

**NATIONAL MARINE FISHERIES SERVICE  
ENDANGERED SPECIES ACT SECTION 7  
BIOLOGICAL OPINION**

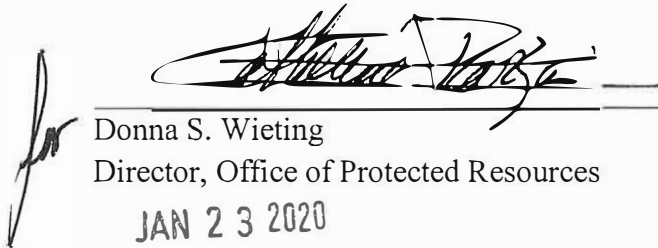
**Title:** Biological Opinion on the National Science Foundation's Low-Energy Marine Geophysical Survey by the Research Vessel/Icebreaker *Nathaniel B. Palmer* in the Amundsen Sea off Antarctica and National Marine Fisheries Service Permits and Conservation Division's Issuance of an Incidental Harassment Authorization pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act

**Consultation Conducted By:** Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce

**Action Agency:** National Science Foundation and Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce

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**Approved:**

  
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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 threatened or endangered species or adversely modify or destroy their designated critical habitat. Federal agencies must do so in consultation with 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.

Updates to the regulations governing interagency consultation (50 C.F.R. §402) are effective on October 28, 2019 (84 FR 44976). This consultation was pending at the time the regulations became effective 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 (opinion) in light of the updated regulations and conclude the opinion is fully consistent with updated regulations.

The action agencies for this consultation are the National Science Foundation’s Office of Polar Programs and the NMFS, Office of Protected Resources, Permits and Conservation Division. Two federal action were considered during consultation. The first was the National Science Foundation’s proposal to sponsor (fund) and conduct a low-energy marine geophysical (seismic) survey in the Amundsen Sea off Antarctica in austral summer (January through March) 2020. The second was the NMFS Permits and Conservation Division’s proposal to issue an incidental harassment authorization authorizing non-lethal “takes” by Level B harassment (as defined by

the Marine Mammal Protection Act [MMPA]) of marine mammals incidental to the planned low-energy seismic survey, pursuant to section 101(a)(5)(D) of the MMPA 16 U.S.C. 1371(a)(5)(D). The consulting agency is the NMFS ESA Interagency Cooperation Division.

This formal consultation, opinion, and incidental take statement, were completed in accordance with section 7(a)(2) of the statute (16 U.S.C. §1536 (a)(2)), associated implementing regulations (50 C.F.R. §§402.01-402.16), and agency policy and guidance. This consultation was conducted by NMFS, Office of Protected Resources, ESA Interagency Cooperation Division (hereafter referred to as “we”). This opinion and incidental take statement were prepared by NMFS, Office of Protected Resources, ESA Interagency Cooperation Division in accordance with section 7(b) of the ESA and implementing regulations at 50 C.F.R. Part 402.

This document represents the NMFS ESA Interagency Cooperation Division’s opinion on the effects of these actions on threatened and endangered species and critical habitat that have been designated for those species (see Table 6 and Table 7). 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’s Office of Polar Programs is proposing to sponsor and conduct a low-energy marine seismic survey for scientific research purposes and data collection in the Amundsen Sea off Antarctica in (February) 2020. In conjunction with this action, the NMFS Permits and Conservation Division will issue an incidental harassment authorization under the MMPA for incidental takes of marine mammals that could occur during the National Science Foundation’s low-energy seismic survey. Both the National Science Foundation and the NMFS Permits and Conservation Division have conducted similar actions in the past and have been the subject of ESA section 7 consultations.

The previous opinions for National Science Foundation’s seismic surveys in the Gulf of Mexico (2003), Eastern Tropical Pacific Ocean (2003), Norwegian Sea (2003), Mid-Atlantic Ocean (2003), Gulf of Alaska (2004), Northeast Pacific Ocean (2004), Southeast Caribbean Sea (2004), Aleutian Islands (2005), Southern Gulf of Mexico (2005), Central America (2005), Arctic Ocean (2005), Southwest Pacific Ocean (2006), Eastern Tropical Pacific Ocean (2006), Louisville Ridge (2006), Arctic Ocean (2006), South Pacific Gyre (2006 through 2007), Indian Ocean (2007), Northeast Pacific Ocean (2007), Northern Gulf of Mexico (2007 through 2008), Central America (2008), Gulf of Alaska (2008), Northeast Pacific Ocean (2008), Santa Barbara Channel (2008), Northeast Pacific Ocean (2009), Canada (2009), Southeast Asia (2009), Tonga (2009), Vancouver and Oregon (2009), Northwest Atlantic Ocean (2009), Central and South America (2010), North Pacific Ocean (2010), Costa Rica (2011), Western Tropical Pacific Ocean (2011), Southeastern Pacific Ocean (2012), Arctic Ocean (2011), Line Islands (2012), Northeast Pacific Ocean (2012), Tropical Western Pacific Ocean (2013), Northeast Atlantic Ocean (2013), New Jersey (2014), North Carolina (2014), Dumont d’Urville Sea (2014), Scotia Sea (2014), New

Zealand (2015), Mediterranean Sea (2015), Ross Sea (2015), Southeast Pacific Ocean (2016), South Atlantic Ocean (2016), New Zealand (2017), Oregon (2017), Hawaii (2018), Northwest Atlantic Ocean (2018), Western Gulf of Alaska (2019), Northeast Pacific Ocean (2019), Southwest Atlantic Ocean (2019), and Namibia (2019) and the issuance of an incidental harassment authorization determined that the authorized activities are not likely to jeopardize the continued existence of ESA-listed species, or the destruction or adverse modification of designated critical habitat.

