales, compensate for masking by changing the frequency, source level, redundancy, or timing of their signals, but the long-term implications of these adjustments are currently unknown (Parks 2003; McDonald et al. 2006a; Parks 2009). We assume similar impacts have occurred and will continue to affect marine species in the action area.

Despite the potential for these impacts to affect individual ESA-listed cetaceans, information is not currently available to determine the potential population level effects of anthropogenic sound levels in the marine environment (MMC 2007) and therefore within the action area. For example, we currently lack empirical data on how sound impacts growth, survival, reproduction, and vital rates, nor do we understand the relative influence of such effects on the population being considered. As a result, the consequences of anthropogenic sound on ESA-listed cetaceans at the population or species scale remain uncertain, although recent efforts have made progress establishing frameworks to consider such effects (NAS 2017).

9.10.1 Vessel Sound and Commercial Shipping

Much of the increase in sound in the ocean environment is due to increased shipping, as vessels become more numerous and of larger tonnage (NRC 2003b; Hildebrand 2009b; Mckenna et al. 2012). Commercial shipping continues a major source of low-frequency sound in the ocean, particularly in the Northern Hemisphere where the majority of vessel traffic occurs. Although large vessels emit predominantly low frequency sound, studies report broadband sound from large cargo vessels above 2 kilohertz. The low frequency sounds from large vessels overlap with many mysticetes predicted hearing ranges (7 Hertz to 35 kilohertz) (NOAA 2018) and may mask their vocalizations and cause stress (Rolland et al. 2012). The broadband sounds from large vessels may interfere with important biological functions of odontocetes, including foraging (Holt 2008; Blair et al. 2016). At frequencies below 300 Hertz, ambient sound levels are elevated by 15 to 20 dB when exposed to sounds from vessels at a distance (McKenna et al. 2013). Analysis of sound from vessels revealed that their propulsion systems are a dominant source of radiated underwater sound at frequencies less than 200 Hertz (Ross 1976). Additional sources of vessel sound include rotational and reciprocating machinery that produces tones and pulses at a constant rate. Other commercial and recreational vessels also operate within the action area and may produce similar sounds, although to a lesser extent given their much smaller size.

Individual vessels produce unique acoustic signatures, although these signatures may change with vessel speed, vessel load, and activities that may be taking place on the vessel. Peak spectral levels for individual commercial vessels are in the frequency band of 10 to 50 Hertz and range from 195 dB re: μPa^2-s at 1 meter for fast-moving (greater than 37 kilometers per hour [20 knots]) supertankers to 140 dB re: μPa^2-s at 1 meter for small fishing vessels (NRC 2003b). Small boats with outboard or inboard engines produce sound that is generally highest in the mid-frequency (1 to 5 kilohertz) range and at moderate (150 to 180 dB re: 1 µPa at 1 meter) source levels (Erbe 2002b; Gabriele et al. 2003; Kipple and Gabriele 2004). On average, sound levels are higher for the larger vessels, and increased vessel speeds result in higher sound levels. Measurements made over the period 1950 through 1970 indicated low frequency (50 Hertz) vessel traffic sound in the eastern North Pacific Ocean and western North Atlantic Ocean was increasing by 0.55 dB per year (Ross 1976; Ross 1993; Ross 2005). Whether or not such trends continue today is unclear. Most data indicate vessel sound is likely still increasing (Hildebrand 2009a). However, the rate of increase appears to have slowed in some areas (Chapman and Price 2011), and in some places, ambient sound including that produced by vessels appears to be decreasing (Miksis-Olds and Nichols 2016). (Pirotta et al. 2019) acknowledged that while it is impractical to limit the use of current vessel shipping routes, the development of new routes should be limited in certain areas, particularly in the Arctic, where cetaceans are being exposed to increasing levels of vessel traffic and noise as a result of climate change. Efforts are underway to better document changes in ambient sound (Haver et al. 2018), which will help provide a better understanding of current and future impacts of vessel sound on ESA-listed species.

Sonar systems are used on commercial, recreational, and military vessels and may also affect cetaceans (NRC 2003a). The action area may host many of these vessel types during any time of the year as shown in the global vessel density map below (See Figure 9). As shown, the action area is a high vessel density area with many ships travelling to and from Walvis Bay, Namibia and Cape Town, South Africa in the Southeast Atlantic Rio de Janeiro, Brazil in the Southwest Atlantic. Although little information is available on potential effects of multiple commercial and recreational sonars to cetaceans, the distribution of these sounds will be small because of their short durations and the fact that the high frequencies of the signals attenuate quickly in seawater (Nowacek et al. 2007). However, military sonar, particularly low frequency active sonar, often produces intense sounds at high source levels, and these may impact cetacean behavior (Southall et al. 2016).

Figure 9. 2017 Global Vessel Traffic Density.

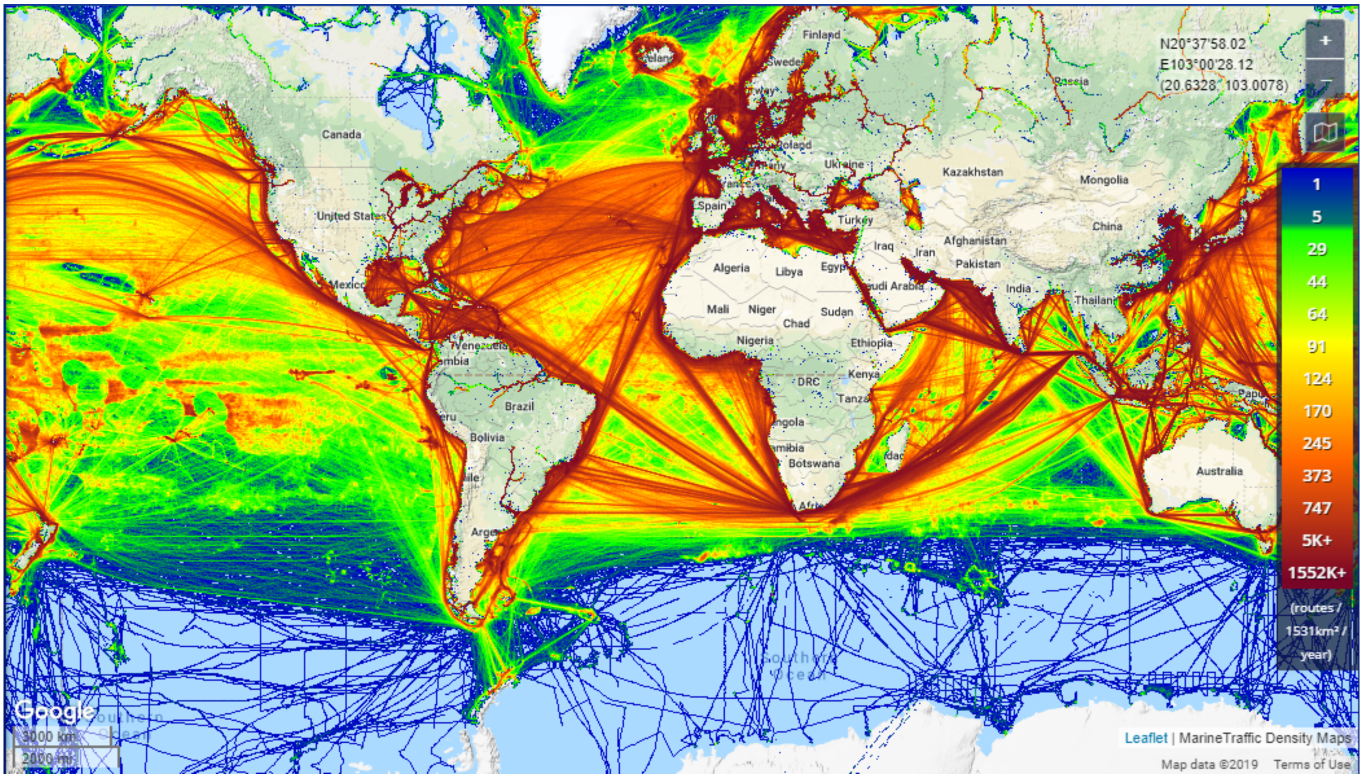

Image retrieved from Marine Traffic (2019)

9.10.2 Aircraft

Aircraft within the action area may consist of small commercial or recreational airplanes, helicopters, or large commercial airliners. These aircraft produce a variety of sounds that could potentially enter the water and impact cetaceans. While it is difficult to assess these impacts, several studies have documented what appear to be minor behavioral disturbances in response to aircraft presence (Nowacek et al. 2007). Erbe et al. (2018) recorded underwater noise from commercial airplanes reaching as high as 36 decibels above ambient noise. Sound pressure levels received at depth were comparable to cargo and container ships traveling at distances of 1 to 3 kilometers (0.5 to 1.6 nautical miles) away, although the airplane noises ceased as soon as the planes left the area, which was relatively quickly compared to a cargo vessel. While such noise levels are relatively low and brief, they still have the potential to be heard by cetaceans at certain frequencies. Nevertheless, noise from aircraft is expected to be minimal due to the location of the action area which is approximately 650 kilometers (404 miles) from shore.

9.10.3 Seismic Surveys

There are seismic survey activities involving towed airgun arrays that may occur within the action area. They are the primary exploration technique to locate oil and gas deposits, fault structure, and other geological hazards. These activities may produce noise that could impact ESA-listed cetaceans within the action area. These airgun arrays generate intense low-frequency sound pressure waves capable of penetrating the seafloor and are fired repetitively at intervals of ten to 20 seconds for extended periods (NRC 2003b). Most of the energy from the airguns is directed vertically downward, but significant sound emission also extends horizontally. Peak sound pressure levels from airguns usually reach 235 to 240 dB at dominant frequencies of five to 300 Hertz (NRC 2003a). Most of the sound energy is at frequencies below 500 Hertz, which is within the hearing range of baleen whales (Nowacek et al. 2007). In the U.S., all seismic surveys involving the use of airguns with the potential to take cetaceans are covered by incidental take authorizations under the MMPA, and if they involve ESA-listed species, undergo formal ESA section 7 consultation. In addition, the Bureau of Ocean Energy Management authorizes oil and gas activities in domestic waters as well as the National Science Foundation and U.S. Geological Survey funds and/or conducts these activities in domestic, international, and foreign waters, and in doing so, consults with NMFS to ensure their actions do not jeopardize the continued existence of ESA-listed species or adversely modify or destroy designated critical habitat. More information on the effects of these activities on ESA-listed species, including authorized takes, can be found in recent biological opinions.

Seismic surveys occur off the coast of Brazil and west Africa for the purposes of oil and gas exploration and geological studies (IONGEO 2015b; IONGEO 2015a). These surveys are generally confined to coastal waters, and do not extend out into the waters of the proposed action area.

9.10.4 Marine Construction

Marine construction in the action area that produces sound includes drilling, dredging, pile-driving, cable-laying, and explosions. These activities are known to cause behavioral disturbance and physical damage to cetaceans (NRC 2003a). While most of these activities are coastal, offshore construction may occur.

9.11 Scientific Research Activities

Regulations for section 10(a)(1)(A) of the ESA allow issuance of permits authorizing take of certain ESA-listed species for the purposes of scientific research. Prior to the issuance of such a permit, the proposal must be reviewed for compliance with section 7 of the ESA. Scientific research permits issued by NMFS currently authorize studies of ESA-listed species in the South Atlantic Ocean, some of which extend into portions of the action area for the proposed action. Cetaceans have been the subject of field studies for decades. The primary objective of most of these field studies has generally been monitoring populations or gathering data for behavioral and ecological studies. Over time, NMFS has issued dozens of permits on an annual basis for various forms of “take” of cetaceans in the action area from a variety of research activities.

Authorized research on ESA-listed cetaceans includes aerial and vessel surveys, close approaches, photography, videography, behavioral observations, active acoustics, remote ultrasound, passive acoustic monitoring, biological sampling (i.e., biopsy, breath, fecal, sloughed skin), and tagging. Research activities involve non-lethal "takes" of these cetaceans.

There have been numerous research permits issued since 2009 under the provisions of both the MMPA and ESA authorizing scientific research on cetaceans worldwide, which potentially could include research in the action area. The consultations which took place on the issuance of these ESA scientific research permits each found that the authorized research activities will have no more than short-term effects and were not determined to result in jeopardy to the species or adverse modification of designated critical habitat.

Although cetaceans are generally wide-ranging, we do not expect many of the authorized "takes" for scientific research activities to involve individuals that will also be "taken" under the proposed seismic survey activities.

9.12 Synthesis of Environmental Baseline Impacts on Endangered Species Act-Listed Species

Collectively, the stressors described above have had, and likely continue to have, lasting impacts on the ESA-listed cetaceans considered in this consultation. Some of these stressors result in mortality or serious injury to individual animals (e.g., vessel strikes and whaling), whereas others result in more indirect (e.g., fishing that impacts prey availability) or non-lethal (e.g., whale watching) impacts.

Assessing the aggregate impacts of these stressors on the species considered in this opinion is difficult. This difficulty is compounded by the fact that many of the species in this opinion are wide-ranging and subject to stressors in locations throughout and outside the action area.

We consider the best indicator of the aggregate impacts of stressors to the *Environmental Baseline* on ESA-listed resources to be the status and trends of those species. As noted in Section 8, some of the species considered in this consultation are experiencing increases in population abundance, some are declining, and for others, their status remains unknown. Taken together, this indicates that the *Environmental Baseline* is impacting species in different ways. The species experiencing increasing population abundances are doing so despite the potential negative impacts of the activities described in the *Environmental Baseline*. Therefore, while the *Environmental Baseline* may slow their recovery, recovery is not being prevented. For the species that may be declining in abundance, it is possible that the suite of conditions described in the *Environmental Baseline* is preventing their recovery. However, is also possible that their populations are at such low levels (e.g., due to historical commercial whaling) that even when the species' primary threats are removed, the species may not be able to achieve recovery. At small population sizes, species may experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their limited population size to become a threat in and of itself. A thorough review of the status and trends of each species is discussed in the *Status of Species Likely to be Adversely Affected* section of this opinion and what this means for the populations and critical habitats is discussed in the *Integration and Synthesis* (Section 11).

10 EFFECTS OF THE ACTION

Section 7 regulations define "effects of the action" as the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 C.F.R. §402.02). Indirect effects are those that are caused by the proposed action and are later in time, but are reasonably certain to occur. This effects analysis section is organized following the stressor, exposure, response, and risk assessment framework described in Section 2 above.

In this section, we further describe the potential stressors associated with the proposed action, the probability of individuals of ESA-listed species being exposed to these stressors based on the best scientific and commercial evidence available, and the probable responses of those individuals (given probable exposures) based on the available evidence. As described in Section 10.3.2, for any responses that would be expected to reduce an individual's fitness (i.e., growth, survival, annual reproductive success, or lifetime reproductive success), the assessment would consider the risk posed to the viability of the population(s) those individuals comprise and to the ESA-listed species those populations represent. For this consultation, we are particularly concerned about behavioral and stress-related physiological disruptions and potential unintentional mortality that may result in animals that fail to feed, reproduce, or survive because these responses are likely to have population-level consequences. The purpose of this assessment and, ultimately, of this consultation is to determine if it is reasonable to expect the proposed action to have effects on ESA-listed species that could appreciably reduce their likelihood of surviving and recovering in the wild.

10.1 Stressors Associated with the Proposed Action

Stressors are any physical, chemical, or biological entity that may induce an adverse response either in an ESA-listed species or their designated critical habitat. The seismic survey activities and issuance of an incidental harassment authorization will authorize activities that may expose ESA-listed cetaceans within the action area to a variety of stressors.

The potential stressors we expect to result from the proposed action are:

1. Pollution by oil for fuel leakage;
2. Vessel strike;
3. Vessel noise;
4. Entanglement in towed hydrophone streamer; and
5. Sound fields produced by the multi-beam echosounder, and sub-bottom profiler.
6. Sound fields produced by airgun array.

Based on a review of available information, during consultation we determined which of these possible stressors will be likely to occur and which will be discountable or insignificant for the species affected by these activities. These species were discussed in Section 6, 7, and 8. Stressors (i.e., sound fields produced by the airgun array that are likely to adversely affect ESA-listed species are discussed in the *Exposure and Response Analysis* sections below.

During consultation we determined that sound levels and their associated sound fields produced by the airgun array, multi-beam echosounder, and sub-bottom profiler may adversely affect ESA-listed species by introducing harmful acoustic energy into the marine environment. This stressor and the likely effects on ESA-listed species are discussed starting in Section 10.3.

10.2 Mitigation Measures to Minimize or Avoid Exposure

As described in the *Description of the Proposed Action* (Section 3), the National Science Foundation and Lamont-Doherty Earth Observatory's proposed action and NMFS Permits and Conservation Division's proposed incidental harassment authorization requires monitoring and mitigation measures that includes the use of proposed exclusion and buffer zones, power-down procedures, shutdown procedures, ramp-up procedures, visual monitoring with NMFS-approved protected species observers, passive acoustic monitoring, vessel strike avoidance measures, and additional mitigation measures considered in the presence of ESA-listed as species to minimize or avoid exposure. The NMFS Permits and Conservation Division's proposed incidental harassment authorization will contain additional mitigation measures to minimize or avoid exposure that are described in Appendix A (see Section 18.1).

10.3 Exposure and Response Analysis

Exposure analyses identify the ESA-listed species that are likely to co-occur with the action's effects on the environment in space and time, and identify the nature of that co-occurrence. The *Exposure Analysis* identifies, as possible, the number, age or life stage, and gender of the individuals likely to be exposed to the action's effects and the population(s) or sub-population(s) those individuals represent. The *Response Analysis* evaluates the available evidence to determine how individuals of those ESA-listed species are likely to respond given their estimated exposure. The *Response Analysis* also considers information on the potential stranding and the potential effects on the prey of ESA-listed cetaceans in the action area.

10.3.1 Exposure Analysis

Although there are multiple acoustic and non-acoustic stressors associated with the proposed action, the stressor of primary concern is the acoustic impacts of the airgun arrays. Airguns contribute a massive amount of anthropogenic energy to the world's oceans (3.9×10^{13} Joules cumulatively), second only to nuclear explosions (Moore and Angliss 2006). Although most energy is in the low-frequency range, airguns emit a substantial amount of energy up to 150 kilohertz (Goold and Coates 2006). Seismic airgun noise can propagate substantial distances at low frequencies (e.g., Nieukirk et al. 2004).

In this section, we quantify the likely exposure of ESA-listed cetaceans to sound from the airgun array. For this consultation, the National Science Foundation, Scripps Institution of

Oceanography, and NMFS Permits and Conservation Division estimated exposure to the sounds from the airgun array that will result in take, as defined under the MMPA, for all cetacean species including those listed under the ESA.