## **1.2 Consultation History**

This opinion is based on information provided in the National Science Foundation's biological assessment, 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 threatened and endangered 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 February 5, 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 Amundsen Sea as well as recommended data sources for marine mammal 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 Amundsen Sea, Antarctica, as well as recommended data sources for marine mammal abundances and densities in the action area.
- On July 26, 2019, the National Science Foundation submitted an incidental harassment authorization application to us and the NMFS Permits and Conservation Division. NMFS Permits and Conservation Division deemed the incidental harassment authorization application adequate and complete on November 22, 2019.
- On August 27, 2019, we received a request from the National Science Foundation for ESA section 7 consultation for a proposed low-energy seismic survey to be undertaken in the Amundsen Sea, Antarctica in 2020. The National Science Foundation provided a letter and biological assessment, in support of the request. The National Science Foundation requested the biological opinion be completed by January 13, 2020, to allow sufficient time for conclusion of the entire environmental compliance process by the commencement date of February 6, 2020 for the low-energy seismic survey.
- On October 11, 2019, we received a revised biological assessment and incidental harassment authorization application and take estimates from the National Science Foundation.

- On October 11, 2019, we determined there was sufficient information to initiate formal consultation. We provided the National Science Foundation with an initiation letter on December 16, 2019.
- On November 8, 2019, we participated in the NMFS Permits and Conservation Division's Early Review Team meeting to discuss the National Science Foundation's low-energy seismic survey on the Research Vessel/Icebreaker (RVIB) *Nathaniel B. Palmer* in the Amundsen Sea off Antarctica.
- On November 18, 2019, we received a revised incidental harassment authorization application and take estimates from the National Science Foundation.
- On December 16, 2019, we received a draft final notice of proposed incidental harassment authorization, request for comments on proposed authorization and possible renewal from the NMFS Permits and Conservation Division.
- On December 17, 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 low-energy seismic survey on the RVIB *Nathaniel B. Palmer* in the Amundsen Sea off Antarctica. The consultation request package included an initiation memorandum, incidental harassment authorization application, draft *Federal Register* notice of a proposed incidental harassment authorization and request for comments on proposed authorization and possible renewal, and draft incidental harassment authorization.
- On December 17, 2019, we determined there was sufficient information to initiate formal consultation. We provided NMFS Permits and Conservation Division with an initiation letter on December 17, 2019.
- On December 19, 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 National Science Foundation's low-energy marine seismic survey on the RVIB *Nathaniel B. Palmer* in the Amundsen Sea off Antarctica.
- On January 6, 2020, we provided the National Science Foundation and NMFS Permits and Conservation Division with additional questions. The National Science Foundation and NMFS Permits and Conservation Division responded to the questions on January 8, 2020. We received a revised draft final incidental harassment authorization from the NMFS Permits and Conservation Division on January 8, 2020.
- On January 6, 2020, NMFS Permits and Conservation Division notified us that they will be updating the calculations for exposures and revising the number of authorized takes by MMPA Level B harassment of blue whales, fin whales, sei whales, and sperm whales for icebreaking.
- On January 8, 2020, NMFS Permits and Conservation Division notified us that they will be including blue whales in the formal consultation as well as revising the number of

authorized takes by MMPA Level B harassment of blue whales, fin whales, sei whales, and sperm whales in the final incidental harassment authorization based on comments received from the Marine Mammal Commission during the 30-day public comment period.

- On January 21, 2020, the public comment period closed for the *Federal Register* notice of proposed incidental harassment authorization and request for comments on proposed incidental harassment authorization and possible renewal. During the 30-day public comment period, NMFS Permits and Conservation Division received comment letters from the Marine Mammal Commission.

## 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 threatened or endangered 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 and describe the stressors that could occur as a result of the proposed action and affect ESA-listed species and designated critical habitat.

*Species 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 6.2.5): During the ESA section 7 consultation process, we identify the ESA-listed species 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.

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

*Environmental Baseline* (Section 9): We describe the environmental baseline as the condition of ESA-listed species or its designated critical habitat in the action area, without the consequences to the ESA-listed species or designated critical habitat caused by the proposed action. The environmental baseline includes: 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. The consequences to ESA-listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline.

*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 subpopulations 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. We also consider how the action may affect designated critical habitat. 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. The adverse modification analysis considers the impacts of the proposed action on the essential features and conservation value of designated critical habitat.

*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 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 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 (50 C.F.R. 402. §02).

Two federal actions were evaluated in during consultation. The first proposed action for this consultation is the National Science Foundation's Office of Polar Programs, through the U.S. Antarctic Program proposal to sponsor and conduct a low-energy (high-resolution) marine seismic survey on the RVIB *Nathaniel B. Palmer* in the Amundsen Sea off Antarctica in

(February) 2020. The National Science Foundation’s proposed action is a collaborative, multidisciplinary component of the joint initiative by the National Science Foundation and the United Kingdom Natural Environment Research Council to study the Thwaites Glacier system. The RVIB *Nathaniel B. Palmer*, which is owned by Offshore Vessel Services LLC and is operated by the Galliano Marine Service LLC, is chartered by the National Science Foundation to support the U.S. Antarctic Program. Because of the extent of sea ice in the Amundsen Sea that typically occurs during January through February, icebreaking activities are expected to be required during the low-energy seismic survey. 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) pursuant to section 101(a)(5)(D) of the MMPA for the National Science Foundation’s low-energy marine seismic survey in the Amundsen Sea, Antarctica.

The proposed action includes a two-dimensional low-energy seismic surveys in International Waters in the Amundsen Sea off Antarctica. 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 low-energy 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.

The information presented here is based primarily on the draft biological assessment, 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 Proposed Action**

The National Science Foundation, through the United States Antarctic Program, proposes to fund and conduct a low-energy seismic survey in the Amundsen Sea off Antarctica on the RVIB *Nathaniel B. Palmer*. An airgun array, single-beam echosounder, split-beam echosounder, multi-beam echosounder, and acoustic Doppler current profiler will be deployed as an energy source. The National Science Foundation will also conduct icebreaking on the RVIB *Nathaniel B. Palmer*.

#### **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 low-energy seismic survey is designed to collect data that will facilitate more accurate projections of ice loss and sea level rise originating from Thwaites Glacier in West Antarctica. Satellite observations over the last 25 years show that Thwaites Glacier is rapidly thinning and accelerating. Over this same period, the Thwaites grounding line, the point at which the glacier transitions from sitting on the seabed to floating, has retreated. Oceanographic studies demonstrate that the main driver of these changes is deep-ocean warm water flowing beneath the floating ice shelf and causing basal melting. This period of satellite observation is not long enough to determine how a large glacier such as Thwaites Glacier responds to long-term and near-term changes in the ocean or the atmosphere. As a result, records of glacial change from the pre-satellite era are required to build a holistic understanding of glacier behavior. Ocean-floor sediments deposited at the retreating grounding line and further offshore contain longer-term records of change in the glacier and adjacent ocean. An additional unknown is the topography of the seafloor and how it influences the interaction between warm, landward-flowing water and Thwaites Glacier, affecting the glacier's stability. The proposed seismic survey activities will collect data in support of a research proposal that has been reviewed through the National Science Foundation merit review process and have been identified as a National Science Foundation program priorities to meet the agency's critical need to foster an understanding of Earth processes.

The proposed low-energy seismic survey will focus on seafloor offshore from Thwaites Glacier and on records of past glacial and ocean change contained in sediments deposited by the glacier and surrounding ocean. Uncertainty in model projections of the future of Thwaites Glacier will be significantly reduced by cross-disciplinary investigations seaward of the current grounding line, including extracting records of decadal to millennial variations in warm water incursion, determining a pre-satellite era history of grounding-line migration, and containing the bathymetric pathways that control the flow of warm water to the grounding line. Sedimentary records and glacial landforms preserved on the seafloor will allow reconstructing changes in drivers and glacial response to drivers over a range of timescales, thus providing reference data that can be used to initiate and evaluate model reliability. Such data will further provide insights on the influence of poorly understood process on marine ice sheet dynamics.

The National Science Foundation's THwaites Offshore Research (THOR) Project will complement Thwaites Glacier and other Amundsen Sea oceanographic and geological/geophysical studies and provide reference data that can be used to initiate and evaluate the reliability of ocean models. Data obtained by the proposed action will assist in establishing boundary conditions seaward of the Thwaites Glacier grounding line, elucidating external drivers of change, improving knowledge of processes leading to the collapse of Thwaites Glacier, and determining a history of past change in grounding line migration and conditions at the glacier base.

Researchers from the University of Houston propose to conduct a low-energy marine seismic survey for scientific research purposes, with funding from the National Science Foundation,

using an airgun array in the waters of the Southern Ocean in austral summer 2020. The principal investigator is Dr. Julia Wellner. The two-dimensional low-energy seismic survey will use a towed single or two airgun array with a maximum discharge volume of approximately 3,441 cubic centimeters (210 cubic inches). The seismic survey will take place in International Waters outside of the Southern Ocean (Amundsen Sea off Antarctica) in waters depths of approximately 100 to greater than 1,000 meters (328.1 to 3,280.1 feet). The seismic survey is tentatively planned to depart port on January 25, 2020 and return to port on approximately March 25, 2020. The seismic survey activities will consist of a total of approximately 60 days, including approximately 8 days of airgun array operations, approximately two days of contingency time, approximately two days of icebreaking, and approximately 16 days of transit. The low-energy seismic survey will take approximately eight days, beginning on or around February 6, 2020 and end on approximately February 14, 2020. In addition to the eight days of seismic survey activities, approximately two additional days are scheduled for contingency time (e.g., weather days, mechanical issues, etc.). The RVIB *Nathaniel B. Palmer* is planning to depart (on January 25, 2020) from and return (on approximately March 25, 2020) to Punta Arenas, Chile, with one-way transit covering approximately 3,445 kilometers (1,860 nautical miles). Some minor deviation from the dates is possible, depending on logistics and weather.