Under the MMPA, take is defined as “to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal (16 U.S.C. §1361 et seq.) and further defined by regulation (50 C.F.R. §216.3) as “to harass, hunt, capture, collect, or kill, or attempt to harass, hunt, capture, collect, or kill any marine mammal.” This includes, without limitation, any of the following:

- The collection of dead animals, or parts thereof
- The restraint or detention of a marine mammal, no matter how temporary
- Tagging a marine mammal
- The negligent or intentional operation of an aircraft or vessel
- The doing of any other negligent or intentional act which results in disturbing or molesting a marine mammal
- Feeding or attempting to feed a marine mammal in the wild.”

For purposes of the proposed action, the two levels of harassment are further defined under the MMPA as any act of pursuit, torment, or annoyance which:

- Has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment); or
- Has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (Level B harassment). Under NMFS regulation, Level B harassment does not include an act that has the potential to injure a marine mammal or marine mammal stock in the wild.

Under the ESA take is defined as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct.” Harm is defined by regulation (50 C.F.R. §222.102) as “an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding, or sheltering.” NMFS does not have a regulatory definition of “harass.” However, on December 21, 2016, NMFS issued interim guidance on the term “harass,” defining it as to “create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to breeding, feeding, or sheltering.”

NMFS’ interim ESA harass definition does not specifically equate to MMPA Level A or Level B harassment, but shares some similarities with both in the use of the terms “injury/injure” and a focus on a disruption of behavior patterns. Since the proposed permits will authorize take under both the ESA and MMPA, our ESA analysis, which relies on NMFS' interim guidance on the ESA term harass, may result in different conclusions than those reached by the NMFS Permits and Conservation Division in their MMPA analysis. Given the differences between the MMPA and ESA standards for harassment, there may be circumstances in which an act is considered harassment, and thus take, under the MMPA but not the ESA.

For ESA-listed cetacean species, consultations that involve the NMFS Permits and Conservation Division's incidental take authorization under the MMPA have historically relied on the MMPA definition of harassment. As a result, MMPA Level B harassment has been used in estimating the number of instances of harassment of ESA-listed cetaceans, whereas estimates of MMPA Level A harassment have been considered instances of harm and/or injury under the ESA depending on the nature of the effects.

We use the numbers of individuals expected to be taken from the MMPA's definition of Level A and Level B harassment to estimate the number ESA-listed cetaceans that are likely to be harmed or harassed as a result of the proposed actions. This is a conservative approach since we assume all forms of Level B harassment under the MMPA necessarily constitute harassment under the ESA and all forms of Level A harassment under the MMPA constitute harm under the ESA (e.g., NMFS 2017).

Therefore, under the ESA, harassment is expected to occur during the seismic survey activities' and may involve a wide range of behavioral responses for ESA-listed cetaceans including but not limited to avoidance, changes in vocalizations or dive patterns, or disruption of feeding, migrating, or reproductive behaviors. The MMPA Level B harassment exposure estimates do not differentiate between the types of behavioral responses, nor do they provide information regarding the potential fitness or other biological consequences of the responses on the affected individuals. Therefore, in the following sections we consider the best available scientific evidence to determine the likely nature of these behavioral responses and their potential fitness consequences in accordance with the definitions of "take" related to harm or harass under the ESA for ESA-listed cetacean species.

Our exposure analysis relies on two basic components: (1) information on species distribution (i.e., density within the action area), and (2) information on the level of exposure to sound at which species are likely to be affected (i.e., exhibit some response). Using this information, and information on the proposed seismic survey (e.g., active acoustic sound source specifications, trackline locations, months of operation, etc.), we then estimate the number of instances in which an ESA-listed species may be exposed to sound fields from the airgun array that are likely to result in adverse effects such as harm or harassment. In many cases, estimating the potential exposure of animals to anthropogenic stressors is difficult due to limited information on animal density estimates in the action area and overall abundance, the temporal and spatial location of animals; and proximity to and duration of exposure to the sound source. For these reasons, we evaluate the best available data and information in order to reduce the level of uncertainty in making our final exposure estimates.

10.3.1.1 Exposure Estimates of Endangered Species Act-Listed Cetaceans

As discussed in the *Status of Species Likely to be Adversely Affected* section, there are five ESA-listed cetacean species that are likely to be adversely affected by the proposed action: blue, fin, sei, southern right and sperm whales.

During the proposed action, ESA-listed cetaceans may be exposed to sound from the airgun array, multi-beam echosounder, and sub-bottom profiler used during the proposed survey. The National Science Foundation, Scripps Institution of Oceanography, and NMFS Permits and Conservation Division provided estimates of the expected number of ESA-listed cetaceans exposed to received levels greater than or equal to 160 dB re: 1 µPa (rms) for these sound sources. Our exposure estimates stem from the best available information on cetacean densities and predicted radii (rms) (Table 12 and Table 13) along seismic survey tracklines. Based upon information presented in the *Response Analysis*, ESA-listed cetaceans exposed to these sound sources could exhibit changes in behavior and/or suffer stress. No ESA instances of harm (i.e., MMPA Level A takes) are expected or authorized under the proposed action.

10.3.1.2 Exposure of Endangered Species Act-Listed Cetaceans to Airguns

The National Science Foundation and Scripps Institution of Oceanography applied acoustic thresholds to determine at what point during exposure to the airgun arrays cetaceans are "harassed," based on definitions provided in the MMPA (16 U.S.C. §1362(18)(a)). As part of the application for the incidental harassment authorization pursuant to the MMPA, the National Science Foundation and Scripps Institution of Oceanography provided an estimate of the number of cetaceans that will be exposed to levels of sound in which they should be considered "taken" under the MMPA during the proposed seismic survey. We used the same values to determine the type and extent of take for ESA-listed cetaceans. An estimate of the number of cetaceans that will be exposed to sounds from the airgun array is also included in the National Science Foundation's draft environmental analysis.

A pulse of sound from the airgun array displaces water around the airgun array and creates a wave of pressure, resulting in physical effects on the marine environment that can then affect ESA-listed cetaceans considered in this opinion. Possible responses considered in this analysis consist of:

- Hearing threshold shifts;
- Auditory interference (masking);
- Behavioral responses; and
- Non-auditory physical or physiological effects.

In their *Federal Register* notice of the proposed incidental harassment authorization, the NMFS Permits and Conservation Division stated that they did not expect the sound emanating from the other equipment to exceed the levels produced by the airgun array. Therefore, the NMFS Permits and Conservation Division did not expect additional exposure from sound sources other than the airgun array since all active acoustic sources would be operated concurrently. We agree with this assessment and similarly focus our analysis on exposure from the airgun array. The multi-beam echosounder and sub-bottom profiler also expected to affect a smaller ensonified area within the larger sound field produced by the airgun array and are not expected to be of sufficient duration that will lead to the onset of TTS or PTS for an animal.

During the development of the incidental harassment authorization, the NMFS Permits and Conservation Division conducted an independent exposure analysis. The exposure analysis concluded that there would no ESA-listed cetaceans likely to be exposed to received levels at MMPA Level A harassment thresholds in the absence of monitoring and mitigation measures. Therefore, no ESA instances of harm (MMPA level A takes) are expected or authorized under the proposed action.

In this section, we describe the National Science Foundation, Scripps Institution of Oceanography, and NMFS Permits and Conservation Division's analytical methods to estimate the number of ESA-listed cetacean species that might be exposed to the sound field and experience an adverse response. We also rely on acoustic thresholds to determine sound levels at which cetaceans are expected to exhibit a response that may be considered take under the ESA such as harm or harassment, then utilize these thresholds to calculate ensonified areas, and finally, multiply these areas by data on cetacean density to estimate the number of cetaceans exposed to sounds generated by the airgun array.

For our ESA section 7 consultation, we evaluated both the National Science Foundation, Scripps Institution of Oceanography, and the NMFS Permit and Conservation Division's exposure estimates of the number of ESA-listed cetaceans that will be "taken" relative to the definition of MMPA Level A and Level B harassment, which we have adopted to evaluate harassment of ESA-listed cetaceans in this consultation. We adopted the NMFS Permits and Conservation Division's analysis because, after our independent review, we determined it utilized the best available information and methods to evaluate exposure to ESA-listed cetaceans. Below we describe the exposure analysis for ESA-listed cetaceans.

Acoustic Thresholds

To determine at what point during exposure to airgun arrays (and other active acoustic sources) cetaceans are considered "harassed" under the MMPA, NMFS applies certain acoustic thresholds. These thresholds are used in the development of radii for exclusion zones around a sound source and the necessary mitigation requirements necessary to limit cetacean exposure to harmful levels of sound (NOAA 2018). For Level B harassment under the MMPA, and behavioral responses under the ESA, NMFS has historically relied on an acoustic threshold for 160 dB re: 1 µPa (rms). This value is based on observations of behavioral responses of mysticetes, but is used for all cetacean species. For the proposed action, the NMFS Permits and Conservation Division continued to rely on this historic NMFS acoustic threshold to estimate the number of takes by MMPA Level B harassment, and accordingly, take of ESA-listed cetaceans that are proposed in the incidental harassment authorization.

For physiological responses to active acoustic sources, such as TTS[3] and PTS, the NMFS Permits and Conservation Division relied on NMFS' recently issued technical guidance for auditory injury of cetaceans (NOAA 2018). Unlike NMFS' 160 dB re: 1 µPa (rms) MMPA Level B harassment threshold, TTS and PTS auditory thresholds differ by species hearing group (Table 8). Furthermore, these acoustic thresholds are dual metric criteria for impulsive sounds, with one threshold based on peak sound pressure level (0 to peak SPL) that does not include the duration of exposure. The other metric, the cumulative sound (SEL_{cum}) exposure criteria incorporates auditory weighting functions based upon a species group's hearing sensitivity, and thus susceptibility to TTS and PTS, over the exposed frequency range and duration of exposure. The metric that results in a largest distance from the sound source (i.e., produces the largest field of exposure) is used in estimating total range to potential exposure and effect, since it is the more precautionary criteria. In recognition of the fact that the requirement to calculate ESA harm (MMPA Level A harassment) ensonified areas can be more technically challenging to predict due to the duration component and the use of weighting functions in the SEL_{cum} thresholds, NMFS developed an optional user spreadsheet that includes tools to help predict a simple isopleth that can be used in conjunction with cetacean density or occurrence to facilitate the estimation of take numbers.

In using these acoustic thresholds to estimate the number of individuals that may experience auditory injury, the NMFS Permits and Conservation Division classify any exposure equal to or above the acoustic threshold for the onset of PTS as auditory injury, and thus MMPA Level A harassment, and harm under the ESA. Any exposure below the threshold for the onset of PTS, but equal to or above the 160 dB re: 1 µPa (rms) acoustic threshold is classified as MMPA Level B harassment, which will also be considered ESA harassment. Among ESA harassment (MMPA Level B harassment) exposures, the NMFS Permits and Conservation Division does not distinguish between those individuals that are expected to experience TTS and those that will only exhibit a behavioral response.

[3] A TTS results in a temporary change to hearing sensitivity and the impairment can last minutes to days, but full recovery of hearing sensitivity is expected.

Table 8. Functional hearing groups, generalized hearing ranges, and acoustic thresholds identifying the onset of permanent threshold shift and temporary threshold shift for cetaceans exposed to impulsive sounds (NOAA 2018).

Hearing Group	Generalized Hearing Range*	Permanent Threshold Shift Onset	Temporary Threshold Shift Onset
Low-Frequency Cetaceans (Baleen Whales) (LE,LF,24 hour)	7 Hertz to 35 kilohertz	$L_{pk,flat}$: 219 dB $L_{E,LF,24h}$: 183 dB	213 dB peak SPL 168 dB SEL
Mid-Frequency Cetaceans (Dolphins, Toothed Whales, Beaked Whales, Bottlenose Whales) (LE,MF,24 Hour)	150 Hertz to 160 kilohertz	$L_{pk,flat}$: 230 dB $L_{E,MF,24h}$: 185 dB	224 dB peak SPL 170 dB SEL
Otariid Pinnipeds (Guadalupe Fur Seals) (LE,MF,24 Hour) – Underwater	60 Hertz to 39 kilohertz	$L_{pk,flat}$: 232 dB $L_{E,MF,24h}$: 203 dB	212 dB peak SPL 170 dB SEL

LE, X, 24 Hour=Frequency Sound Exposure Level (SEL) Cumulated over 24 Hour
LF=Low-Frequency
MF=Mid-Frequency
*Represents the generalized hearing range for the entire group as a composite (i.e., all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range chosen based on approximately 65 dB threshold from normalized composite audiogram, with the exception for lower limits for low frequency cetaceans (Southall et al. 2007) (approximation).
Note: Dual metric acoustic thresholds for impulsive sounds (peak and/or SEL_{cum}): Use whichever results in the largest (most conservative for the ESA-listed species) isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.
Note: Peak sound pressure (Lpk) has a reference value of 1 μPa, and cumulative sound exposure level (LE) has a reference value of 1 $\mu Pa^2 s$. In this table, thresholds are abbreviated to reflect American National Standards Institute standards (ANSI 2013). However, peak sound pressure is defined by ANSI as incorporating frequency weighting, which is not the intent for this technical guidance. Hence, the subscript "flat" is being included to indicate peak sound pressure should be flat weighted or unweighted within the generalized hearing range. The subscript associated with cumulative sound exposure level thresholds indicates the designated marine mammal auditory weighting function and that the recommended accumulation period is 24 hours. The cumulative sound exposure level thresholds could be exceeded in a multitude of ways (i.e., varying exposure levels and durations, duty cycle). When possible, it is valuable for action proponents to indicate the conditions under which these acoustic thresholds will be exceeded.

Using the above acoustic thresholds, the NMFS Permits and Conservation Division evaluated the exposure and take estimates of ESA-listed cetaceans associated with the sounds from the airgun array.

Modeled Sound Fields of Airguns

In this section, we first evaluate the likelihood that cetaceans will be exposed to sound fields from the seismic survey at or above 160 dB re: 1 μPa (rms) based upon the information described above, and the acoustic thresholds correlating to onset of PTS or TTS provided in Table 8. If we find that such exposure above any particular threshold is likely, we then estimate the number of instances in which we expect cetaceans to be exposed to these sound levels, based on the ensonified areas at or above these sound levels and information on cetacean density.

The methodology for estimating the number of ESA-listed species that might be exposed to the sound field used by the National Science Foundation, Scripps Institution of Oceanography, and NMFS Permits and Conservation Division were largely the same regarding MMPA level B analysis. However, NMFS Permits and Conservation Division did not believe MMPA level A takes were needed due to the small zone of MMPA Level A ensonification and the effectiveness of mitigation measures (e.g. 100 meter exclusion zone and shutdown protocols), which we concur with. Therefore, no MMPA level A takes were authorized for any species and no takes of ESA-harm are authorized in this opinion's incidental take statement. Both the National Science Foundation, Scripps Institution of Oceanography, and NMFS Permits and Conservation Division estimated the number of cetaceans predicted to be exposed to sound levels that will result in MMPA Level B harassment by using radial distances to predicted isopleths. Both used those distances to calculate the ensonified area around the airgun array for the 160 dB re: 1 µPa (rms) zone, which corresponds to the MMPA Level B harassment threshold for ESA-listed cetaceans and in the case of this opinion, the threshold for ESA harassment.

Based on information provided by the National Science Foundation, Scripps Institution of Oceanography, and NMFS Permits and Conservation Division, we have determined that ESA-listed cetaceans are likely to be exposed to sound levels at or above the threshold at which TTS and behavioral harassment will occur. From modeling by the Scripps Institution of Oceanography, the National Science Foundation and Scripps Institution of Oceanography provided sound source levels of the airgun array (Table 9) and estimated distances for the 160 dB re: 1 µPa (rms) sound levels as well as MMPA Level A harassment thresholds generated by the two airgun array configurations and water depth. The predicted and modeled radial distances for the various MMPA Level A and B harassment thresholds for cetaceans for the R/V *Thomas R. Thompson*'s airgun arrays can be found in Table 10 and Table 11.

Table 9. Modeled sound source levels (decibels) for the R/V Thomas R. Thompson's single 90 cubic inch airgun array.

Functional Hearing Group	8 knot survey with 8 meter airgun separation: Peak SPL_{flat}	8 knot survey with 8 meter airgun separation: Peak SPL_{cum}	5 knot survey with 2 meter airgun separation: Peak SPL_{flat}	5 knot survey with 2 meter airgun separation: Peak SPL_{cum}
Low Frequency Cetaceans (L_{pk} flat: 219 dB;	228.8	207	232.8	206.7

$L_{E,LF,24h}$: 183 dB)				
Mid Frequency Cetaceans (L_{pk} flat: 230 dB; $L_{E,MF,24h}$: 185 dB)	NA	206.7	232.9	207.2

NA indicates source level not applicable or not available

Table 10. Predicted radial distances in meters from the R/V Thomas G. Thompson seismic sound sources to isopleth corresponding to greater than or equal to 160 decibels re: 1 μPa (rms) threshold.

Source	Volume (in^3)	Tow Depth (m)	Water Depth (m)	Predicted Distance to Threshold (160 dB re: 1 μPa [rms]) (m)[1]
Two 45 in^3 GI airguns/2 meter separation – five knot survey	90	4	>1,000	539[1]
			100 to 1,000	809[2]
Two 45 in^3 GI airguns/8 meter separation– eight knot survey	90	4	>1,000	578[1]
			100 to 1,000	867[2]

in^3=cubic inches
m=meters
[1] Distance is based on Lamont-Doherty Earth Observatory model results.
[2] Distance is based on Lamont-Doherty Earth Observatory model results with a 1.5 × correction factor between deep and intermediate water depths.

Table 11. Modeled radial distances in meters from the R/V *Thomas R. Thompson*'s 90 cubic inch airgun array for the two survey configurations corresponding to harm (Marine Mammal Protection Act Level A harassment) thresholds.

Functional Hearing Group	8 knot survey with 8 meter airgun separation:	8 knot survey with 8 meter airgun separation:	5 knot survey with 2 meter airgun separation:	5 knot survey with 2 meter airgun separation:

	Peak SPL_{flat}	**Peak SPL_{cum}**	**Peak SPL_{flat}**	**Peak SPL_{cum}**
Low Frequency Cetaceans (L_{pk} flat: 219 dB; $L_{E,LF,24h}$: 183 dB)	3.08	2.4	4.89	6.5
Mid Frequency Cetaceans (L_{pk} flat: 230 dB; $L_{E,MF,24h}$: 185 dB)	0	0	0.98	0

Note: The largest distance of the dual criteria (SELcum or Peak SPLflat) were used to calculate takes and harm (MMPA Level A harassment) threshold distances. Because of some of the assumptions included in the methods used, isopleths produced may be overestimates to some degree, which will ultimately result in some degree of overestimate of takes by harm (MMPA Level A harassment). However, these tools offer the best way to predict appropriate isopleths when more sophisticated three-dimensional modeling methods are not available, and NMFS continues to develop ways to quantitatively refine these tools and will qualitatively address the output where appropriate. For mobile sources, such as the proposed seismic surveys, the NMFS user spreadsheet predicts the closest distance at which a stationary animal will not incur PTS if the sound source traveled by the animal in a straight line at a constant speed. Only Low-frequency and Mid-frequency Level A thresholds are shown since these are the only thresholds that correspond to the ESA-listed species likely to be adversely affected by the proposed action.

Exposure Estimates (Density Estimates)

We reviewed available cetacean densities with the National Science Foundation and the NMFS Permits and Conservation Division and agreed upon which densities constituted the best available scientific information for each ESA-listed species. The NMFS Permits and Conservation Division adopted these estimates for use in their proposed incidental harassment authorization and we have adopted them for our ESA exposure analysis.

For the National Science Foundation and Scripps Institution of Oceanography’s environmental assessment and incidental harassment authorization application, the preferred source of density data for the ESA-listed cetacean species that might be encountered in the proposed project area in the South Atlantic was the Navy Marine Species Density Database based on the University of St. Andrew’s Sea Mammal Research Unit Limited’s marine species global spatial density estimate model U.S. Navy (2012a) and density estimates developed by Di Tullio et al. (2016) from eight ship-based surveys carried out during the austral spring and autumn of 2009 and 2014 on the outer continental shelf (approximately 150 meters) and slope (1500 meters) off southeastern and southern Brazil (approximately 23 degrees South to approximately 34 degrees South). The density estimates for all ESA-listed cetacean species except the southern right whale were taken from these two sources. The southern right whale density was derived from the survey report written for a British Antarctic Survey in January to February 2003 in the Scotia Sea (British Antarctic Survey 2003). The densities for each of these three sources are shown in Table

12. The approach used here is based on the best available data and calculated exposures are the best estimates for the proposed surveys.

Table 12. Densities of ESA-listed cetaceans in the action area during National Science Foundation and Scripps Institution of Oceanography's seismic survey in the South Atlantic Ocean.

Species	Reported Density (number per km^2)	Mean Group Size*	Density Reference	Mean Group Size Reference
Blue Whale	0.000051	3	(U.S. Navy 2012a)	(Bradford et al. 2017)
Fin Whale	0.000356	4	(Di Tullio et al. 2016)	(Di Tullio et al. 2016)
Sei Whale	0.000086	3	(Di Tullio et al. 2016)	(Bradford et al. 2017)
Southern Right Whale	0.007965	2	(British Antarctic Survey 2003)	(Barendse and Best 2014)
Sperm Whale	0.005975	5	(Di Tullio et al. 2016)	(Di Tullio et al. 2016)

*Rounded to nearest whole number

Blue Whale - At least four records of blue whales exist for Angola; all sightings were made in 2012, with at least one sighting in July, two in August, and one in October (Figueiredo and Weir 2014). Sightings were also made off Namibia in 2014 from seismic vessels (Brownell et al. 2016). Antarctic blue whale calls were detected on acoustic recorders that were deployed northwest of Walvis Ridge (just to the north of the Valdivia Bank survey area) from November 2011 through May 2013 during all months except during September and October, indicating that not all whales migrate to higher latitudes during the summer (Thomisch 2016). One offshore sighting of a blue whale was made at 13.4 degrees South, 26.8 degrees West and the other at 15.9 degrees South, 4.6 degrees West (OBIS 2019). There are approximately 1845 blue whale records for the South Atlantic in the OBIS database; however, no records occur within the proposed project area (OBIS 2019).

Fin Whale- According to Edwards et al. (2015), fin whale sightings have been made south of South Africa from December–February although they did not report any sightings or acoustic detections near the proposed project area. Several fin whale sightings and strandings have been reported for Namibia in the last decade (LGL 2019). Fin whale calls were detected on acoustic recorders that were deployed northwest of Walvis Ridge from November 2011 through May 2013 during the months of November, January, and June through August, indicating that the waters off Namibia serve as wintering grounds (Thomisch 2016). Several sightings were made off western South Africa during November 2009; one sighting was reported near 30 degrees South and 2 degrees East (near the proposed Tristan survey area), and several other sightings were made near 35 degrees South and 11 degrees East (Shirshov Institute n.d.). Two sightings were made during seismic surveys off the coast of northern Angola between 2004 and 2009 (Weir 2011). Forty fin whales were seen during a transatlantic voyage along 20 degrees South during August 1943 between 5 degrees and 25 degrees West (Wheeler 1946 *in* Best 2007). A group of two fin whales were sighted near Trindade Island, at 20.5 degrees South, 29.3 degrees West, on 31 August 2010 (Wedekin et al. 2014). A fin whale sighting was also made southeast of the survey areas at approximately 41 degrees South, 15 degrees West (Scheidat et al. 2011). There are approximately 2570 fin whale records in the OBIS database for the South Atlantic; no records occur within the proposed project area (OBIS 2019). Fin whales could be encountered during the proposed project area during their migration to more southerly latitudes.

Sei Whale- In the Southern Hemisphere, sei whales typically concentrate between the Subtropical and Antarctic convergences during the summer (Horwood 2018) between 40 degrees South and 50 degrees South; larger, older whales typically travel into the northern Antarctic zone while smaller, younger individuals remain in the lower latitudes (Acevedo et al. 2017). Best (2007) showed summer concentrations between 30 degrees South and 50 degrees South, including near the three proposed survey areas (Central, Tristan, Gough) in the Guyot Province of Walvis Ridge. Waters off northern Namibia may serve as wintering grounds (Best 2007).

A sighting of a mother and calf were made off Namibia in March 2012, and one stranding was reported in July 2013 (NDP unpublished data *in* Pisces Environmental Services 2017). One sighting was made during seismic surveys off the coast of northern Angola between 2004 and 2009 (Weir 2011). A group of two to four sei whales was seen near St. Helena during April 2011 (Clingham et al. 2013). Although the occurrence of sei whales is likely in the Tristan da Cunha archipelago (Bester and Ryan 2008), there have been no recent records of sei whales in the region; however, sei whale catches were made here in the 1960s (Best et al. 2009). Sei whales were also taken off southern Africa during the 1960s, with some catches reported just to the southeast of the proposed survey area; catches were made during the May–July northward migration as well as during the August–October southward migration (Best and Lockyer 2002). In the OBIS database, there are 40 sei whale records for the South Atlantic; the closest records were reported at 33.3 degrees South, 8.0 degrees West and 35.1 degrees South, 6.4 degrees West (OBIS 2019). Sei whales could be encountered in any of the proposed survey areas at the time of the surveys, in particular in the Gough, Tristan, and Central survey areas.

Sperm Whale- Whaling data from the South Atlantic indicate that sperm whales may be migratory off South Africa, with peak abundances reported in the region during autumn and late winter/spring (Best 2007). The waters of northern Namibia and Angola were also historical whaling grounds (Best 2007; Weir 2019). Sperm whales were the most frequently sighted cetacean during seismic surveys off the coast of northern Angola between 2004 and 2009; hundreds of sightings were made off Angola and a few sightings were reported off Gabon (Weir

2019). Sperm whales have also been sighted off South Africa during surveys of the Southern Ocean (Van Waerebeek et al. 2010). In addition, a sighting was made at 30.1 degrees South, 14.3 degrees East (Clingham et al. 2013). Bester and Ryan (2008) reported that sperm whales might be common in the Tristan da Cunha archipelago. Catches of sperm whales in the 19th century were made in Tristan waters between October and January (Best et al. 2009) and catches also occurred there in the 1960s (Best et al. 2009). One group was seen at St. Helena during July 2009 (Clingham et al. 2013). There are approximately 3080 records of sperm whales for the South Atlantic in the OBIS database, including nearshore waters of South American and Africa and offshore waters (OBIS 2019). Most (3069) records are from historical catch data, which include captures within the proposed project area (OBIS 2019). Sperm whales could be encountered in the proposed project area at the time of the surveys.

Southern Right Whale- Travel by right whales from the coasts of South America and Africa to the waters of the mid-Atlantic have been documented (Mate et al. 2010). Based on photo-identification work, right whales were reported to have traveled between Gough Island and South Africa, and from Argentina to Tristan da Cunha (Best et al. 1993). Adult right whales at Gough Island were sighted on 10 September 1983, and two adult whales and a calf were observed at Tristan da Cunha on 14 October 1989 (Best et al. 1993). Six right whale sightings were also made in Tristan waters from August–October 1971. Right whales were also documented to travel from feeding areas off Argentina to South Georgia (Best et al. 1993) and Shag Rocks (Moore et al. 1999). In September 2001, 21 right whales were equipped with radio tags in South Africa (Mate et al. 2010). Five of them migrated southward to waters southeast of Gough Island, Bouvet Island, and beyond; four whales traveled into a potential feeding area in St. Helena Bay on the west coast of South Africa (Mate et al. 2010). Other tagged whales moved southward and appeared to remain near the Subtropical Convergence and Antarctic Polar Front, presumably to feed (Mate et al. 2010). 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).

Best et al. (2009) also reported southern right whale sightings and catches in the Tristan da Cunha archipelago. From 1983 to 1991, 75 sightings totaling 116 right whales were observed during aerial surveys of Tristan waters (Best et al. 2009). One sighting was made off Inaccessible Island; all others were made at Tristan Island (Best et al. 2009). The majority of sightings occurred during September–October, but sightings were also made during April, June–August, and November–December (Best et al. 2009). This region is likely an oceanic nursing area for the right whale (Best et al. 2009). A single southern right whale has been reported for waters near St. Helena, approximately 15.9 degrees South, 5.7 degrees West (Clingham et al. 2013).

Historically, right whale catches were made between 30 and 40 degrees South, from the coast of Africa to the coast of South America; most catches were made from October–January at whaling grounds including the Tristan and Pegeon grounds, and False and Brazil banks (Best et al. 1993; Best et al. 2009). Right whale catches were also made at the Tristan da Cunha archipelago from

1951 to 1971 by Soviet fleets (Tormosov et al. 1998). There are approximately 3843 records of southern right whales for the South Atlantic in the Ocean Biogeographic Information System (OBIS) database, including nearshore and offshore waters (OBIS 2019). Southern right whales could be seen in any of the proposed survey areas at the time of the survey, in particular in the Gough, Tristan, and Central survey areas.

Total Ensonified Area

As shown in Table 13, the total daily ensonified area calculated by the National Science Foundation and Scripps Institution of Oceanography is based on survey type (i.e., speed of survey), water depth, and the relevant isopleth for MMPA Level A and Level B harassment. The National Science Foundation and Scripps Institution of Oceanography used the relevant isopleth for each survey speed, water depth, and MMPA threshold to create a buffer around specific trackline segments of the proposed survey using ArcGIS software. These buffered trackline segments are representative of a day's worth of survey effort at each specific water depth, survey speed, and MMPA threshold. The total geodesic area for each of these buffers were calculated to obtain the total daily ensonified area. The total daily ensonified areas were then multiplied by the number of survey days for which daily ensonification at the same speed, water depth, and MMPA threshold level is proposed to occur. To account for possible delays during the seismic survey (e.g., weather, equipment malfunction) and additional seismic survey activities, a 25 percent contingency (associated with turns, airgun array testing, and repeat coverage for any areas where initial data quality is sub-standard) was multiplied by the daily ensonification and number of proposed survey days to get the total ensonified area.

Table 13. Relevant isopleths for cetaceans, daily ensonified area, number of survey days, percent increase, and total ensonified areas during the National Science Foundation and Scripps Institution of Oceanography's seismic survey in the South Atlantic Ocean.

Survey type	Water Depth (meters)	Relevant isopleth (meters)	Daily Ensonified Area (km^2)	Total survey days	25 percent increase	Total ensonified area (km^2)
5 Knot Survey	**Level B Harassment (160 dB)**					
	100-1000	809	14.67	10	1.25	183.34
	> 1000	539	231.31	10	1.25	2,891.42
	Level A Harassment					
	LF cetacean	6.5	2.89	10	1.25	36.08
	MF cetacean	1	0.44	10	1.25	5.55
8 Knot Survey	**Level B Harassment (160 dB)**					

	100-1000	867	25.95	4	1.25	129.75
	> 1000	578	395.88	4	1.25	1979.38
	Level A Harassment					
	LF cetacean	3.1	2.21	4	1.25	11.04
	MF cetacean	0	0	4	1.25	0

Calculating Exposures

To calculate the number of exposures to ESA harassment, we used the method applied by the National Science Foundation, Scripps Institution of Oceanography, and NMFS Permits and Conservation Division. This method multiplied the total area of ensonfication during the 14 days of the proposed seismic survey by the cetacean density estimates presented in Table 13. As stated earlier, due to the National Science Foundation and Scripps Institution of Oceanography's proposed mitigation and monitoring measures[4] that will be utilized during the survey, we do not expect ESA harm to occur. Therefore, only the total amount of ESA harassment, including instances of TTS and behavioral disturbance, was calculated using the MMPA Level B harassment threshold of 160 dB re: 1 µPa (rms). The total number of estimated exposures of ESA-listed cetaceans to ESA harassment is presented in Table 14 below.

Table 14. Estimated exposures of Endangered Species Act-listed cetaceans calculated by the National Science Foundation, Scripps Institution of Oceanography, and National Marine Fisheries Service Permits and Conservation Division during the proposed seismic survey in the South Atlantic Ocean.

Species	160 dB re: 1 µPa (rms) Ensonified Area (km^2) for all depths and survey types	Density Estimates of ESA-listed Species in Proposed Action Area	Potential Temporary Threshold Shift and Behavioral Harassment
Blue Whale	5184 **km^2**	0.000051	3*
Fin Whale	5184 **km^2**	0.000356	4*
Sei Whale	5184 **km^2**	0.000086	3*
Southern Right Whale	5184 **km^2**	0.007965	41

[4] As discussed in Section 3 the National Science Foundation and Scripps Institution of Oceanography propose to use of a 100 meter radius exclusion zone. This zone is far greater than all MMPA Level A harassment isopleths presented in Table 11.

Sperm Whale	5184 **km^2**	0.005975	31

*TTS and behavioral harassment increased to average group size.

During the proposed survey blue, sei, sperm, and south Atlantic right whales of all age classes are likely to be exposed during the proposed seismic survey activities. Whales are expected to be feeding, traveling, or migrating in the action area and some females will have young-of-the-year accompanying them. These individuals can be exposed to the proposed seismic survey activities while they are transiting through the action area. We will normally assume that sex distribution is even for blue, fin, and south Atlantic right whales and sexes are exposed at a relatively equal level. However, sperm whales in the action area likely consist of more females than males in the group as females generally inhabit waters >1000 meters deep at latitudes <40 degrees where sea surface temperatures are <15 degrees Celsius (Whitehead 2018). Therefore, we expect a female bias to sperm whale exposure. For sperm whales, exposure for adult male sperm whales is expected to be lower than other age and sex class combinations as they are generally solitary and may migrate toward the northern portion of the range (poleward of about 40 to 50 degrees latitude) (Whitehead 2018).

It should be noted that the proposed exposure numbers by ESA harassment (MMPA Level B harassment) are expected to be conservative for several reasons. As previously stated, 25 percent has been added in the form of operational seismic survey days to account for the possibility of additional seismic survey activities associated with airgun array testing and repeat coverage of any areas where initial data quality is sub-standard, and in recognition of the uncertainties in the density estimates used to estimate exposures as described above. Additionally, cetaceans will be expected to move away from a loud sound source that represents an aversive stimulus, such as an airgun array, potentially reducing the number of exposures by ESA harm (MMPA Level A harassment). However, the extent to which cetaceans will move away from the sound source is difficult to quantify and is, therefore, not accounted for in the exposure estimates.

The seasonality of the seismic survey activities will likely not affect the exposure analysis because the best available species densities for any time of the year have been used for all species. Due to a lack of density data near the proposed action area, seasonal-specific density estimates were not available.

Exposures as a Percentage of Population

Blue Whale – The estimated potential instances of take under the ESA of the Southern Hemisphere population of blue whale is a total of three, through harassment, which is approximately .13 percent of the estimated 2,300 individuals considered in the population (IWC 2019). The number of takes represents the mean group size for blue whales in the Southern Hemisphere (Bradford et al. 2017). For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual number of exposures that will occur. Due to the large range of blue whales, the rarity of the species in the action area, and the small size of the National Science Foundation and Scrips Institution of Oceanography survey area combined with the relatively short duration of the seismic survey activities, it is more likely that there will be no instances of take for blue whales that will occur within the action area.

Fin Whale – The estimated potential instances of take under the ESA of the Southern Hemisphere population of fin whales is a total of four, through harassment, which is approximately .02 percent of the estimated 15,000 individuals considered in the population (Thomas et al. 2016). For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual number of exposures that will occur. Due to the large range of fin whales, the rarity of the species in the action area, and the small size of the National Science Foundation and Scrips Institution of Oceanography survey area combined with the relatively short duration of the seismic survey activities, it is more likely that these numbers will be smaller than estimated here for fin whales that will occur within the action area.

Sei Whale – The estimated potential instances of take under the ESA of the Southern Ocean population of sei whales is a total of three instances of take through behavioral harassment, which is approximately .03 percent of the population of the estimated 10,000 individuals considered in the population(Boyd 2002). For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual number of exposures that will occur. Due to the large range of sei whales, the rarity of the species in the action area, and the small size of the National Science Foundation and Scrips Institution of Oceanography survey area combined with the relatively short duration of the seismic survey activities, it is more likely that these numbers will be smaller than estimated here for sei whales that will occur within the action area.

Southern Right Whale – The expected potential instances of take under the ESA of the South African population of southern right whales is a total of 41, through harassment, which is one percent of the population of the estimated 4,100 individuals considered in the population (Brandão et al. 2010; Brandão et al. 2011). For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual number of exposures that will occur. Due to the large range of southern right whales and the small size of the National Science Foundation and Scrips Institution of Oceanography survey area combined with the relatively short duration of the seismic survey activities, it is more likely that there will be fewer numbers than estimated here for southern right whales that will occur within the action area.

Sperm Whale – The expected potential instances of take under the ESA of the Southern Ocean population of sperm whales is a total of 31, through harassment, which is approximately .25 percent of the population of the estimated 12,069 individuals considered in the population (Whitehead 2002). For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual number of exposures that will occur. Due to the large range of sperm whales and the small size of the National Science Foundation and Scrips Institution of Oceanography survey area combined with the relatively short duration of the seismic survey activities, it is more likely that these numbers will be smaller than estimated here for sperm whales that will occur within the action area.