The National Science Foundation will use conventional seismic survey methodology and the procedures will be similar to those used during previous seismic surveys. Seismic survey protocols generally involve a predetermined set of tracklines. The seismic acquisition or sound source vessel travels down a linear trackline for some distance until a line of data is acquired, then turns and acquires data on a different trackline.

The RVIB *Nathaniel B. Palmer* will deploy either a single Generator Injector (GI) airgun or a two GI airgun array in harmonic mode or true GI mode, with one 100 to 300 meter (328 to 984 feet) towed solid-state hydrophone streamer behind the vessel and an airgun array to conduct the two-dimensional low-energy seismic survey. An extra airgun will serve as a “hot spare” back-up, to be used in the event that the primary airgun array malfunctions. The location of the tracklines are considered representative and may shift from what is depicted in Figure 2 depending on factors such as science drivers, poor data quality, weather, ice conditions, etc.

The seismic survey activities will be conducted along 1,600 kilometers (863.9 nautical miles) of tracklines. The proposed activities will occur 24 hours per day during the proposed low-energy seismic survey. There will be additional airgun array operations in the seismic survey area associated with start-ups, line changes and turns, airgun array testing, recovery, and repeat coverage of any areas where initial data quality is considered sub-standard by the project scientists. A section of a trackline may need to be repeated when data quality is poor or missing due to equipment failure (e.g., airgun array or towed hydrophone streamer problems; data acquisition system issues, research vessel issues); shut-downs or ramp-ups for protected species, which will tie into good data on the other side of the trackline. To account for these additional airgun array operations in the estimate of incidental takes of marine mammals that will occur as a

result of the seismic survey, the National Science Foundation added 25 percent to the total number of operational days (which is the equivalent to adding 25 percent to the total proposed trackline kilometers) to the seismic survey for their calculations of marine mammal exposures to sounds exceeding the ESA harassment (MMPA Level B harassment) thresholds. All planned seismic data acquisition activities will be conducted by the National Science Foundation and researchers, with onboard assistance by technical staff and the marine operations group. The research vessel will be self-contained, and the scientific party and crew will live aboard the vessel for the entire seismic survey. Since the low-energy seismic survey will be conducted during the austral summer, activities will mainly occur in daylight conditions. The National Science Foundation's biological assessment and incidental harassment authorization application present more detailed information on the project.

### **3.1.2 Source Vessel Specifications**

The low-energy seismic survey will involve one source vessel, the U.S.-flagged RVIB *Nathaniel B. Palmer*. The RVIB *Nathaniel B. Palmer* is owned by the Offshore Vessel Services, LLC and operated by the Galliano Marine Services, LLC. The RVIB *Nathaniel B. Palmer* will tow a source airgun array as a sound source along predetermined lines. The RVIB *Nathaniel B. Palmer* has a length of 93.9 meters (308 feet), a beam of 18.3 meters (60 feet), and a design draft of 6.8 meters (22.3 feet). Its propulsion system consists of four Caterpillar Model 3608 diesel engines, each producing 3,300 brake horsepower at 900 revolutions per minute, and a water jet azimuthing bowthruster. Electrical power is provided by four Caterpillar 3512, 1050 kiloWatt diesel generators. During the two-dimensional seismic survey, the vessel speed will be varying from approximately 7.4 to 11.1 kilometers per hour (4 to 6 knots). When not towing seismic survey gear, the RVIB *Nathaniel B. Palmer* typically cruises at 26.8 kilometers per hour (14.5 knots). The maximum speeds is approximately 26.8 kilometers per hour (14.5 knots) and the average speed is 18.7 kilometers per hour (10.1 knots). During the low-energy seismic survey, the vessel will attempt to maintain a constant speed of approximately 8.3 kilometers per hour (4.5 knots). It has an operating range of approximately 27,780 kilometers (15,000 nautical miles), which translates to an operating period of approximately 70 to 75 days. No chase vessel will be used during seismic survey activities. The RVIB *Nathaniel B. Palmer* will also serve as the platform from which vessel-based protected species observers (visual) will watch for animals (e.g., marine mammals). See

Table 1 for additional details regarding the RVIB *Nathaniel B. Palmer*.

**Table 1. Additional details of the Research Vessel/Icebreaker *Nathaniel B. Palmer*.**

Research Vessel/Icebreaker Specifications	
Owner	Offshore Vessel Services, LLC
Vessel Operator	Galliano Marine Services, LLC
Chartered By	National Science Foundation
Flag	United States of America
Date Built	1992
Gross Tonnage	6,174 U.S. tons (5,600 metric tons)
Accommodation Capacity	61 including approximately 22 Crew and 39 Scientists/Researchers

### 3.1.3 Airgun Array and Acoustic Receivers Description

The energy source for the low-energy seismic survey was chosen by the National Science Foundation to be the lowest practical to meet the scientific objectives. During the low-energy seismic survey, the RVIB *Nathaniel B. Palmer* will deploy an airgun array (i.e., a certain number of airguns of varying sizes in a certain arrangement) as an energy source. An airgun is a device used to emit acoustic energy pulses downward through the water column and into the seafloor, and generally consists of a steel cylinder that is charged with high-pressure air. Release of the compressed air into the water column generates a signal that reflects (or refracts) off the seafloor and/or sub-surface layers having acoustic impedance contrast. When fired, a brief (approximately 0.1 second) pulse of sound is emitted by all airguns nearly simultaneously. The airguns are silent during the intervening periods with the array typically fired on a fixed distance (or shot point) interval. The return signal is recorded by a listening device (e.g., receiving system) and later analyzed with computer interpretation and mapping systems used to depict the sub-surface.

The airgun array for the two-dimensional low-energy seismic survey will consist of one or two GI airguns (two by 45/105 cubic inch in true GI mode, preferred; two by 105/105 cubic inch in harmonic mode; used for take request) with varying displacement volumes (Table 2). The total maximum discharge volume for the largest, two airgun array will be 3,441 cubic centimeters (210 cubic inches). In harmonic mode, the injector volume is designed to destructively interfere with the reverberations of the generator (the sound source component). Firing the airgun array in harmonic mode maximizes resolution in the data and minimizes excess noise in the water column or in the data, caused by the reverberations (or bubble pulses). If the preferred configuration of the airgun array (i.e., two airgun array in true GI mode) does not provide the data to meet scientific objectives, alternate configurations will be utilized. All airguns in the array will be fired simultaneously. The airgun array will be towed behind the RVIB *Nathaniel B. Palmer*. The shot interval will be approximately 5 seconds (approximately 12.5 meters [41 feet])

for the two-dimensional low-energy seismic survey. There will be approximately 720 shots per hour. The firing pressure of the airgun array will be approximately 2,000 pounds per square inch (psi) (140 square kilograms per centimeter). The airgun array will be towed approximately 15 to 40 meters (49.2 to 131.2 feet) behind the vessel at a tow depth of 2 to 4 meters (6.6 to 13.1 feet) and spaced approximately 3 meters (9.8 feet) apart for the two-dimensional seismic survey. Weather conditions permitting, it is anticipated that seismic survey activities will not exceed approximately 240 hours of operation. It is expected that the airgun array will be active 24 hours per day during the seismic survey. Airguns will operate continually during the seismic survey period except for unscheduled shut-downs. See Table 2 for the specifications of the RVIB *Nathaniel B. Palmer*'s airgun array, trackline distances, and water depths associated with the seismic survey in the Amundsen Sea off Antarctica.

**Table 2. Specifications of the source airgun array to be used by the Research Vessel/Icebreaker *Nathaniel B. Palmer* during the proposed low-energy seismic survey in the Amundsen Sea off Antarctica.**

Source Airgun Array Specifications	
Energy Source – Number of Airguns	<p>Preferred Configuration – 2 Airguns of 45/105 in<sup>3</sup> in True GI Mode (2,000 psi)</p> <p>Alternate 1 Configuration – 1 Airgun of 45/105in<sup>3</sup> in True GI Mode (2,000 psi)</p> <p>Alternate 2 Configuration – 2 Airguns of 105/105 in<sup>3</sup> in Harmonic Mode (2,000 psi)</p> <p>Alternate 3 Configuration – 1 Airgun of 105/105 in<sup>3</sup> in Harmonic Mode (2,000 psi)</p>
Source Output (Downward) of 1 and 2 Airgun Array	<p>Peak-to-Peak = 4.0 bar-m</p> <p>0-to-Peak = NA</p> <p>Peak-to-Peak = 2.9 bar-m</p> <p>0-to-Peak = NA</p>
Tow Depth	2 to 3 m (6.6 to 13 ft)
Air Discharge Volume of 2 Airgun Array	Approximately 210 in <sup>3</sup>
Dominant Frequency Components	1 to 125 Hz
Pulse Duration	Less than Approximately 0.02 Seconds
Shot Interval	Approximately 5 Seconds

in<sup>3</sup>=cubic inches, GI=Generator Injector, psi=pounds per square inch, NA=Not Available, dB=decibel, m=meters, ft=feet, Hz=Hertz

The receiving system will consist of a single 100 to 300 meter (328.1 to 984.3 feet) long towed hydrophone streamer. As the airgun array is towed along the tracklines, the hydrophone streamer will receive the returning acoustic signals and transfer the data to the onboard processing system.

In addition to monitoring for the presence of protected species (e.g., marine mammals), weather and sea state conditions, and visibility, the presence of pack ice can hinder the airgun array and acoustic receivers will closely be monitored. If researchers encounter situations that pose a risk to the equipment, impede data collection, or require the vessel to stop forward progress, seismic survey equipment will be shut-down and retrieved until conditions improve. In general, the airgun array and towed hydrophone streamer can be retrieved in less than 30 minutes.