10.3.1.3 Exposure of Endangered Species Act-Listed Cetaceans to Multi-Beam Echosounder, Sub-Bottom Profiler, Acoustic Doppler Current Profiler, and Acoustic Release Transponder

The multi-beam echosounder and sub-bottom profiler are the two additional active acoustic systems that will operate during the proposed seismic survey on the R/V *Thompson*. The multi-beam echosounder and sub-bottom profiler have the potential to expose ESA-listed cetacean species to sound levels above the 160 dB re: 1 μPa (rms) threshold. As stated earlier, the multi-beam echosounder and sub-bottom profiler operate at generally higher frequencies than airgun array operations (10 to 13.5 [usually 12] kilohertz for the multi-beam echosounder, 3.5 kilohertz for the sub-bottom profiler, 75 kilohertz for the acoustic Doppler current profiler, and 8 to 13 kilohertz for the acoustic release transponder). As such, the frequencies from these devices will attenuate more rapidly than those from airgun array sound sources. For these reasons, ESA-listed cetaceans will likely experience higher levels of sound from the airgun array well before the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler sound of equal amplitude since these other sound sources will drop off faster than the airgun arrays.

While the airgun array is not operational, visual protected species observers will remain on duty to collect sighting data. If ESA-listed cetaceans closely approach the research vessel, the R/V *Thompson* will take evasive actions to avoid a vessel-strike and simultaneously avoid exposure to very high sound source levels. Vessel strike has already been ruled out as a discountable effect. We also rule out high-level ensonification of ESA-listed cetaceans (multi-beam echosounder sound source level equals 242 dB re: 1 μPa [rms] and sub-bottom profiler sound source level equals 222 dB re: 1 μPa [rms, because it presents a low risk for auditory or other damage to occur. Boebel et al. (2006) and Lurton and DeRuiter (2011) concluded that multi-beam echosounders and sub-bottom profilers similar to those to be used during the proposed seismic survey activities presented a low risk for auditory damage or any other injury. To be susceptible to TTS, a cetacean will have to pass at very close range and match the vessel's speed and direction; we expect a very small probability of this during the proposed seismic survey. An individual will have to be located well within 100 meters (328.1 feet) of the research vessel to experience a single multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler pulse that could result in TTS (LGL Ltd. 2008). It is possible, however, that some small number of ESA-listed cetaceans (fewer than those exposed to the airgun array) can experience low-level exposure to the multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder. We are unable to quantify the level of exposure from the secondary sound sources, but do not expect any exposure at levels sufficient to cause more than behavioral responses (e.g., avoidance of the sound source) in some species capable of hearing frequencies produced by the multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder. As discussed earlier, the sound levels produced by the airgun array are of primary concern in terms of exposure, due to their greater energy power, and the potential to cause injury or disrupt essential behavioral patterns.

10.3.2 Response Analysis

A pulse of sound from the airgun array displaces water around the airgun array and creates a wave of pressure, resulting in physical effects on the marine environment that can then affect marine organisms, such as ESA-listed cetaceans considered in this opinion. Possible responses considered in this analysis consist of:

- Hearing threshold shifts;
- Auditory interference (masking);
- Behavioral responses; and
- Non-auditory physical or physiological effects.

The *Response Analysis* also considers information on the potential for stranding and the potential effects on prey of ESA-listed cetaceans in the action area.

As discussed in *The Assessment Framework* (Section 2) of this opinion, response analyses determine how ESA-listed resources are likely to respond after exposure to an action's effects on the environment or directly on ESA-listed species themselves. For the purposes of consultation, our assessments try to detect potential lethal, sub-lethal (or physiological), or behavioral responses that might result in reduced fitness of ESA-listed individuals. Ideally, response analyses will consider and weigh evidence of adverse consequences as well as evidence suggesting the absence of such consequences.

10.3.2.1 Potential Response of ESA-Listed Cetaceans to Acoustic Sources Cetacean Hearing Thresholds

Exposure of cetaceans to very strong impulsive sound sources from airgun arrays can result in auditory damage, such as changes to sensory hairs in the inner ear, which may temporarily or permanently impair hearing by decreasing the range of sound an animal can detect within its normal hearing ranges. Hearing threshold shifts depend upon the duration, frequency, sound pressure, and rise time of the sound. A TTS results in a temporary change to hearing sensitivity (Finneran 2013), and the impairment can last minutes to days, but full recovery of hearing sensitivity is expected. However, a study looking at the effects of sound on mice hearing, has shown that although full hearing can be regained from TTS (i.e., the sensory cells actually receiving sound are normal), damage can still occur to nerves of the cochlear nerve leading to delayed but permanent hearing damage (Kujawa and Liberman 2009). At higher received levels, particularly in frequency ranges where animals are more sensitive, permanent threshold shift can occur, meaning lost auditory sensitivity is unrecoverable. Either of these conditions can occur as a result of exposure to a single pulse or from the accumulated effects of multiple pulses, in which case each pulse does not need to be as loud as a single pulse to have the same accumulated effect. A TTS and PTS are generally specific to the frequencies over which exposure occurs but can extend to a half-octave above or below the center frequency of the source in tonal exposures (less evident in broadband noise such as the sound sources associated with the proposed action (Schlundt 2000; Kastak 2005; Ketten 2012)).

Few data are available to precisely define each ESA-listed species hearing range, let alone its sensitivity and levels necessary to induce TTS or PTS. Baleen whales (e.g., blue, fin, sei, and southern right whales) have an estimated functional hearing frequency range of 7 Hertz to 35 kilohertz and sperm whales have an estimated functional hearing frequency range of 150 Hertz to 160 kilohertz (see Table 8) (Southall 2007).

Based upon captive studies of odontocetes, our understanding of terrestrial mammal hearing, and extensive modeling, the best available information supports the position that sound levels at a given frequency will need to be approximately 186 dB SEL or approximately 196 to 201 decibels re: 1 μPa (rms) in order to produce a low-level TTS from a single pulse (Southall et al. 2007). PTS is expected at levels approximately six decibels greater than TTS levels on a peak-pressure basis, or 15 decibels greater on an SEL basis than TTS (Southall et al. 2007). In terms of exposure to the R/V *Thomas G. Thompson*'s airgun array, an individual will need to be within a few meters of the largest airgun to experience a single pulse greater than 230 decibels re: 1 μPa (peak) (Caldwell and Dragoset 2000). If an individual experienced exposure to several airgun pulses of approximately 219 decibels for low-frequency cetaceans and 230 decibels for mid-frequency cetaceans PTS could occur. Cetaceans will have to be within certain modeled radial distances specified in Table 10 and Table 11 from the R/V *Thomas G. Thompson*'s dual airgun array to be within the ESA harm (MMPA Level A harassment) to be within the threshold isopleth and risk a PTS and within the ESA harassment (MMPA Level B harassment) to be within the threshold isopleth and risk behavioral responses. As stated earlier in Section 10.3.1, only ESA harassment in the form of TTS and/or behavioral harassment of ESA-listed cetaceans is expected to occur during the proposed low energy seismic survey. Behavioral reactions will be short-term, likely lasting the duration of the exposure, and long-term consequences for individuals or populations are unlikely. Take in the form of ESA harm (i.e., PTS) is not expected to occur nor is it authorized in this opinion's incidental take statement (See Section 14).

Overall, we do not expect the majority of ESA-listed animals to experience TTS as a result of exposure to the airgun array since the probability of occurrence is anticipated to be low. We expect that most individuals will move away from the airgun array as it approaches decreasing their duration of exposure and reducing the chance for TTS onset; however, a few individuals may be exposed to sound levels that may result in TTS. Additionally, as the seismic survey proceeds along each transect trackline and approaches ESA-listed individuals, the sound intensity increases, and individuals may experience conditions (stress, loss of prey, discomfort, etc.) that could prompt them to move away from the research vessel and sound source and thus avoid exposures that will induce TTS. Ramp-ups will also reduce the probability of TTS-inducing exposure at the start of seismic survey activities for the same reasons, as acoustic intensity increases, animals are expected to move away and therefore will unlikely accumulate more injurious sound levels. Furthermore, mitigation measures will be in place to initiate a shutdown if individuals enter or are about to enter the 100 meter (328 feet) exclusion zone [500 meters (1640 feet) for southern right whales, aggregations of large whales, or large whales with a calf] during all airgun array operations, which is beyond the distances believed to have the potential for PTS onset in any of the ESA-listed cetaceans as described above. As stated in the *Exposure Analysis*, each individual is expected to be potentially be exposed to sound levels at or above 160 decibels re: 1 μPa (rms). We anticipate the number of TTS onset from this exposure to be low and we expect that individuals will recover from TTS between each of these exposures. This is due to past measurements of TTS recovery time for cetaceans. Although studies of TTS on large whales are lacking, studies on other surrogate species have occurred. For example, air guns caused a beluga whale to incur a six to seven dB of TTS, which was almost completely recovered from in approximately 4 minutes from exposure (Finneran et al. 2002). In addition, other studies of cetaceans have shown similar results for TTS recovery times from airguns (Finneran 2015; Kastelein et al. 2017). In summary, we do not expect most animals to be present for a sufficient duration to accumulate sound pressure levels that will lead to the onset of TTS and if TTS occurs, recovery rates are predicted to be fast and an animal will only experience TTS for a short period of time. .

Cetaceans and Auditory Interference (Masking)

Interference, or masking, occurs when a sound is a similar frequency and similar to or louder than the sound an animal is trying to hear (Clark et al. 2009; Erbe et al. 2016). Masking can interfere with an individual's ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and other environmental cues (Richardson 1995). This can result in loss of environmental cues of predatory risk, mating opportunity, or foraging options (Francis and Barber 2013). Low frequency sounds are broad and tend to have relatively constant bandwidth, whereas higher frequency bandwidths are narrower (NMFS 2006h).

There is frequency overlap between airgun array sounds and vocalizations of ESA-listed baleen whales and to some extent sperm whales. The proposed seismic survey could mask whale calls at some of the lower frequencies for these species. This could affect communication between individuals, affect their ability to receive information from their environment, or affect sperm whale echolocation (Evans 1998; NMFS 2006h). Most of the energy of sperm whale clicks is concentrated at 2 to 4 kilohertz and 10 to 16 kilohertz, and though the findings by Madsen et al. (2006) suggest frequencies of pulses from airgun arrays can overlap this range, the strongest spectrum levels of airguns are below 200 Hertz (2 to 188 Hertz for the R/V *Thomas G. Thompson*'s airgun array). Any masking that might occur will likely to be temporary because acoustic sources from the seismic surveys are not continuous and the research vessel will continue to transit through the area. In addition, the proposed seismic survey activities on the R/V *Thomas G. Thompson* are planned to occur over the course of approximately 14 days (i.e., approximately 4 days of reconnaissance airgun array seismic operations and approximately 10 days of high-quality airgun array operations for the seismic survey in the South Atlantic Ocean from November to December 2019.

Given the disparity between sperm whale echolocation and communication-related sounds with the dominant frequencies for seismic surveys, masking is not likely to be significant for sperm whales (NMFS 2006h). Overlap of the dominant low frequencies of airgun pulses with low-frequency baleen whale calls will be expected to pose a somewhat greater risk of masking. This heightened risk was presented Nieukirk et al. (2012). Nieukirk et al. (2012) analyzed 10 years of recordings from the Mid-Atlantic Ridge. When several surveys were recorded simultaneously, whale sounds were masked (drowned out), and the airgun noise became the dominant part of background noise levels. However, it is important to note that the R/V. *Thompson*'s airguns will emit a 0.032-second pulse when fired approximately every 9 to 12 seconds. Therefore, pulses will not "cover up" the vocalizations of ESA-listed cetaceans to a significant extent (Madsen et al. 2002b). We address the response of ESA-listed cetaceans stopping vocalizations as a result of airgun sound in the *Cetaceans and Behavioral Responses* section below.

Although sound pulses from airguns begin as short, discrete sounds, they interact with the marine environment and lengthen through processes such as reverberation. This means that in some cases, such as in shallow water environments, airgun sound can become part of the acoustic background. Few studies of how impulsive sound in the marine environment deforms from short bursts to lengthened waveforms exist, but they have been observed to add significantly to the acoustic background (Guerra et al. 2011), potentially interfering with the ability of animals to hear otherwise detectible sounds in their environment.

The sound localization abilities of cetaceans suggest that, if signal and sound come from different directions, masking will not be as severe as the usual types of masking studies might suggest (Richardson 1995). The dominant background noise may be highly directional if it comes from a particular anthropogenic source such as a ship or industrial site. Directional hearing may significantly reduce the masking effects of these sounds by improving the effective signal-to-sound ratio. In the cases of higher frequency hearing by the bottlenose dolphin (*Tursiops truncatus*), beluga whale (*Delphinapterus leucas*), and killer whale, empirical evidence confirms that masking depends strongly on the relative directions of arrival of sound signals and the masking sound (Bain et al. 1993; Bain and Dahlheim 1994; Dubrovskiy 2004). Toothed whales and probably other cetaceans as well, have additional capabilities besides directional hearing that can facilitate detection of sounds in the presence of background sound. There is evidence that some toothed whales can shift the dominant frequencies of their echolocation signals from a frequency range with a lot of ambient sound toward frequencies with less noise (Au et al. 1974; Au 1975; Moore 1990; Thomas 1990; Romanenko and Kitain 1992; Lesage 1999). A few cetacean species increase the source levels or alter the frequency of their calls in the presence of elevated sound levels (Dahlheim 1987; Au 1993; Lesage 1993; Lesage 1999; Terhune 1999; Foote 2004; Parks et al. 2007a; Holt et al. 2009; Parks 2009). These data demonstrating adaptations for reduced masking were used as a surrogate only for sperm whales since there is less information about the existence of corresponding mechanisms for this species.

In summary, high levels of sound generated by the proposed seismic survey activities may act to mask the detection of weaker biologically important sounds by some ESA-listed cetaceans considered in this opinion. This masking is expected to be more prominent for baleen whales given the lower frequencies at which they hear best and produce calls. For sperm whales, which hear best at frequencies above the predominant ones produced by airguns and like other toothed whales mentioned above (e.g., belugas, Au et al. 1985), may have adaptations to allow them to reduce the effects of masking on higher frequency sounds such as echolocation clicks. As such, sperm whales are not expected to experience significant masking during the period of time the airgun arrays are producing sound for the proposed action.

Cetaceans and Behavioral Responses

We expect the greatest response of cetaceans to airgun array sounds in terms of number of responses and overall impact to be in the form of changes in behavior. ESA-listed individuals may briefly respond to underwater sound by slightly changing their behavior or relocating a short distance, in which case some of the responses can equate to harassment of individuals but are unlikely to result in meaningful behavioral responses at the population level. Displacement from important feeding or breeding areas over a prolonged period would likely be more significant for individuals and could affect the population depending on the extent of the feeding area and duration of displacement. This has been suggested for humpback whales along the Brazilian coast as a result of increased seismic survey activity (Parente et al. 2007). Cetacean responses to anthropogenic sound vary by species, state of maturity, prior exposure, current activity, reproductive state, time of day, and other factors (Ellison et al. 2012; Harris et al. 2018); this is reflected in a variety of aquatic, aerial, and terrestrial animal responses to anthropogenic noise that may ultimately have fitness consequences (NRC 2005; Francis and Barber 2013; New et al. 2014; Costa et al. 2016; Fleishman et al. 2016). Although some studies are available which address responses of ESA-listed cetaceans considered in this opinion directly, additional studies to other related whales (such as humpback, bowhead and gray whales) are relevant in determining the responses expected by species under consideration due to their similarities in biological responses.

Therefore, studies from non-ESA-listed or species outside the action area are also considered here. Animals generally respond to anthropogenic perturbations as they will predators, increasing vigilance, and altering habitat selection (Reep et al. 2011). There is increasing support that this predator like response is true for animals' response to anthropogenic sound (Harris et al. 2018). For example, avoidance responses have been reported for baleen whales in response to seismic airgun sounds. Fin whales moved away from a 10-day seismic survey in the Mediterranean and were spatially displaced for at least 14 days after the seismic airgun shooting period.

The survey area affected was estimated to be about 100,000 km^2 (Castellote et al. 2012b). In addition, avoidance responses to airgun sounds at received levels of 160-170 decibels $_{P-P}$ re: 1 μPa have been reported for migrating gray whales (Malme et al. 1984a), bowhead whales (Richardson et al. 1986a), and migrating humpback whales (McCauley et al. 2000a). For additional information on the behavioral responses cetaceans exhibit in response to anthropogenic noise, including non-ESA-listed cetacean species, see the *Federal Register* notice of the proposed incidental harassment authorization (84 FR 51886 to 51928) as well as one of several reviews (e.g., Southall et al. 2007; Gomez et al. 2016).

Several studies have aided in assessing the various levels at which whales may modify or stop their calls in response to sounds for airguns. Whales continue calling while seismic surveys are operating locally (Richardson et al. 1986b; McDonald et al. 1993; McDonald et al. 1995; Greene Jr et al. 1999; Madsen et al. 2002b; Tyack et al. 2003; Nieukirk et al. 2004; Smultea et al. 2004; Jochens et al. 2006). However, humpback whale males increasingly stopped vocal displays on Angolan breeding grounds as received seismic airgun levels increased (Cerchio et al. 2014). Some blue, fin, and sperm whales stopped calling for short and long periods apparently in response to airguns (Bowles et al. 1994; McDonald et al. 1995; Clark and Gagnon 2006). Fin whales (presumably adult males) engaged in singing in the Mediterranean Sea moved out of the area of a seismic survey while airguns were operational as well as for at least a week thereafter (Castellote et al. 2012a). Dunn and Hernandez (2009) tracked blue whales during a seismic survey on the R/V *Maurice Ewing* in 2007 and did not observe changes in call rates and found no evidence of anomalous behavior that they could directly ascribe to the use of airguns at sound levels of approximately less than 145 decibels re: 1 μPa (rms) (Wilcock et al. 2014). Blue whales may also attempt to compensate for elevated ambient sound by calling more frequently during seismic surveys (Iorio and Clark 2009). Bowhead whale calling rates were found to decrease during migration in the Beaufort Sea when seismic surveys were being conducted (Nations et al. 2009). Calling rates decreased when exposed to seismic airguns at estimated received levels of 116 to 129 decibels re: 1 μPa (rms), but did not change at received levels of 99 to 108 decibels re: 1 μPa (rms) (Blackwell et al. 2013). A more recent study examining cumulative sound exposure found that bowhead whales began to increase call rates as soon as airgun sounds were detectable, but this increase leveled off at approximate 94 decibels re: 1 μPa^2-s over the course of ten minutes (Blackwell et al. 2015). Once sound levels exceeded approximately 127 decibels re: 1 μPa^2-s over ten minutes, call rates began to decline and at approximately 160 decibels re: 1 μPa^2-s over 10 minutes, bowhead whales appeared to cease calling all together (Blackwell et al. 2015). While we are aware of no data documenting changes in North Atlantic right whale vocalization in association with seismic surveys, as mentioned previously they do shift calling frequencies and increase call amplitude over both long and short term periods due to chronic exposure to vessel sound (Parks and Clark 2007; Parks et al. 2007a; Parks 2009; Parks et al. 2011; Parks et al. 2012b; Tennessen and Parks 2016). Sperm whales, at least under some conditions, may be particularly sensitive to airgun sounds, as they have been documented to cease calling in association with airguns being fired hundreds of kilometers away (Bowles et al. 1994). Other studies have found no response by sperm whales to received airgun sound levels up to 146 decibels re: 1 μPa (peak-to-peak) (McCall Howard 1999; Madsen et al. 2002a). For the species considered in this consultation, we assume some exposed individual ESA-listed cetaceans may cease calling or otherwise alter their vocal behavior in response to the R/V *Thomas G. Thompson*'s airgun array during the seismic survey activities. However, the effect is expected to be temporary and brief given the research vessel is constantly moving when the airgun array is active; and animals are expected to resume or modify calling at a later time or location away from the R/V *Thomas G. Thompson*'s airgun array during the course of the proposed seismic survey once the acoustic stressor has diminished.

There are numerous studies of the responses of some baleen whales to airgun arrays. Although responses to lower-amplitude sounds are known, most studies seem to support a threshold of approximately 160 decibels re: 1 µPa (rms) (the level used in this opinion to determine the extent of acoustic effects for cetaceans) as the received sound level to cause behavioral responses other than vocalization changes (Richardson et al. 1995a). Activity of individuals seems to influence response (Robertson et al. 2013), as feeding individuals respond less than mother and calf pairs and migrating individuals (Malme et al. 1984b; Malme and Miles 1985; Richardson et al. 1995a; Miller et al. 1999; Richardson et al. 1999; Miller et al. 2005; Harris et al. 2007). Migrating bowhead whales show strong avoidance reactions to received 120 to 130 decibels re: 1 µPa (rms) exposures at distances of 20 to 30 kilometers (10.8 to 16.2 nautical miles), but only changed dive and respiratory patterns while feeding and showed avoidance at higher received sound levels (152 to 178 decibels re: 1 µPa [rms]) (Richardson et al. 1986b; Ljungblad et al. 1988; Richardson et al. 1995a; Miller et al. 1999; Richardson et al. 1999; Miller et al. 2005; Harris et al. 2007). Nations et al. (2009) also found that bowhead whales were displaced during migration in the Beaufort Sea during active seismic surveys. As mentioned previously, the available data indicate that most, if not all, baleen whale species exhibit avoidance of active seismic airguns (Gordon et al. 2003; Stone and Tasker 2006; Potter et al. 2007; Southall et al. 2007; Barkaszi et al. 2012; Castellote et al. 2012a; NAS 2017; Stone et al. 2017). Despite the above observations and exposure to repeated seismic surveys, bowhead whales continue to return to summer feeding areas and when displaced, appear to re-occupy within a day (Richardson et al. 1986b). We do not know whether the individuals exposed in these ensonified areas are the same returning or whether they tolerate repeat exposures, they may still experience a stress response. However, we expect the implemented mitigation measures such as presence of the protected species observers and the shutdown that will occur if a cetacean were present in the exclusion zone will lower the likelihood that cetaceans will be exposed to sounds more than once from the airgun array.

Gray whales respond similarly to seismic survey as described for bowhead whales. Gray whales discontinued feeding and/or moved away at received sound levels of 163 decibels re: 1 µPa (rms) (Malme et al. 1984b; Malme and Miles 1985; Malme et al. 1986; Malme et al. 1987; Würsig et al. 1999; Bain and Williams 2006; Gailey et al. 2007; Johnson et al. 2007; Meier et al. 2007; Yazvenko et al. 2007). Migrating gray whales began to show changes in swimming patterns at approximately 160 decibels re: 1 µPa (rms) and slight behavioral changes at 140 to 160 re: 1 µPa (rms) (Malme et al. 1984b; Malme and Miles 1985). As with bowhead whales, habitat continues to be used despite frequent seismic survey activity, but long-term effects have not been identified, if they are present at all (Malme et al. 1984b). Johnson et al. (2007) reported that gray whales exposed to airgun sounds during seismic surveys off Sakhalin Island, Russia, did not experience any biologically significant or population level effects, based on subsequent research in the area from 2002 through 2005. Furthermore, when strict mitigation measures, such as those proposed by the NMFS Permits and Conservation Division, are taken to avoid conducting seismic surveys during certain times of the year when most gray whales are expected to be present and to closely monitor operations, gray whales may not exhibit any noticeable behavioral responses to seismic survey activities (Gailey et al. 2016). Given the similar mitigations measures that will be implemented for this program, we expect some of the cetacean species considered in this opinion will respond in a similar manner as gray whales.

Humpback whales exhibit a pattern of lower threshold responses when not occupied with feeding. Migrating humpbacks altered their travel path (at least locally) along Western Australia at received levels as low as 140 decibels re: 1 µPa (rms) when females with calves were present, or 7 to 12 kilometers (3.8 to 6.5 nautical miles) from the acoustic source (McCauley et al. 1998a; McCauley et al. 2000b). A startle response occurred as low as 112 decibels re: 1 µPa (rms). Closest approaches were generally limited to 3 to 4 kilometers (1.6 to 2.2 nautical miles), although some individuals (mainly males) approached to within 100 meters (328.1 feet) on occasion where sound levels were 179 decibels re: 1 µPa (rms). Changes in course and speed generally occurred at estimated received levels of 157 to 164 decibels re: 1 µPa (rms). Similarly, on the east coast of Australia, migrating humpback whales appear to avoid seismic airguns at distances of 3 kilometers (1.6 nautical miles) at levels of 140 decibels re: 1 μPa^2-second. A recent study examining the response of migrating humpback whales to a full 51,291.5 cubic centimeters (3,130 cubic inch) airgun array found that humpback whales exhibited no abnormal behaviors in response to the active airgun array, and while there were detectible changes in respiration and diving, these were similar to those observed when baseline groups (i.e., not exposed to active sound sources) were joined by another humpback whale (Dunlop et al. 2017).

While some humpback whales were also found to reduce their speed and change course along their migratory route, overall these results suggest that the behavioral responses exhibited by humpback whales are unlikely to have significant biological consequences for fitness (Dunlop et al. 2017). Feeding humpback whales appear to be somewhat more tolerant. Humpback whales off the coast of Alaska startled at 150 to 169 decibels re: 1 µPa (rms) and no clear evidence of avoidance was apparent at received levels up to 172 decibels re: 1 µPa (rms) (Malme et al. 1984b; Malme et al. 1985). Potter et al. (2007) found that humpback whales on feeding grounds in the Atlantic Ocean did exhibit localized avoidance to airgun arrays. Among humpback whales on Angolan breeding grounds, no clear difference was observed in encounter rate or point of closest approach during seismic versus non-seismic periods (Weir 2008).

Observational data are sparse for specific baleen whale life histories (breeding and feeding grounds) in response to airguns. Available data support a general avoidance response. Some fin and sei whale sighting data indicate similar sighting rates during seismic versus non-seismic periods, but sightings tended to be further away and individuals remained underwater longer (Stone 2003; Stone and Tasker 2006; Stone et al. 2017). Other studies have found at least small differences in sighting rates (lower during seismic survey activities) as well as whales being more distant during seismic survey activities (Moulton and Miller 2005). When spotted at the average sighting distance, individuals will have likely been exposed to approximately 169 decibels re: 1 μPa (rms) (Moulton and Miller 2005).

Sperm whale response to airguns has thus far included mild behavioral disturbance (temporarily disrupted foraging, avoidance, cessation of vocal behavior) or no reaction. Several studies have found sperm whales in the Atlantic Ocean to show little or no response (Davis et al. 2000; Stone 2003; Moulton and Miller 2005; Madsen et al. 2006; Stone and Tasker 2006; Weir 2008; Miller et al. 2009; Stone et al. 2017). Detailed study of sperm whales in the Gulf of Mexico suggests some alteration in foraging from less than 130 to 162 decibels re: 1 μPa peak-to-peak, although other behavioral reactions were not noted by several authors (Gordon et al. 2004; Gordon et al. 2006; Jochens et al. 2006; Madsen et al. 2006; Winsor and Mate 2006). This has been contradicted by other studies, which found avoidance reactions by sperm whales in the Gulf of Mexico in response to seismic ensonification (Mate et al. 1994; Jochens 2003; Jochens and Biggs 2004).

Johnson and Miller (2002) noted possible avoidance at received sound levels of 137 decibels re: 1 μPa. Other anthropogenic sounds, such as pingers and sonars, disrupt behavior and vocal patterns (Watkins and Schevill 1975a; Watkins et al. 1985; Goold 1999). Miller et al. (2009) found sperm whales to be generally unresponsive to airgun exposure in the Gulf of Mexico, although foraging behavior may have been affected based on changes in echolocation rate and slight changes in dive behavior. Displacement from the area was not observed.

Winsor and Mate (2013) did not find a non-random distribution of satellite-tagged sperm whales at and beyond 5 kilometers (2.7 nautical miles) from airgun arrays, suggesting individuals were not displaced or move away from the airgun array at and beyond these distances in the Gulf of Mexico (Winsor and Mate 2013). However, no tagged whales within 5 kilometers (2.7 nautical miles) were available to assess potential displacement within 5 kilometers (2.7 nautical miles) (Winsor and Mate 2013). In a follow-up study using additional data, Winsor et al. (2017) found no evidence to suggest sperm whales avoid active airguns within distances of 50 kilometers (27 nautical miles). The lack of response by this species may in part be due to its higher range of hearing sensitivity and the low-frequency (generally less than 200 Hertz) pulses produced by seismic airguns (Richardson et al. 1995a). However, sperm whales are exposed to considerable energy above 500 Hertz during the course of seismic surveys (Goold and Fish 1998), so even though this species generally hears at higher frequencies, this does not mean that it cannot hear airgun sounds. Nonetheless, reactions of sperm whales to impulse noise likely vary depending on the activity at time of exposure. For example, in the presence of abundant food or during breeding encounters, toothed whales sometimes are extremely tolerant of noise pulses (NMFS 2010a).

In summary, ESA-listed cetaceans are expected to exhibit a wide range of behavioral responses when exposed to sound fields from the airgun array. Baleen whales are expected to mostly exhibit avoidance behavior, and may alter their vocalizations. Toothed whales (i.e., sperm whales) are expected to exhibit less overt behavioral changes, but may alter foraging behavior, including echolocation vocalizations.

Cetaceans and Physical or Physiological Effects

Individual whales exposed to airguns (as well as other sound sources) could experience effects not readily observable, such as stress (Romano et al. 2002), that may have adverse affects. Stress is an adaptive response and does not normally place an animal at risk. Distress involves a stress response resulting in a biological consequence to the individual. The mammalian stress response involves the hypothalamic-pituitary-adrenal axis being stimulated by a stressor, causing a cascade of physiological responses, such as the release of the stress hormones cortisol, adrenaline (epinephrine), glucocorticosteroids, and others (Thomson and Geraci 1986; St. Aubin and Geraci 1988; St. Aubin et al. 1996; Gulland et al. 1999; Gregory and Schmid 2001; Busch and Hayward 2009). These hormones subsequently can cause short-term weight loss, the liberation of glucose into the blood stream, impairment of the immune and nervous systems, elevated heart rate, body temperature, blood pressure, and alertness, and other responses (Thomson and Geraci 1986; Kaufman and Kaufman 1994; Dierauf and Gulland 2001; Cattet et al. 2003; Elftman et al. 2007; Fonfara et al. 2007; Noda et al. 2007; Mancia et al. 2008; Busch and Hayward 2009; Dickens et al. 2010; Costantini et al. 2011). In some species, stress can also increase an individual’s susceptibility to gastrointestinal parasitism (Greer et al. 2005). In highly stressful circumstances, or in species prone to strong “fight-or-flight” responses, more extreme consequences can result, including muscle damage and death (Cowan and Curry 1998; Cowan and Curry 2002; Herraez et al. 2007; Cowan 2008). The most widely-recognized indicator of vertebrate stress, cortisol, normally takes hours to days to return to baseline levels following a significantly stressful event, but other hormones of the hypothalamic-pituitary-adrenal axis may persist for weeks (Dierauf and Gulland 2001). Stress levels can vary by age, sex, season, and health status (St. Aubin et al. 1996; Gardiner and Hall 1997; Hunt et al. 2006; Keay et al. 2006; Romero et al. 2008). For example, stress is lower in immature North Atlantic right whales than adults and mammals with poor diets or undergoing dietary change tend to have higher fecal cortisol levels (Hunt et al. 2006; Keay et al. 2006).

Loud sounds have also been found to generally increase stress indicators in cetaceans (Kight and Swaddle 2011). Romano et al. (2004) found beluga whales and bottlenose dolphins exposed to a seismic watergun (up to 228 decibels re: 1 µPa m peak-to-peak and single pure tones (up to 201 decibels re: 1 µPa) had increases in stress chemicals, including catecholamines, which could affect an individual’s ability to fight off disease. During the time following September 11, 2001, shipping traffic and associated ocean noise decreased along the northeastern U.S. This decrease in ocean sound was associated with a significant decline in fecal stress hormones in North Atlantic right whales, providing evidence that chronic exposure to increased noise levels, although not acutely injurious, can produce stress (Rolland et al. 2012). These levels returned to baseline after 24 hours of traffic resuming.

As whales use hearing for communication as a primary way to gather information about their environment, we assume that limiting these abilities, as is the case when masking occurs, will be stressful. We also assume that any individuals exposed to sound levels sufficient to trigger onset of TTS will also experience physiological stress response (NRC 2003b; NMFS 2006a). Finally, we assume that some individuals exposed at sound levels below those required to induce a TTS, but above the ESA harassment (MMPA Level B harassment) 160 decibels re: 1 μPa (rms) threshold, will experience a stress response, which may also be associated with an overt behavioral response. However, since in all cases of exposure to sounds from airgun arrays (or fisheries echosounder) are expected to be temporary, we expect any such stress responses to be short-term. Given the available data, animals will be expected to return to baseline state (e.g., baseline cortisol level) within hours to days, with the duration of the stress response depending on the severity of the exposure (i.e., we expect a TTS exposure will result in a longer duration before returning to a baseline state as compared to exposure to levels below the TTS threshold). Although we do not have a way to determine the health of the animal at the time of exposure, we assume that the stress responses resulting from these exposures could be more significant or exacerbate other factors if an animal is already in a compromised state.

Data specific to cetaceans are not readily available to access other non-auditory physical and physiological responses to sound, specifically related to reproductive and metabolic functions. However, based on studies of other vertebrates, exposure to loud sound may also adversely affect reproductive and metabolic physiology (reviewed in Kight and Swaddle 2011). Premature birth and indicators of developmental instability (possibly due to disruptions in calcium regulation) have been found in embryonic and neonatal rats exposed to loud sound. Fish eggs and embryos exposed to sound levels only 15 decibels greater than background showed increased mortality and surviving fry and slower growth rates, although the opposite trends have also been found in sea bream. Studies of rats have shown that their small intestine leaks additional cellular fluid during loud sound exposure, potentially exposing individuals to a higher risk of infection (reflected by increases in regional immune response in experimental animals). In addition, exposure to 12 hours of loud sound may alter cardiac tissue in rats. In a variety of response categories, including behavioral and physiological responses, female animals appear to be more sensitive or respond more strongly than males. Given the available data, and the short duration of exposure to sounds generated by airgun arrays, we do not anticipate any effects to reproductive and metabolic physiology of ESA-listed cetaceans.

It is possible that an animal's prior exposure to sounds from seismic surveys influence its future response. Although we have little information available to us as to what response individuals will have to future exposures to sources from seismic surveys compared to prior experience. If prior exposure produces a learned response, then this subsequent learned response will likely be similar to or less than prior responses to other stressors where the individual experienced a stress response associated with the novel stimuli and responded behaviorally as a consequence (such as moving away and reduced time budget for activities otherwise undertaken) (Andre and Lopez Jurado 1997; André et al. 1997; Gordon et al. 2006). However, we do not believe sensitization will occur based upon the lack of severe responses previously observed in cetaceans exposed to sounds from seismic surveys that will be expected to produce a more intense, frequent, and/or earlier response to subsequent exposures. With this said, seismic activities can lead to a potential for cetaceans to habituate to airgun sounds which may lead to additional energetic costs or reductions in foraging success (Nowacek et al. 2015). Nevertheless, the proposed seismic activities will only take place for 14 days; minimizing the likelihood that sensitization or habituation will occur. As stated before, we believe that exposed individuals will move away from the sound source, especially in the open ocean of the action area, where we expect species to be transiting through.

Cetaceans and Strandings

There is some concern regarding the coincidence of cetacean strandings and proximal seismic surveys. No conclusive evidence exists to causally link stranding events to seismic surveys. Suggestions that there was a link between seismic surveys and strandings of humpback whales in Brazil (Engel et al. 2004) were not well founded (Iagc 2004; IWC 2007a). In September 2002, two Cuvier's beaked whales (*Ziphius cavirostris*) stranded in the Gulf of California, Mexico. The R/V *Maurice Ewing* had been operating a 20 airgun array (139,126.2 cubic centimeters [8,490 cubic inch]) 22 kilometers (11.9 nautical miles) offshore the general area at the time that stranding occurred. However, the link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence, as the individuals who happened upon the stranding were ill-equipped to perform an adequate necropsy (Taylor et al. 2004). Furthermore, the small numbers of animals involved and the lack of knowledge regarding the spatial and temporal correlation between the beaked whales and the sound source underlies the uncertainty regarding the linkage between sound sources from seismic surveys and beaked whale strandings (Cox et al. 2006). Numerous studies suggest that the physiology, behavior, habitat relationships, age, or condition of cetaceans may cause them to strand or might pre-dispose them to strand when exposed to another phenomenon. These suggestions are consistent with the conclusions of numerous other studies that have demonstrated that combinations of dissimilar stressors commonly combine to kill an animal or dramatically reduce its fitness, even though one exposure without the other does not produce the same result (Fair and Becker 2000; Moberg 2000; Kerby et al. 2004; Romano et al. 2004; Creel 2005). At present, the factors of airgun arrays from seismic surveys that may contribute to cetacean strandings are unknown and we have no evidence to lead us to believe that aspects of the airgun array proposed for use will cause cetacean strandings. For these reasons, we do not expect ESA-listed cetaceans to strand as a result of the proposed seismic survey. The seismic survey will take place in the South Atlantic Ocean, approximately 650 kilometers (404 miles) from the closest approach to the Namibian coastline. If exposed to seismic survey activities, we expect ESA-listed cetaceans will have sufficient space in the open ocean to move away from the sound source and not be exposed for sufficient duration or be confined in areas that prevent them from escaping the sound source and thus are not expected to strand.