### **3.1.4 Single-Beam Echosounder, Split-Beam Echosounder, Multi-Beam Echosounder, and Acoustic Doppler Current Profiler**

Along with operations of the airgun array, four additional acoustical data acquisition systems will operate during the low-energy seismic survey from the RVIB *Nathaniel B. Palmer*. The Knudsen 3260 single-beam echosounder, EK biological split-beam echosounder, and Simrad EM 122 multi-beam echosounder will map the ocean floor during the low-energy seismic survey. The Teledyne RDI VM-150 and Ocean Surveyor OS-38 acoustic Doppler current profilers will measure water current velocities. The single-beam echosounder, split-beam echosounder, multi-beam echosounder, and acoustic Doppler current profiler sound sources will operate continuously from the RVIB *Nathaniel B. Palmer*, including simultaneously with the airgun array, but not during transit to and from the seismic survey area.

#### **3.1.4.1 Single-Beam Echosounder**

The ocean floor will be mapped with the Knudsen 3260 single-beam echosounder. The single-beam echosounder is a hull-mounted, compressed, high-intensity, radiated (CHIRP) sonar system that will be operated continuously during the seismic survey activities. The instrument is operated at 12 kiloHertz for bottom-tracking purposes or 3.5 kiloHertz in the sub-bottom profiling mode. The instrument emits energy in a 30 degree beam from the bottom the research vessel and has a sound source level of 224 decibels (dB) re: 1 microPascal ( $\mu\text{Pa}$ ) at 1 meter (root mean square [rms]). The time gap is variable. In default configuration, ping rate is dependent upon water depths, but it is possible to introduce delays between pings or to configure multiple pings in the water column.

#### **3.1.4.2 Split-Beam Echosounder**

The ocean floor will be mapped with an EK biological (Simrad ES200-7C, ES38B, ES-120-7C) split-beam echosounder. The split-beam echosounder is a hull-mounted sonar system that will be operated continuously during the seismic survey activities. The instrument is operated at 38, 120, and 200 kiloHertz. The instrument has a sound source level of 183 to 185 dB re: 1  $\mu\text{Pa}$  (rms). The National Science Foundation may not use this system during the seismic survey activities.

#### **3.1.4.3 Multi-Beam Echosounder**

The ocean floor will be mapped with the Simrad EM122 multi-beam echosounder. The multi-beam echosounder is a hull-mounted system operating at 12 kiloHertz. The transmitting beamwidth is very narrow, less than two degrees fore-aft and 150 degrees (maximum)

athwartship (i.e., perpendicular to the ship's line of travel). The maximum sound source level is 242 dB re: 1  $\mu$ Pa at 1 meter (root mean square [rms]). The multi-beam echosounder emits a series of nine consecutive 15 millisecond pulses.

#### **3.1.4.4 Acoustic Doppler Current Profiler**

The Teledyne RDI VM-150 and Ocean Surveyor OS-38 acoustic Doppler current profilers will be mounted on the hull of the RVIB *Nathaniel B. Palmer* to measure the speed of the water currents. The Teledyne RDI VM-150 acoustic Doppler current profiler will operate at a frequency of 150 kiloHertz and a maximum sound source level of 223.6 dB re: 1  $\mu$ Pa at 1 meter (rms) over a conically-shaped 30 degree beam. The Ocean Surveyor OS-38 acoustic Doppler current profiler will serve as a backup to the Teledyne RDI VM-150 acoustic Doppler current profiler and operate at a frequency of 150 kiloHertz and a maximum sound source level of 223.6 dB re: 1  $\mu$ Pa at 1 meter (rms) over a conically-shaped 30 degree beam. The maximum ping rate is 0.4 to 0.7 seconds. An acoustic Doppler current profiler will be operated continuously during the seismic survey activities.

#### **3.1.5 Icebreaking**

Icebreaking will occur in ice covered areas in the Amundsen Sea off Antarctica (between 75.25 degrees South and 73.5 degrees South, and 108.5 degrees West and 101 degrees West) only when needed. The amount of time the RVIB *Nathaniel B. Palmer* will spend icebreaking will vary based on the need and ice cover. The seismic survey activities are designed to avoid areas of heavy sea ice conditions since the RVIB *Nathaniel B. Palmer* is not suited to break multi-year sea ice. The proposed low-energy seismic survey will be more difficult to conduct in icy conditions because ice noise degrades the quality of geophysical data. Additionally, time spent breaking ice takes away from the available time to conduct the low-energy seismic survey. Logistically, if the research vessel were in heavy ice, researchers will not tow the airgun array and hydrophone streamer, as it will likely damage the equipment and generate noise interference. The exception to this is if an ice-free path opens up behind the research vessel, which can be used to conduct seismic survey activities without causing potential damage. If the RVIB *Nathaniel B. Palmer* breaks ice during transits, seismic survey activities will not be conducted concurrently.