Responses of Cetacean Prey

Seismic surveys may also have indirect, adverse effects on prey availability through lethal or sub-lethal damage, stress responses, or alterations in prey behavior or distribution. Studies described herein provide extensive support for this, which is the basis for later discussion on implications for ESA-listed cetaceans. Unfortunately, species-specific information on the prey of ESA-listed cetaceans is not generally available. Until more specific information is available, we expect that teleost fishes, cephalopods, and krill prey species of ESA-listed cetaceans considered in this opinion will react in manners similar to those fishes and invertebrates described herein.

Recently there has been research suggesting that that seismic airgun arrays may lead to a significant reduction in zooplankton, including copepods. McCauley et al. (2017) found that the use of a single airgun (approximately 150 cubic inches) lead to a decrease in zooplankton abundance by over 50 percent and a two- to three-fold increase in dead adult and larval zooplankton when compared to control scenarios. In addition, effects were found out to 1.2 kilometers (0.6 nautical miles), the maximum distance to which sonar equipment used in the study was able to detect changes in abundance. McCauley et al. (2017) noted that for seismic activities to have a significant impact on zooplankton at an ecological scale, the spatial or temporal scale of the seismic activity must be large in comparison to the ecosystem in question. In particular, three-dimensional seismic surveys, which involve the use of multiple overlapping tracklines to extensively and intensively survey a particular area, are of concern (McCauley et al. 2017). This is in part because in order for such activities to have a measurable effect, they need to outweigh the naturally fast turnover rate of zooplankton (McCauley et al. 2017).

However, Fields et al. (2019) has demonstrated different results through a series of control experiments using seismic blasts from two airguns (260 cubic inches) during 2009 and 2010 on *Calanus finmarchicus*. Their data show that seismic blasts have limited effects on the mortality or escape response of *C. finmarchicus* within 10 meters (32.8 feet) of the seismic airguns, but there was no measurable impact at greater distances. Furthermore, Fields et al. (2019) demonstrated that seismic airgun blasts had no effect on the escape response of *C. finmarchicus*. They conclude that the effects of seismic airgun blasts are much less than reported by McCauley et al. (2017).

Given these counterintuitive results from each of these studies, it is difficult to fully assess the exact impact seismic airgun arrays may have on the instantaneous or long-term survivability of zooplankton/krill that are exposed. Furthermore, the reduced energy of the proposed seismic arrays (90 cubic inches versus 150 or 260 cubic inches) proposed in this consultation suggests that any copepod or crustacean directly exposed to the seismic airguns (underneath or within five meters (16.4 feet) would likely suffer mortality to an extent much less than described by McCauley et al. (2017). Additionally, the majority of copepod prey available to baleen whales or fishes which are prey to these whales, are expected to be near the surface (Witherington et al. 2012), results of McCauley et al. (2017) provide little information on the effects to copepods at the surface since their analyses excluded zooplankton at the surface bubble layer. Nonetheless, given that airguns primarily transmit sound downward, and that those associated with the proposed action will be towed at depths of three meters (9.8 feet), we expect that sounds from airgun array will be relatively low at the surface and as such, will effect copepod prey within the action area less than that reported in McCauley et al. (2017).

While the proposed seismic survey may temporarily alter copepod or crustacean abundance in the action, we expect such effects to be insignificant because most copepods will be near the surface where sound from airgun arrays is expected to be relatively low and the high turnover rate of zooplankton and ocean circulation will minimize any effects.

Squid are known to be important prey for sperm whales. Squid responses to operating airguns have also been studied, although to a lesser extent than fishes. In response to airgun exposure, squid exhibited both startle and avoidance responses at received sound levels of 174 decibels re: 1 μPa (rms) by first ejecting ink and then moving rapidly away from the area (McCauley et al. 2000b; McCauley et al. 2000c; Fewtrell 2013b). The authors also noted some movement upward. During ramp-up, squid did not discharge ink but alarm responses occurred when received sound levels reached 156 to 161 decibels re: 1 μPa (rms). Tenera Environmental (2011) reported that Norris and Mohl (1983, summarized in (Moriyasu et al. 2004)) observed lethal effects in squid (*Loligo vulgaris*) at levels of 246 to 252 decibels after three to 11 minutes. Andre et al. (2011) exposed four cephalopod species (*Loligo vulgaris*, *Sepia officinalis*, *Octopus vulgaris*, and *Ilex coindetii*) to two hours of continuous sound from 50 to 400 Hertz at 157 ±5 decibels re: 1 μPa. They reported lesions to the sensory hair cells of the statocysts of the exposed animals that increased in severity with time, suggesting that cephalopods are particularly sensitive to low-frequency sound. The received sound pressure level was 157 ±5 decibels re: 1 μPa, with peak levels at 175 decibels re: 1 μPa. Guerra et al. (2004) suggested that giant squid mortalities were associated with seismic surveys based upon coincidence of carcasses with the seismic surveys in time and space, as well as pathological information from the carcasses. Another laboratory story observed abnormalities in larval scallops after exposure to low frequency noise in tanks (de Soto et al. 2013).

Some support has been found for fish or invertebrate mortality resulting from exposure to airguns, and this is limited to close-range exposure to high amplitudes (Falk and Lawrence 1973; Kostyuchenko 1973; Holliday et al. 1987; La Bella et al. 1996; Santulli et al. 1999; McCauley et al. 2000b; McCauley et al. 2000c; Bjarti 2002; Hassel et al. 2003; McCauley et al. 2003; Popper et al. 2005). Lethal effects, if any, are expected within a few meters of the airgun array (Dalen and Knutsen 1986; Buchanan et al. 2004). For fishes that are located at distances greater than this, we expect that if fishes detect the sound and perceive it as a threat or some other signal that induces them to leave the area, they are capable of moving away from the sound source (e.g., airgun array) if it causes them discomfort and will return to the area as available prey for cetaceans. For example, a common response by fishes to airgun sound is a startle or distributional response, where fish react momentarily by changing orientation or swimming speed, or change their vertical distribution in the water column (Fewtrell 2013a; Davidsen et al.

2019). During airgun studies in which the received sound levels were not reported, Fewtrell (2013a) observed caged *Pelates* spp., pink snapper, and trevally (*Caranx ignobilis*) to generally exhibited startle, displacement, and/or grouping responses upon exposure to airguns. This effect generally persisted for several minutes, although subsequent exposures to the same individuals did not necessarily elicit a response (Fewtrell 2013a). In addition, Davidsen et al. (2019) performed controlled exposure experiments on Atlantic cod (*Gadus morhua*) and saithe (*Pollachius virens*) to test their response to airgun noise. Davidsen et al. (2019) noted the cod exhibited reduced heart rate (bradycardia) in response to the particle motion component of the sound from the airgun, indicative of an initial flight response, however no behavioral startle response to the airgun was observed. Furthermore, both the Atlantic cod and saithe changed both swimming depth and horizontal position more frequently during airgun sound production(Davidsen et al. 2019).

There are reports showing sub-lethal effects to some fish species. Several species at various life stages have been exposed to high-intensity sound sources (220 to 242 decibels re: 1 μPa) at close distances, with some cases of injury (Booman et al. 1996; McCauley et al. 2003). Effects from TTS were not found in whitefish at received levels of approximately 175 decibels re: 1 $\mu Pa^2 s$, but pike did show 10 to 15 decibels of hearing loss with recovery within one day (Popper et al. 2005). Exposure to airguns at close range were found to produce balance issues in exposed fry (Dalen and Knutsen 1986). Exposure of monkfish (*Lophius* spp.) and capelin (*Mallotus villosus*) eggs at close range to airguns did not produce differences in mortality compared to control groups (Payne 2009). Salmonid swim bladders were reportedly damaged by received sound levels of approximately 230 decibels re: 1 μPa (Falk and Lawrence 1973).

Startle responses were observed in rockfish at received airgun levels of 200 decibels re: 1 μPa 0-to-peak and alarm responses at greater than 177 decibels re: 1 μPa 0-to-peak (Pearson et al. 1992). Fish also tightened schools and shifted their distribution downward. Normal position and behavior resumed 20 to 60 minutes after firing of the airgun ceased. A downward shift was also noted by Skalski et al. (1992) at received seismic sounds of 186 to 191 re: 1 μPa 0-to-peak. Caged European sea bass (*Dichentrarchus labrax*) showed elevated stress levels when exposed to airguns, but levels returned to normal after three days (Skalski 1992). These fish also showed a startle response when the seismic survey vessel was as much as 2.5 kilometer (1.3 nautical miles) away; this response increased in severity as the vessel approached and sound levels increased, but returned to normal after about two hours following cessation of airgun activity.

Whiting (*Merlangius merlangus*) exhibited a downward distributional shift upon exposure to 178 decibels re: 1 μPa 0-to-peak sound from airguns, but habituated to the sound after one hour and returned to normal depth (sound environments of 185 to 192 decibels re: 1 μPa) despite airgun activity (Chapman and Hawkins 1969). Whiting may also flee from sounds from airguns (Dalen and Knutsen 1986). Hake (*Merluccius* spp.) may re-distribute downward (La Bella et al. 1996). Lesser sand eels (*Ammodytes tobianus*) exhibited initial startle responses and upward vertical movements before fleeing from the seismic survey area upon approach of a vessel with an active source (Hassel et al. 2003; Hassel et al. 2004).

McCauley et al. (2000; 2000b) found small fish show startle responses at lower levels than larger fish in a variety of fish species and generally observed responses at received sound levels of 156 to 161 decibels re: 1 μPa (rms), but responses tended to decrease over time suggesting habituation. As with studies previously noted in this opinion (Fewtrell 2013a; Davidsen et al. 2019), caged fish showed increases in swimming speeds and downward vertical shifts. Pollock (*Pollachius* spp.) did not respond to sounds from airguns received at 195 to 218 decibels re: 1 μPa 0-to-peak, but did exhibit continual startle responses and fled from the acoustic source when visible (Wardle et al. 2001). Blue whiting (*Micromesistius poutassou*) and mesopelagic fishes were found to re-distribute 20 to 50 meters (65.6 to 164 feet) deeper in response to airgun ensonification and a shift away from the seismic survey area was also found (Slotte et al. 2004). Startle responses were infrequently observed from salmonids receiving 142 to 186 decibels re: 1 μPa peak-to-peak sound levels from an airgun (Thomsen 2002). Cod (*Gadus* spp.) and haddock (*Melanogrammus aeglefinus*) likely vacate seismic survey areas in response to airgun activity and estimated catchability decreased starting at received sound levels of 160 to 180 decibels re: 1 μPa 0-to-peak (Dalen and Knutsen 1986; Løkkeborg 1991; Engås et al. 1993; Løkkeborg and Soldal 1993; Turnpenny et al. 1994; Engås et al. 1996).

Increased swimming activity in response to airgun exposure on fish, as well as reduced foraging activity, is supported by data collected by Lokkeborg et al. (2012). Bass did not appear to vacate during a shallow-water seismic survey with received sound levels of 163 to 191 decibels re: 1 μPa 0-to-peak (Turnpenny and Nedwell 1994). Similarly, European sea bass apparently did not leave their inshore habitat during a four to five month seismic survey (Pickett et al. 1994). La Bella et al. (1996) found no differences in trawl catch data before and after seismic survey activities and echosurveys of fish occurrence did not reveal differences in pelagic biomass. However, fish kept in cages did show behavioral responses to approaching operating airguns.

Lobsters did not exhibit delayed mortality, or apparent damage to mechanobalancing systems after up to eight months post-exposure to airguns fired at 202 or 227 decibels peak-to-peak pressure (Payne et al. 2013). However, feeding did increase in exposed individuals (Payne et al. 2013). Sperm whales regularly feed on squid and some fishes and we expect individuals to feed while in the action area during the proposed seismic survey activities. Based upon the best available information, fishes and squids located within the sound fields corresponding to the approximate 160 decibels re: 1 μPa (rms) isopleths could vacate the area and/or dive to greater depths.

The overall response of fishes and cephalopods (e.g. squid) is to exhibit startle behaviors and undergo vertical and horizontal movements away from the sound field. We are not aware of any specific studies regarding sound effects on and the detection ability of other invertebrates such as krill (*Euphausiacea* spp.), the primary prey of most ESA-listed baleen whales. However, as discussed above we do not expect the abundance of krill to severely decline as a result of effects from sounds of airguns. Although some of the baleen whales consume fish regularly, we expect that any disruption or small losses in numbers of their prey will be temporary or minor. Therefore, we do not expect any adverse effects from lack of prey availability to baleen whales. Sperm whales regularly feed on squid and some fishes and we expect individuals to feed while in the action area during the proposed seismic survey activities. Based upon the best available information, fishes and squids located within the sound fields corresponding to the approximate 160 decibels re: 1 µPa (rms) isopleths could vacate the area and/or dive to greater depths. However, we do not expect indirect effects from airgun array operations through reduced feeding opportunities for ESA-listed cetaceans to be sufficient to reach a significant level. Effects are likely to be temporary and, if displaced, both cetaceans and their prey are anticipated to re-distribute back into the action area once seismic survey activities have passed or concluded.

Cetacean Response to Multi-Beam Echosounder, Sub-Bottom Profiler, Acoustic Doppler Current Profiler, and Acoustic Release Transponder

We expect ESA-listed cetaceans to experience ensonification from not only the airgun array, but also from the multi-beam echosounder and sub-bottom profiler. As discussed, the multi-beam echosounder and sub-bottom profiler operate at a frequency of 10.5 to 13 (usually 12) kilohertz and 3.5 kilohertz, respectively. These frequencies are within the functional hearing range of the ESA-listed cetaceans in this opinion (7 Hertz to 35 kilohertz for blue, fin, right and sei whales and 150 Hertz to 160 kilohertz for sperm whales (NOAA 2018)). Although Todd et al. (1992) found that mysticetes reacted to sonar sounds at 3.5 kilohertz within the 80 to 90 dB re: 1 µPa range, it is difficult to determine the significance of this because the sound source was a signal designed to be alarming and the sound level was well below typical ambient noise. Goldbogen et al. (2013) found blue whales to respond to 3.5 to 4 kilohertz mid-frequency sonar at received levels below 90 dB re: 1 µPa. Responses included cessation of foraging, increased swimming speed, and directed travel away from the source (Goldbogen 2013). Hearing is poorly understood for ESA-listed baleen whales, but it is assumed that they are most sensitive to frequencies over which they vocalize, which are much lower than frequencies emitted by the multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder (Richardson et al. 1995c; Ketten 1997).

Assumptions for sperm whale hearing are much different than for ESA-listed baleen whales. Sperm whales vocalize between 3.5 to 12.6 kilohertz and an audiogram of a juvenile sperm whale provides direct support for hearing over this entire range (Payne 1970; Winn et al. 1970; Levenson 1974; Tyack 1983; Tyack and Whitehead 1983; Payne and Payne 1985; Silber 1986; Thompson et al. 1986; Carder and Ridgway 1990; Weilgart and Whitehead 1993; Goold and Jones 1995; Richardson et al. 1995c; Weilgart and Whitehead 1997a; Au 2000; Frazer and Mercado 2000; Erbe 2002a; Au et al. 2006; Weir et al. 2007). The response of a blue whale to 3.5 kilohertz sonar supports this species' ability to hear this signal as well (Goldbogen 2013). Kremser et al. (2005) concluded the probability of a cetacean swimming through the area of exposure when such sources emit a pulse is small, as the animal will have to pass at close range and be swimming at speeds similar to the vessel. The animal will have to pass the transducer at close range and be swimming at speeds similar to the vessel in order to receive the multiple pulses that might result in sufficient exposure to cause TTS. Sperm whales have stopped vocalizing in response to 6 to 13 kilohertz pingers, but did not respond to 12 kilohertz echosounders (Backus and Schevill 1966; Watkins and Schevill 1975b; Watkins 1977). Sperm whales exhibited a startle response to 10 kilohertz pulses upon exposure while resting and feeding, but not while traveling (Andre 1997; André 1997).

Investigations stemming from a 2008 stranding event in Madagascar indicated a 12 kilohertz multi-beam echosounder, similar in operating characteristics as that proposed for use aboard the R/V *Thompson*, suggest that this sonar played a significant role in the mass stranding of a large group of melon-headed whales (*Peponocephala electra*) (Southall 2013). Although pathological data suggest a direct physical effect are lacking and the authors acknowledge that while the use of this type of sonar is widespread and common place globally without noted incidents (like the Madagascar stranding), all other possibilities were either ruled out or believed to be of much lower likelihood as a cause or contributor to stranding compared to the use of the multi-beam echosounder (Southall 2013). This incident highlights the caution needed when interpreting effects that may or may not stem from anthropogenic sound sources, such as the R/V *Thompson's* multi-beam echosounder and sub-bottom profiler. Although effects such as this have not been documented for ESA-listed species, the combination of exposure of this stressor with other factors, such as behavioral and reproductive state, oceanographic and bathymetric conditions, movement of the source, previous experience of individuals with the stressor, and other factors may combine to produce a response that is greater than will otherwise be anticipated or has been documented to date (Ellison et al. 2012; Francis 2013).

Although navigational sonars are operated routinely by thousands of vessels around the world, strandings have not been correlated to use of these sonars. Stranding events associated with the operation of naval sonar suggest that mid-frequency sonar sounds may have the capacity to cause serious impacts to cetaceans. The sonars proposed for use by the R/V *Thompson* differ from sonars used during naval operations, which generally have a longer pulse duration and more horizontal orientation than the more downward-directed multi-beam echosounder. The sound energy received by any individuals exposed to the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler sound sources during the proposed seismic survey activities is lower relative to naval sonars, as is the duration of exposure. The area of possible influence for the multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder is also much smaller, consisting of a narrow zone close to and below the source vessel. Because of these differences, we do not expect these systems to contribute to a stranding event.

We do not expect masking of blue, fin, humpback, sei, or sperm whales communication to appreciably occur due to the multi-beam echosounder and sub-bottom profiler, and acoustic Doppler current profiler's signal directionality, low duty cycle, and brief period when an individual could be within their beam. These factors were considered when Burkhardt et al. (2013) estimated the risk of injury from multi-beam echosounder was less than three percent that of vessel strike. Behavioral responses to the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler are likely to be similar to the other pulsed sources discussed earlier if received at the same levels. Also, we do not expect hearing impairment such as TTS and other physical effects if the animal is in the area, as it would have to pass the transducers at close range in order to be subjected to sound levels that could cause these effects.

10.4 Risk Analysis

In this section, we assess the consequences of the responses of the individuals that have been exposed, the populations those individuals represent, and the species those populations comprise.

We measure risks to individuals of threatened or endangered species based upon effects on the individual's fitness, which may be indicated by changes to the individual's growth, survival, annual reproductive fitness, and lifetime reproductive success. We expect up to 3 blue, 4 fin, 3 sei, 41 southern right, and 31 sperm whales (see .

Table 14), to be exposed to the airgun array within the 160 decibels re: 1 µPa (rms) ensonified areas during the seismic survey activities. We expect zero ESA-listed cetaceans to be exposed to the airgun array ensonified areas at levels to incur PTS during the seismic survey activities and therefore no ESA harm from PTS is expected or exempted.

When we do not expect individual ESA-listed cetaceans exposed to an action's effects to experience reductions in fitness, we will not expect the action to have adverse consequences on the viability of the populations those individuals belong or the species those populations comprise. As a result, if we conclude that ESA-listed cetaceans are not likely to experience reductions in their fitness, we will conclude our assessment. If, however, we conclude that individual animals are likely to experience reductions in fitness, we will assess the consequences of those fitness reductions on the population(s) to which those individuals belong.

Because of the mitigation measures in the incidental harassment authorization, and the nature of the seismic survey activities (low-energy airgun array and reduced zones of ensonification), as described above, we do not expect any mortality to occur for cetaceans from the exposure to the acoustic sources that result from the proposed action. As described above, the proposed action will result in temporary harassment to the exposed cetaceans. Harassment is not expected to have more than short-term effects on individual ESA-listed species (blue, fin, sei, southern right, and sperm whales). While exempted, harassment under the ESA is not expected to occur in large numbers given the mitigation measures (e.g., shutdown procedures) in place for the proposed seismic survey activities to protect ESA-listed species. As such we do not expect ESA-listed cetaceans exposed to the action's effects to experience reductions in fitness, nor do we expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise.

11 INTEGRATION AND SYNTHESIS

The *Integration and Synthesis* section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the *Effects of the Action* (Section 10) to the *Environmental Baseline* (Section 9) and the *Cumulative Effects* (Section 12) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminishes the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the *Species and Critical Habitat Not Likely to be Adversely Affected* (Section 6), *Species Likely to be Adversely Affected* (Section 7), and *Status of the Species Likely to be Adversely Affected* (Section 8).

The following discussions separately summarize the probable risks the proposed actions pose to ESA-listed cetaceans that are likely to be exposed to the stressors associated with the seismic survey activities. These summaries integrate the exposure profiles presented previously with the results of our response analyses for each of the actions considered in this opinion.

11.1 Blue Whale

No reduction in the distribution of blue whales from the South Atlantic Ocean is expected because of the National Science Foundation and Scripps Institution of Oceanography's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

The blue whale is endangered as a result of past commercial whaling. In the North Atlantic Ocean, at least 11,000 blue whales were taken from the late 19^{th} to mid-20^{th} centuries. In the North Pacific Ocean, at least 9,500 whales were killed between 1910 and 1965. Commercial whaling no longer occurs, but blue whales are affected by anthropogenic noise, threatened by ship strikes, entanglement in fishing gear, pollution, harassment due to whale watching, and reduced prey abundance and habitat degradation due to climate change.

In the Southern Hemisphere, the latest abundance estimate for blue whales is 2,300 individuals in 1997/1998 (95 percent confidence interval 1,160 to 4,500) (IWC 2019). Population growth estimates are available only for Antarctic blue whales, which estimate a population growth rate of 8.2 percent per year (95 percent confidence interval 1.6 to 14.8 percent) (Branch 2007). Due to the population increasing in size, the species appears to be somewhat resilient to current threats; however, the species has not recovered to pre-exploitation levels.

No reduction in numbers of blue whales is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected as a result of the proposed actions. There are expected to be no individuals harmed and only three individuals harassed as a result of the proposed seismic survey activities. Because we do not anticipate a reduction in the distribution, numbers or reproduction of blue whales as a result of the proposed seismic survey activities and the

NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The Final Recovery Plan for the blue whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Reduce or eliminate human-caused injury and mortality of blue whales.
- Minimize detrimental effects of directed vessel interactions with blue whales.
- Coordinate state, federal, and international efforts to implement recovery actions for blue whales.

Because no mortalities or effects on the abundance, distribution, and reproduction of blue whale populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for blue whales. In conclusion, we believe the non-lethal effects associated with the proposed actions are not expected to appreciably reduce the likelihood of survival and recovery of blue whales in the wild.

11.2 Fin Whale

No reduction in the distribution of fin whales from the South Atlantic Ocean is expected because of the National Science Foundation and Scripps Institution of Oceanography's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

Historically, over 725,000 fin whales were recorded caught in the Southern Hemisphere during 1905-76 (NMFS 2019). Recent abundance data for the Southern Hemisphere stock of fin whales are limited. In 1983, there were assumed to be somewhat more than 15,000 whales (Thomas et al. 2016). More recent estimates include a circumpolar population estimate in the Antarctic, south of 60 degrees South, at 5,445 individuals between 1991 and 2004 (Leaper and Miller 2011).

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected as a result of the proposed actions. There are expected to be no individuals harmed and only four individuals harassed as a result of the proposed seismic survey activities. Because we do not anticipate a reduction in the distribution, numbers or reproduction of fin whales as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2010 Final Recovery Plan for the fin whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Achieve sufficient and viable population in all ocean basins.
- Ensure significant threats are addressed.

Because no mortalities or effects on the abundance, distribution, and reproduction of fin whale populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for fin whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of fin whales in the wild.

11.3 Sei Whale

No reduction in the distribution of sei whales from the South Atlantic Ocean is expected because of the National Science Foundation and Scripps Institution of Oceanography's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

In the Southern Hemisphere, pre-exploitation abundance of sei whales is estimated at 65,000 individuals, with recent abundance estimated at 10,000 whales (Boyd 2002). Population growth rates for sei whales are not available at this time as there are little to no systematic survey efforts to study sei whales.

No reduction in numbers are anticipated as part of the proposed actions. There are expected to be no individuals harmed and three individuals harassed as a result of the proposed seismic survey activities. Therefore, no reduction in reproduction is expected as a result of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of sei whales as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2001 Final Recovery Plan for the sei whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Achieve sufficient and viable populations in all ocean basins.
- Ensure significant threats are addressed.

Because no mortalities or effects on the abundance, distribution, and reproduction of sei whales are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for sei whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of sei whales s in the wild.

11.4 Southern Right Whale

No reduction in the distribution of Southern right whales from the South Atlantic Ocean is expected because of the National Science Foundation and Scripps Institution of Oceanography's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

In 2010, there were an estimated 15,000 Southern right whales worldwide; this is over twice the species estimate of 7,000 in 1997. The population structure of Southern right whales is uncertain, but some separation to the population level exists. Breeding populations can be delineated based on geographic region: South Africa, Argentina, Brazil, Peru and Chile, Australia, and New Zealand. Confirmed calving in Namibia waters represents the northernmost established breeding population in the southeast Atlantic, abundance and trends are unknown for the Namibia population(Roux et al. 2015a).

The estimated abundance for the South African population, which is the largest population located nearest to the proposed action area, is 4,100 and is increasing about 7 percent each year (Brandão et al. 2010; Brandão et al. 2011). Based on cumulative catch estimates from 1785-1805, the 2006 population estimate likely represents about 20 percent of historical abundance; however, the historical estimate ignored recruitment and may under-estimate the extent of population recovery (Brandão et al. 2010).

No reduction in numbers is anticipated as part of the proposed action. There are expected to be no individuals harmed and 41 individuals harassed as a result of the proposed seismic survey activities. Therefore, no reduction in reproduction is expected as a result of the proposed action. Because we do not anticipate a reduction in numbers or reproduction of Southern right whales as a result of the proposed research and enhancement activities, a reduction in the species' likelihood of survival is not expected.

There is currently no recovery plan for the Southern right whale.

Because no mortalities or effects on the abundance, distribution, and reproduction of Southern right whales are expected as a result of the proposed action, we do not anticipate the proposed seismic activities will impede the recovery objectives for Southern right whales. In conclusion, we believe the effects associated with the proposed action are not expected to cause a reduction in the likelihood of survival and recovery of Southern right whales in the wild.

11.5 Sperm Whale

No reduction in the distribution of sperm whales from the South Atlantic Ocean is expected because of the National Science Foundation and Scripps Institution of Oceanography's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

The sperm whale is the most abundant of the large whale species, with total abundance estimates between 200,000 and 1,500,000. The most recent estimate indicated a global population of between 300,000 and 450,000 individuals (Whitehead 2009). The higher estimates may be approaching population sizes prior to commercial whaling. Estimates of the circumpolar population of sperm whales in the Antarctic, south of 60 degrees South, is approximately 12,069 individuals (Whitehead 2002).

No reduction in numbers is anticipated as part of the proposed actions. There are expected to be no individuals harmed and 31 individuals harassed as a result of the proposed seismic survey activities. Therefore, no reduction in reproduction is expected as a result of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of sperm whales as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2010 Final Recovery Plan for the sperm whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Achieve sufficient and viable populations in all ocean basins.
- Ensure significant threats are addressed.

Because no mortalities or effects on the abundance, distribution, and reproduction of sperm whales are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for sperm whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of sperm whales in the wild.

12 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 C.F.R. §402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

We expect that those threats described in the *Environmental Baseline* (Section 9) will continue to impact ESA-listed resources into the foreseeable future. We expect climate change, oceanic temperature regimes, whaling and subsistence harvesting, vessel strikes, whale watching, fisheries (fisheries interactions and aquaculture), pollution (marine debris, pesticides and contaminants, and hydrocarbons), deep sea-bed mining, aquatic nuisance species, anthropogenic sound (vessel sound and commercial shipping, aircraft, seismic surveys, and marine construction), and scientific research activities to continue into the future for cetaceans.

During this consultation, we searched for information on future state, tribal, local, or private (non-Federal) actions that were reasonably certain to occur in the action area. We conducted electronic searches of *Google* and other electronic search engines for other potential future state or private activities that are likely to occur in the action area. We are not aware of any state or private activities that are likely to occur in the action area during the foreseeable future that were not considered in the *Environmental Baseline* section of this opinion.

13 CONCLUSION

After reviewing the current status of the ESA-listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence or recovery of blue, fin, sei, southern right, and sperm whales.

14 INCIDENTAL TAKE STATEMENT

Section 8 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct" (16 U.S.C. §1532(19)). "Harm" is further defined by regulation to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 C.F.R. §222.102).

Incidental take is take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. NMFS had not yet defined "harass" under the ESA in regulation. On December 21, 2016, NMFS issued interim guidance on the term "harass," defining it as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering."

For purposes of this consultation, we relied on NMFS' interim definition of harassment to evaluate when the proposed activities are likely to harass ESA-listed cetaceans and the ESA interim definition of harassment to estimate the number of instances of harassment for ESA species.

ESA section 7(b)(4) states that take of ESA-listed marine mammals must be authorized under MMPA section 101(a)(5) before the Secretary can issue an incidental take statement for ESA-listed marine mammals. NMFS' implementing regulations for MMPA section 101(a)(5)(D) specify that an incidental harassment authorization is required to conduct activities pursuant to any incidental take authorization for a specific activity that will "take" marine mammals. Once NMFS has authorized the incidental take of marine mammals under an incidental harassment authorization for the period of August 8, 2018, through August 7, 2019, under the MMPA, the incidental take of ESA-listed cetaceans is exempt from the ESA take prohibitions as stated in this incidental take statement pursuant to section 7(b)(4) and 7(o)(2).

Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this incidental take statement.

14.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent, of such incidental taking on the species (50 C.F.R. §402.14(i)(1)(i)). The amount of take represents the number of individuals that are expected to be taken by actions while the extent of take specifies the impact, i.e., the amount or extent, of such incidental taking on the species and may be used if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (see 80 FR 26832).

If the amount or location of tracklines during the seismic survey changes, or the number of seismic survey days is increased, then incidental take for cetaceams may be exceeded. As such, if more tracklines are conducted during the seismic survey, an increase in the number of days beyond the 25 percent contingency, greater estimates of sound propagation, and/or increases in airgun array source levels occur, reinitiation of consultation will be necessary.

14.1.1 ESA-Listed Cetaceans

We and the NMFS Permits and Conservation Division anticipate the proposed seismic survey in the South Atlantic Ocean are likely to result in the incidental take of ESA-listed cetaceans by harassment (Table 15). Behavioral harassment (including TTS) is expected to occur at received levels at or above 160 decibels re: 1 µPa (rms) for ESA-listed cetaceans. For all species of ESA-listed cetaceans, this incidental take will result from exposure to acoustic energy during airgun array operations and will be in the form harassment (corresponding to MMPA Level B harassment), and is not expected to result in the death or injury of any ESA-listed cetaceans that will be exposed. In addition, no instances of ESA harm (MMPA Level A takes) will be incurred as a result of the proposed activity. If TTS were to occur, it is expected to be temporary and would be unlikely to affect the fitness of any individuals over the long-term, because of the constant movement of both the RV *Thomas G. Thompson* and of the cetaceans in the project areas, as well as the fact that the vessel is not expected to remain in any one area in which individual cetaceans would be expected to concentrate for an extended period of time (*i.e.*, since the duration of exposure to loud sounds will be relatively short). Also, as described above, we expect that cetaceans would be able to likely to move away from a sound source that represents an aversive stimulus, especially at levels that would be expected to result in TTS, given the relatively low approach speeds of the RV *Thomas G. Thompson's* during the proposed seismic surveys.

Table 15. Estimated amount of incidental take of Endangered Species Act-listed cetaceans authorized in the South Atlantic Ocean by the incidental take statement.

Species	Potential Temporary Threshold Shift and Behavioral Harassment	Potential Permanent Threshold Shift and Harm
Blue Whale	1	0
Fin Whale	4	0
Sei Whale	3	0
Southern Right Whale	41	0
Sperm Whale	31	0

14.2 Effects of the Take

In this Opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to jeopardize the continued existence of the species considered in this opinion.

14.3 Reasonable and Prudent Measures

The measures described below are nondiscretionary, and must be undertaken by National Science foundation and the NMFS Permits and Conservation Division so that they become binding conditions for the exemption in section 7(o)(2) to apply. Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of ESA-listed cetacean species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. To minimize such impacts, reasonable and prudent measures, and terms and conditions to implement the measures, must be provided. Only incidental take resulting from the agency actions and any specified reasonable and prudent measures and terms and conditions identified in the incidental take statement are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

"Reasonable and prudent measures" are nondiscretionary measures to minimize the amount or extent of incidental take (50 C.F.R. §402.02). NMFS believes the reasonable and prudent measures described below are necessary and appropriate to minimize the impacts of incidental take on threatened and endangered species:

- The NMFS Permits and Conservation Division must ensure that the National Science foundation implements a program to mitigate and report the potential effects of seismic survey activities as well as the effectiveness of mitigation measures incorporated as part of the proposed incidental harassment authorization for the incidental taking of blue, fin, sei, southern right, and sperm whales pursuant to section 101(a)(5)(D) of the MMPA. In addition, the NMFS Permits and Conservation Division must ensure that the provisions of the incidental harassment authorization are carried out, and to inform the NMFS ESA Interagency Cooperation Division if take is exceeded.

- The NMFS Permits and Conservation Division must ensure that the National Science foundation implement a program to monitor and report any potential interactions between seismic survey activities and threatened and endangered species of cetaceans.

14.4 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, the National Science foundation and NMFS Permits and Conservation Division must comply with the following terms and conditions, which implement the Reasonable and Prudent Measures described above. These include the take minimization, monitoring and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)). These terms and conditions are non-discretionary. If the National Science foundation and NMFS Permits and Conservation Division fail to ensure compliance with these terms and conditions and their implementing reasonable and prudent measures, the protective coverage of section 7(o)(2) may lapse.

To implement the reasonable and prudent measures, the National Science foundation, and the NMFS Permits and Conservation Division shall implement the following terms and conditions.

1. A copy of the draft comprehensive report on all seismic survey activities and monitoring results must be provided to the ESA Interagency Cooperation Division within 90 days of the completion of the seismic survey, or expiration of the incidental harassment authorization, whichever comes sooner.
2. Any reports of injured or dead ESA-listed species must be provided to the ESA Interagency Cooperation Division immediately to Cathy Tortorici, Chief, ESA Interagency Cooperation Division by email at cathy.tortorici@noaa.gov.

15 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat, to help implement recovery plans or develop information (50 C.F.R. §402.02).

We recommend the following conservation recommendations, which will provide information for future consultations involving seismic surveys and the issuance of incidental harassment authorizations that may affect ESA-listed species as well as reduce harassment related to the authorized seismic survey activities.

1. We recommend that the National Science Foundation develop a more robust propagation model that incorporates environmental variables into estimates of how far sound levels reach from airgun arrays.
2. We recommend that the NMFS Permits and Conservation Division develop a flow chart with decision points for mitigation and monitoring measures to be included in future incidental harassment authorizations for seismic surveys.
3. We recommend the National Science Foundation use (and NMFS Permits and Conservation require in MMPA incidental take authorizations) thermal imaging cameras, in addition to binoculars and the naked eye, for use during daytime and nighttime visual observations and test their effectiveness at detecting threatened and endangered species.
4. We recommend the NSF and NMFS Permits and Conservation Division work to make the data collected as part of the required monitoring and reporting available to the public and scientific community in an easily accessible online database that can be queried to aggregate data across protected species observer reports. Access to such data, which may include sightings as well as responses to seismic survey activities, will not only help us understand the biology of ESA-listed species (e.g., their range), it will inform future consultations and incidental take authorizations/permits by providing information on the effectiveness of the conservation measures and the impact of seismic survey activities on ESA-listed species.
5. We recommend the vessel operator and other relevant vessel personnel (e.g., crew members) on the RV *Thomas G. Thompson* take the U.S. Navy's marine species awareness training available online at: https://www.youtube.com/watch?v=KKo3r1yVBBA in order to detect ESA-listed species and relay information to protected species observers.

In order for NMFS' Endangered Species Act Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, ESA-listed species or their critical habitat the NMFS Permits and Conservation Division should notify the NMFS Endangered Species Act Interagency Cooperation Division of any conservation recommendations they implement in their final action.

16 Reinitiation Notice

This concludes formal consultation for [*action agency and proposed action*]. As 50 C.F.R. §402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if:

(1) The amount or extent of taking specified in the incidental take statement is exceeded.
(2) New information reveals effects of the agency action that may affect ESA-listed species or critical habitat in a manner or to an extent not previously considered.
(3) The identified action is subsequently modified in a manner that causes an effect to ESA-listed species or designated critical habitat that was not considered in this opinion.

(4) A new species is listed or critical habitat designated under the ESA that may be affected by the action.