While seismic survey activities will attempt to avoid areas of heavy sea ice, icebreaking is expected to be required during the seismic survey, based on the likely extent of sea ice in the Amundsen Sea during January through February. The RVIB *Nathaniel B. Palmer* will push through the ice, the hull of the vessel is not designed to drive the vessel up on top of the ice until the weight of the vessel breaks the ice as the general method for icebreaking. The RVIB *Nathaniel B. Palmer* may need to conduct icebreaking along an estimated distance up to 445 kilometers (240.3 nautical miles). In moderate ice conditions and based on a vessel speed of 9.2 kilometers per hour (5 knots) 445 kilometers (240.3 nautical miles) represents approximately 48 hours (two days) of icebreaking activities. However, because the RVIB *Nathaniel B. Palmer* is not rated to routinely break multi-year ice, icebreaking activities will generally avoid transit



through older ice (i.e., two years or older or thicker than 1 meter [3.3 feet]). The National Science Foundation anticipates that the RVIB *Nathaniel B. Palmer* will proceed primarily through one-year sea ice (including very thin, new ice) and will follow leads whenever possible. The research vessel will typically transit through areas of primarily open water containing brash or pancake ice, which is not considered icebreaking.

### **3.1.6 Mitigation, Monitoring, and Reporting**

The National Science Foundation 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 the likelihood of adverse effects to ESA-listed marine species or adverse effects on their designated critical habitats. Mitigation is a measure that avoids or reduces the severity of the effects of the action on ESA-listed species. Monitoring is used to observe or check the progress of the mitigation over time and to ensure that any measures implemented to reduce or avoid adverse effects on ESA-listed species are successful.

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

- Proposed exclusion and buffer zones;
- Shut-down 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., shut-down and ramp-up procedures) as well as reporting can be found in NMFS Permits and Conservation Division *Federal Register* notice of proposed incidental harassment authorization and request for comments on proposed incidental harassment authorization and possible renewal (84 FR 69950 to 69978) and Appendix A (Section 18.1).

#### **3.1.6.1 Proposed Exclusion and Buffer Zones – Ensonified Area**

The NMFS Permits and Conservation Division will require, and the National Science Foundation will implement, exclusion zones around the RVIB *Nathaniel B. Palmer* to minimize any potential adverse effects of the sound from the airgun array on MMPA and ESA-listed species. The exclusion zones are areas within which occurrence of a marine mammal triggers a shut-down of the airgun array, to reduce exposure of marine mammals to sound levels expected to

have adverse effects on the species or habitats. These exclusion zones are based upon modeled sound levels at various distances from the RVIB *Nathaniel B. Palmer*, and correspond to the respective species sound threshold for ESA harm (e.g., injury) and harassment.

### ***Ensonified Area***

When the NMFS *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NOAA 2016) was published, in recognition of the fact that ensonified area/volume can be more technically challenging to predict because of the duration component in the new thresholds, we developed a user spreadsheet that includes tools to help predict a simple isopleth that can be used in conjunction with marine mammal density or occurrence to help predict takes. We note that because of some of the assumptions included in the methods used for these tools, we anticipate that isopleths produced are typically going to be overestimates of some degree, which may result in some degree of overestimate of take 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 moving sound sources such as seismic surveys and icebreaking, the user spreadsheet predicts the closest distance at which a stationary animal will not incur permanent threshold shift if the sound source traveled by the animal in a straight line at a constant speed. Inputs used in the user spreadsheet and the resulting isopleths are described further in the National Science Foundation's biological assessment and incidental harassment authorization application and NMFS Permits and Conservation Division's proposed incidental harassment authorization (80 FR 69950 to 69978).

Lamont-Doherty Earth Observatory model results are used to determine the 160 dB re: 1  $\mu$ Pa (rms) radius for the two GI airgun array in deep water (greater than 1,000 meters [3,280.8 feet]) down to a maximum water depth of 2,000 meters (6,561.7 feet). 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  $\mu$ Pa (rms) distances were acquired 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 (Diebold et al. 2010; Tolstoy et al. 2009). 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 (3 meters [9.8 feet]). Because propagation varies with airgun array depth, correction factors have been applied to the distances reported by Tolstoy et al. (2009).

For deep and intermediate water depth cases, the field measurements in the Gulf of Mexico cannot be used readily to derive harm and harassment (MMPA Level A and Level B harassment) isopleths, as at those sites the calibration hydrophone was located at a roughly constant depth of 350 to 500 meters (1,148.3 to 1,640.4 feet), which may not intersect all the sound pressure level isopleths at their widest point from the sea surface down to the maximum relevant water depth for marine mammals of approximately 2,000 meters (6,561.7 feet). At short ranges, where the direct arrivals dominate and the effects of seafloor interactions are minimal, the data recorded at the deep and slope sites are suitable for comparison with modeled levels at the depth of the calibration hydrophone. At longer ranges, the comparison with the model, constructed from the maximum sound pressure level through the entire water column at varying distances from the airgun array, is the most relevant.