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18 APPENDICES

18.1 Appendix A- Proposed Incidental Harassment Authorization

DRAFT INCIDENTAL HARASSMENT AUTHORIZATION

The Scripps Institution of Oceanography (SIO) is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA; 16 U.S.C. 1371(a)(5)(D)) to harass marine mammals incidental to a low-energy marine geophysical survey in the South Atlantic Ocean, when adhering to the following terms and conditions.

1. This incidental harassment authorization (IHA) is valid for a period of one year from the date of issuance.

2. This IHA is valid only for marine geophysical survey activity, as specified in the Scripps Institution of Oceanography's (SIO) IHA application and using an airgun array aboard the R/V *Thompson* with characteristics specified in the application, in the South Atlantic Ocean.

3. General Conditions

   (a) A copy of this IHA must be in the possession of SIO, the vessel operator and other relevant personnel, the lead protected species observer (PSO), and any other relevant designees of SIO operating under the authority of this IHA.

   (b) The species authorized for taking are listed in Table 1. The taking, by Level B harassment only, is limited to the species and numbers listed in Table 1. Any taking exceeding the authorized amounts listed in Table 1 is prohibited and may result in the modification, suspension, or revocation of this IHA.

   (c) The taking by injury, serious injury or death of any species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this IHA.

   (d) During use of the airgun(s), if marine mammal species other than those listed in Table 1, or species whose authorized take numbers have been met, are detected by PSOs, the acoustic source must be shut down to avoid unauthorized take.

   (e) SIO must ensure that the vessel operator and other relevant vessel personnel are briefed on all responsibilities, communication procedures, marine mammal monitoring protocol, operational procedures, and IHA requirements prior to the start of survey activity, and when relevant new personnel join the survey operations.

4. Mitigation Requirements

   The holder of this Authorization is required to implement the following mitigation measures:

   (a) SIO must use at least three (3) dedicated, trained, NMFS-approved Protected Species Observers (PSO). The PSOs must have no tasks other than to conduct observational effort, record observational data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and mitigation requirements. PSO resumes must be provided to NMFS for approval.

(b) At least one PSO must have a minimum of 90 days at-sea experience working as a PSO during a deep penetration seismic survey, with no more than eighteen months elapsed since the conclusion of the at-sea experience. One “experienced” visual PSO must be designated as the lead for the entire protected species observation team. The lead PSO must serve as primary point of contact for the vessel operator.

(c) Visual Observation

(i) During survey operations (*e.g.*, any day on which use of the acoustic source is planned to occur; whenever the acoustic source is in the water, whether activated or not), typically two, and minimally one, PSO(s) must be on duty and conducting visual observations at all times during daylight hours (*i.e.*, from 30 minutes prior to sunrise through 30 minutes following sunset).

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

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

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

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

(d) Exclusion Zone and buffer zone – PSOs must establish and monitor a 100-m exclusion zone (EZ) and 200-m buffer zone. The zones must be based upon radial distance from any element of the airgun array (rather than being based on the center of the array or around the vessel itself). During use of the acoustic source, occurrence of marine mammals outside the EZ but within 200 m from any element of the airgun array must be communicated to the operator to prepare for potential further mitigation measures as described below. During use of the acoustic source, occurrence of marine mammals within the EZ, or on a course to enter the EZ, must trigger further mitigation measures as described below. PSOs must also monitor to the extent of the estimated Level B harassment zone for the active survey configuration (Table 2), or as far as possible if the extent of the Level B zone is not visible.

(i) An extended EZ of 500 m must be enforced for the following species and circumstances:

(A) All beaked whales, *Kogia* species, and southern right whales.

(B) Large whales (*i.e.*, sperm whale or any baleen whale) with calf, with "calf" defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult.

(C) An aggregation (*i.e.*, six or more animals) of large whales of any species (*i.e.*, sperm whale or any baleen whale) that does not appear to be traveling (*e.g.*, feeding, socializing, etc.).

(e) Ramp-up – A ramp-up procedure is required at all times as part of the activation of the acoustic source. Ramp-up would begin with one 45-in^3 airgun, and the second 45-in^3 airgun would be added after 5 minutes.

(i) If the airgun array has been shut down due to a marine mammal detection, ramp-up must not occur until all marine mammals have cleared the EZ. A marine mammal is considered to have cleared the EZ if:

(A) It has been visually observed to have left the EZ; or

(B) It has not been observed within the EZ, for 15 minutes (in the case of small odontocetes and pinnipeds) or for 30 minutes (in the case of mysticetes and large odontocetes (i.e., sperm whale), and also pygmy and dwarf sperm whales, beaked whales and Risso's dolphin.

(ii) Thirty minutes of pre-clearance observation of the 100-m EZ and 200-m buffer zone is required prior to ramp-up for any shutdown of longer than 30 minutes. This pre-clearance period may occur during any vessel activity. If any marine mammal (including delphinids) is observed within or approaching the 100-m EZ during the 30 minute pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting the EZ or until an additional time period has elapsed with no further sightings (*i.e.*, 15 minutes for small odontocetes and pinnipeds, and 30 minutes for all other species).

(iii) During ramp-up, two PSOs must monitor the 100-m EZ and 200-m buffer zone. Ramp-up may not be initiated if any marine mammal (including delphinids) is observed within or approaching the 100-m EZ. If a marine mammal is observed within or approaching the 100-m EZ during ramp-up, a shutdown must be implemented as though the full array were operational. Ramp-up may not begin again until the animal(s) has been observed exiting the 100-m EZ or until an additional time period has elapsed with no further sightings (*i.e.*, 15 minutes for small odontocetes and pinnipeds, and 30 minutes for mysticetes and large odontocetes odontocetes (i.e., sperm whale), and also pygmy and dwarf sperm whales, beaked whales, and Risso's dolphin.

(iv) If the airgun array has been shut down for reasons other than mitigation (*e.g.*, mechanical difficulty) for a period of less than 30 minutes, it may be activated again without ramp-up if PSOs have maintained constant visual observation and no visual detections of any marine mammal have occurred within the buffer zone.

(v) Ramp-up at night and at times of poor visibility must only occur where operational planning cannot reasonably avoid such circumstances. Ramp-up may occur at night and during poor visibility if the 100-m EZ and 200-m buffer zone have been continually monitored by PSOs for 30 minutes prior to ramp-up with no marine mammal detections.

(vi) The vessel operator must notify a designated PSO of the planned start of ramp-up. The designated PSO must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the PSO to proceed.

(f) Shutdown requirements – An EZ of 100 m must be established and monitored by PSOs. If a marine mammal is observed within, entering, or approaching the 100-m EZ all airguns must be shut down.

(i) Any PSO on duty has the authority to call for shutdown of the airgun array. When there is certainty regarding the need for mitigation action on the basis of visual detection, the relevant PSO(s) must call for such action immediately.

(ii) The operator must establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the airgun array to ensure that shutdown commands are conveyed swiftly while allowing PSOs to maintain watch.

(iii) When a shutdown is called for by a PSO, the shutdown must occur and any dispute resolved only following shutdown.

(iv) The shutdown requirement is waived for dolphins of the following genera: *Delphinus, Lagenodelphis, Lagenorhynchus, Lissodelphis, Stenella*, *Steno*, and *Tursiops*. The shutdown waiver only applies if dolphins are traveling, including approaching the vessel. If dolphins are stationary and the vessel approaches the dolphins, the shutdown requirement applies. If there is uncertainty regarding identification (*i.e.*, whether the observed animal(s) belongs to the group described above) or whether the dolphins are traveling, shutdown must be implemented.

(v) Upon implementation of a shutdown, the source may be reactivated under the conditions described at 4(e). Where there is no relevant zone, a 30-min clearance period must be observed following the last observation of the animal(s).

(vi) Shutdown of the array is required upon observation of a species for which authorization has not been granted, or a species for which authorization has been granted but the authorized number of takes has been met, approaching or observed within the Level A or Level B harassment zone (Table 2).

(g) Vessel Strike Avoidance – Vessel operator and crew must maintain a vigilant watch for all marine mammals and slow down or stop the vessel or alter course, as appropriate, to avoid striking any marine mammal. These requirements do not apply in any case where compliance would create an imminent and serious threat to a person or vessel or to the extent that a vessel is restricted in its ability to maneuver and, because of the restriction, cannot comply. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel according to the parameters stated below. Visual observers monitoring the vessel strike avoidance zone can be either third-party observers or crew members, but crew members responsible for these duties must be provided sufficient training to distinguish marine mammals from other phenomena.

(i) The vessel must maintain a minimum separation distance of 100 m from large whales, including sperm whales and all mysticetes. The following avoidance measures must be taken if a large whale is within 100 m of the vessel:

(A) The vessel must reduce speed and shift the engine to neutral, when feasible, and must not engage the engines until the whale has moved outside of the vessel's path and the minimum separation distance has been established.

(B) If the vessel is stationary, the vessel must not engage engines until the whale(s) has moved out of the vessel's path and is beyond 100 m.

(ii) The vessel must maintain a minimum separation distance of 50 m from all other marine mammals, with an exception made for animals described in 4(e)(iv) that approach the vessel. If an animal is encountered during transit, the vessel must attempt to remain parallel to the animal's course, avoiding excessive speed or abrupt changes in course.

(iii) Vessel speeds must be reduced to 10 knots or less when mother/calf pairs or large assemblages of cetaceans are observed near the vessel; the vessel operator may use professional judgment as to when such circumstances warranting additional caution are present.

(h) Miscellaneous Protocols

(i) The airgun array must be deactivated when not acquiring data or preparing to acquire data, except as necessary for testing. Unnecessary use of the acoustic source must be avoided. Operational capacity of 90 in^3 (not including redundant backup airguns) must not be exceeded during the survey, except where unavoidable for source testing and calibration purposes. All occasions where activated source volume exceeds notified operational capacity must be noticed to the PSO(s) on duty and fully documented. The lead PSO must be granted access to relevant instrumentation documenting acoustic source power and/or operational volume.

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

5. Monitoring Requirements

The holder of this Authorization is required to conduct marine mammal monitoring during survey activity. Monitoring must be conducted in accordance with the following requirements:

(a) The operator must provide a night-vision device suited for the marine environment for use during nighttime ramp-up pre-clearance, at the discretion of the PSOs. At minimum, the device should feature automatic brightness and gain control, bright light protection, infrared illumination, and optics suited for low-light situations.

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

(c) PSO Qualifications

(i) PSOs must have successfully completed relevant training, including completion of all required coursework and passing a written and/or oral examination developed for the training program.

(ii) PSOs must have successfully attained a bachelor's degree from an accredited college or university with a major in one of the natural sciences and a minimum of 30 semester hours or equivalent in the biological sciences and at least one undergraduate course in math or statistics. The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver must include written justification. Alternate experience that may be considered includes, but is not limited to (1) secondary education and/or experience comparable to PSO duties; (2) previous work experience conducting academic, commercial, or government-sponsored marine mammal surveys; or (3) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.

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

(i) PSO names and affiliations

(ii) Dates of departures and returns to port with port name

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

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

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

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

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

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

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

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

(B) PSO who sighted the animal;

(C) Time of sighting;

(D) Vessel location at time of sighting;

(E) Water depth;

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

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

(H) Pace of the animal;

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

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

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

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

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

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

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

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

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

6. Reporting

(a) SIO must submit a draft comprehensive report on all activities and monitoring results within 90 days of the completion of the survey or expiration of the IHA, whichever comes sooner. The draft report must include the following:

(i) Summary of all activities conducted and sightings of protected species near the activities;

(ii) Full documentation of methods, results, and interpretation pertaining to all monitoring;

(iii) Summary of dates and locations of survey operations and all protected species sightings (dates, times, locations, activities, associated survey activities);

(iv) Geo-referenced time-stamped vessel tracklines for all time periods during which airguns were operating. Tracklines should include points recording any change in airgun status (*e.g.*, when airguns began operating, when they were turned off);

(v) GIS files in ESRI shapefile format and UTC date and time, and latitude and longitude in decimal degrees. All coordinates must be referenced to the WGS84 geographic coordinate system;

(vi) Raw observational data;

(vii) Estimates of the number and nature of exposures that occurred above the harassment threshold, including an estimate of those that were not detected.

(viii) Certification from the lead PSO as to the accuracy of the report

(A) The lead PSO may submit statement directly to NMFS concerning implementation and effectiveness of the required mitigation and monitoring.

(ix) A final report must be submitted within 30 days following resolution of any NMFS comments on the draft report.

(b) The report must describe all activities conducted and sightings of marine mammals near the activities, must provide full documentation of methods, results, and interpretation pertaining to all monitoring, and must summarize the dates and locations of survey operations and all marine mammal sightings (dates, times, locations, activities, associated survey activities). The report must also include estimates of the number and nature of exposures that occurred above the harassment threshold based on PSO observations, including an estimate of those that were not detected in consideration of both the characteristics and behaviors of the species of marine mammals that affect detectability, as well as the environmental factors that affect detectability. Geospatial data regarding locations where the acoustic source was used must be provided as an ESRI shapefile with all necessary files and appropriate metadata. In addition to the report, all raw observational data must be made available to NMFS. The report must summarize the data collected as required under condition 5(d) of this IHA. The draft report must be accompanied by a certification from the lead PSO as to the accuracy of the report, and the lead PSO may submit directly to NMFS a statement concerning implementation and effectiveness of the required mitigation and monitoring. A final report must be submitted within 30 days following resolution of any comments from NMFS on the draft report.

(c) Reporting injured or dead marine mammals:

(i) In the event that the specified activity clearly causes the take of a marine mammal in a manner not permitted by this IHA, such as serious injury or mortality, SIO must immediately cease the specified activities and immediately report the incident to the NFMS Office of Protected Resources (301-427-8401). The report must include the following information:

(A) Time, date, and location (latitude/longitude) of the incident;

(B) Vessel's speed during and leading up to the incident;

(C) Description of the incident;

(D) Status of all sound source use in the 24 hours preceding the incident;

(E) Water depth;

(F) Environmental conditions (*e.g.*, wind speed and direction, Beaufort sea state, cloud cover, and visibility);

(G) Description of all marine mammal observations in the 24 hours preceding the incident;

(H) Species identification or description of the animal(s) involved;

(I) Fate of the animal(s); and

(J) Photographs or video footage of the animal(s).

(ii) Activities must not resume until NMFS is able to review the circumstances of the prohibited take. NMFS will work with SIO to determine what measures are necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. SIO must not resume their activities until notified by NMFS.

(iii) In the event that SIO discovers an injured or dead marine mammal, and the lead observer determines that the cause of injury or death is unknown and the death is relatively recent (*e.g.*, in less than a moderate state of decomposition), SIO must immediately report the incident to the NMFS Office of Protected Resources (301-427-8401). The report must include the same information identified in condition 6(b)(i) of this IHA. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with SIO to determine whether additional mitigation measures or modifications to the activities are appropriate.

(iv) In the event that SIO discovers an injured or dead marine mammal, and the lead observer determines that the injury or death is not associated with or related to the specified activities (*e.g.*, previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), SIO must report the incident to NMFS Office of Protected Resources (301-427-8401) within 24 hours of the discovery. SIO must photographs or video footage or other documentation of the sighting to NMFS.

7. This Authorization may be modified, suspended or withdrawn if the holder fails to abide by the conditions prescribed herein, or if NMFS determines the authorized taking is having more than a negligible impact on the species or stock of affected marine mammals.

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

(a) A request for renewal is received no later than 60 days prior to expiration of the current IHA.

(b) The request for renewal must include the following:

(i) An explanation that the activities to be conducted beyond the initial dates either are identical to the previously analyzed activities or include changes so minor that the changes do not affect the previous analyses, take estimates, or mitigation and monitoring requirements.

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

(c) Upon review of the request for renewal, the status of the affected species or stocks, and any other pertinent information, NMFS determines that there are no more than minor changes in the activities, the mitigation and monitoring measures remain the same and appropriate, and the original findings remain valid.

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Donna S. Wieting, Date
Director, Office of Protected Resources,
National Marine Fisheries Service.

Table 1. Numbers of Potential Incidental Take of Marine Mammals.

Species	Proposed Takes by Level B Harassment
Low Frequency Cetaceans	
Southern right whale	41
Pygmy right whale	2
Blue whale	3
Fin whale	4
Sei whale	3
Bryde's whale	20
Common (dwarf) minke whale	404
Antarctic minke whale	404
Humpback whale	20
Mid Frequency Cetaceans	
Sperm whale	31
Arnoux's beaked whale	59
Cuvier's beaked whale	3
Southern bottlenose whale	41
Shepherd's beaked whale	48
Blainville's beaked whale	7
Gray's beaked whale	10
Hector's beaked whale	2
Gervais' beaked whale	7
True's beaked whale	2
Strap-toothed beaked whale	3
Andrew's beaked whale	2
Spade-toothed beaked whale	2
Risso's dolphin	78

Species	Proposed Takes by Level B Harassment
Rough-toothed dolphin	55
Common bottlenose dolphin	209
Pantropical spotted dolphin	104
Atlantic spotted dolphin	1108
Spinner dolphin	315
Clymene dolphin	35
Striped dolphin	110
Short-beaked common dolphin	3718
Fraser's dolphin	283
Dusky dolphin	67
Southern right whale dolphin	35
Killer whale	5
Short-finned pilot whale	41
Long-finned pilot whale	111
False killer whale	19
Pygmy killer whale	26
Melon-headed whale	170
High Frequency Cetaceans	
Pygmy sperm whale	18
Dwarf sperm whale	13
Hourglass dolphin	58
Otariids	
Subantarctic fur seal	14
Cape fur seal	20
Phocids	
Crabeater seal	34

Species	Proposed Takes by Level B Harassment
Leopard seal	8
Southern elephant seal	8

Table 2. Areas (km^2) to be Ensonified to Level A and Level B Harassment Thresholds.

Survey type	Criteria	Relevant isopleth (m)	Daily Ensonified Area (km^2)	Total survey days	25 percent increase	Total ensonified area (km^2)
5-kn survey	Level B Harassment (160 dB)					
	Intermediate water	809	14.67	10	1.25	183.34
	Deep water	539	231.31	10	1.25	2891.42
	Level A Harassment					
	LF cetacean	6.5	2.89	10	1.25	36.125
	MF cetacean	1	0.44	10	1.25	5.55
	HF cetacean	34.6	15.37	10	1.25	192.13
	Phocids	5.5	2.44	10	1.25	30.53
	Otariids	0.5	0.22	10	1.25	2.77
8-kn survey	Level B Harassment (160 dB)					
	Intermediate water	867	25.95	4	1.25	129.75
	Deep water	578	395.88	4	1.25	1979.38
	Level A Harassment					
	LF cetacean	3.1	2.21	4	1.25	11.04
	MF cetacean	0	0	4	1.25	0
	HF cetacean	34.8	24.78	4	1.25	124
	Phocids	4	2.85	4	1.25	14.24
	Otariids	0	0	4	1.25	0