In deep and intermediate water depths, comparisons at short ranges between sound levels for direct arrivals recorded by the calibration hydrophone and model results from the same airgun array tow depth are in good agreement. Consequently, isopleths falling within this domain can be predicted reliably by the Lamont-Doherty Earth Observatory model, although they may be imperfectly sampled by measurements recorded at a single depth. At greater distances, the calibration data show that seafloor-reflected and sub-seafloor-refracted arrivals dominate, whereas the direct arrivals become weak and/or incoherent. Aside from local topography effects, the region around the critical distance is where the observed levels rise closest to the model curve. However, the observed sound levels are found to fall almost entirely below the model curve. Thus, analysis of the Gulf of Mexico calibration measurements demonstrates that although simple, the Lamont-Doherty Earth Observatory model is a robust tool for conservatively estimating isopleths. For deep water depths (greater than 1,000 meters [3,280.8 feet]), Lamont-Doherty Earth Observatory used the deep water radii obtained from model results down to a maximum water depth of 2,000 meters (6,561.7 feet). The radii for intermediate water depths (100 to 1,000 meters [328.1 to 3,280.8 feet]) are derived from the deep-water ones by applying a correction factor (multiplication) of 1.5, such that observed levels at very near offsets fall below the corrected mitigation curve. The shallow water radii are obtained by scaling the empirically derived measurements from the Gulf of Mexico calibration survey to account for the differences in source volume and tow depth between the calibration survey and the proposed low-energy seismic survey; whereas the shallow water in the Gulf of Mexico may not exactly replicate the shallow water environment in the proposed action area, it has been shown to serve as a good and very conservative proxy (Crone 2014). A simple scaling factor is calculated from the ratios of the isopleths determined by the deep-water mode, which are essentially a measure of the energy radiated by the airgun array. The estimated distances to the 160 dB re: 1  $\mu$ Pa (rms) isopleths for the two airgun array in each water depth category are in

Table 4.

***Establishment of Proposed Exclusion and Buffer Zones***

An exclusion zone is a defined area within which occurrence of a marine mammal triggers mitigation action intended to reduce the potential for certain outcomes (e.g., auditory injury, disruption of critical behaviors). Protected species observers will establish a default (minimum) exclusion zone with a 100 meter (328.1 feet) radius for visual monitoring for the one or two airgun array, per the *Final Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey* (USGS and NSF 2011). The 100 meter (328.1 feet) exclusion zone will be based on the radial distance from any element of the airgun array (rather than being based on the center of the airgun array or around the vessel itself). With certain exceptions (described below), if a marine mammal appears within, enters, or appears on course to enter this exclusion zone, the airgun array will be shut-down.

The 100 meter (328.1 feet) exclusion zone is intended to be precautionary in the sense that it will be expected to contain sound exceeding the injury criteria for all cetacean hearing groups (based on the dual criteria of  $SEL_{cum}$  and peak SPL), while also providing a consistent, reasonably observable zone within which protected species observers will typically be able to conduct effective observational effort. In this case, the 100 meter (328.1 feet) radial distance will also be expected to contain sound levels that will exceed the harm (MMPA Level A harassment) threshold based on cumulative sound exposure level criteria for all marine mammal hearing groups. In the 2011 *Final Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey* (USGS and NSF 2011), Alternative B (the Preferred Alternative) conservatively applied a 100 meter (328.1 feet) exclusion zone for all low-energy sound sources in water depths greater than 100 meters (328.1 feet), with low-energy sound sources defined as any towed acoustic source with a single or a pair of clustered airguns with individual volumes of less than or equal to 250 cubic inches. Thus, the 100 meter (328.1 feet) exclusion zone proposed for this low-energy seismic survey is consistent.

The intent in prescribing a standard distance for the exclusion zone is to (1) encompass zones within which auditory injury can occur on the basis of instantaneous exposure; (2) provide additional protection from the potential for more severe behavioral responses for marine mammals at relatively close range to the sound source; (3) provide consistency for protected species observers, who need to monitor and implement the exclusion zone; and (4) define a distance within which detection probabilities (using binoculars and the naked eye) are reasonably high for most marine mammal species under typical conditions.

Protected species observers will also establish and monitor a 200 meter (656.2 feet) buffer zone. During use of the sound source, occurrence of marine mammals within the buffer zone (but outside the exclusion zone) will be communicated to the operator to prepare for potential shut-down of the airgun array.

**Table 3. Predicted distances to permanent threshold shift thresholds for impulsive sources for various marine mammal hearing groups that could be received from the two-airgun array during the proposed low-energy seismic survey in the Amundsen Sea off Antarctica.**

Threshold	Low Frequency Cetaceans (m)	Mid Frequency Cetaceans (m)
<b>Source – 2 Airgun Array</b>		
SEL <sub>cum</sub>	31.1	0
Peak SPL <sub>flat</sub>	7.55	1.58

m=meters, SEL=sound exposure level, SPL=sound pressure level

The National Science Foundation's biological assessment and Lamont-Doherty Earth Observatory's incidental harassment authorization application have a detailed description of the modeling for the RVIB *Nathaniel B. Palmer*'s airgun arrays as well as the resulting isopleths to thresholds for the various marine mammal hearing groups (

Table 4). Predicted distances to 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>). The 160 dB re: 1  $\mu$ Pa (rms) isopleth is the distance at which ESA harassment (take by MMPA Level B harassment) is expected to occur (see

Table 4).

**Table 4. Predicted distances to which sound levels of 160 re: 1  $\mu$ Pa (rms) for harassment (Marine Mammal Protection Act Level B harassment) for impulsive sound sources will be received from the two Generator Injector airgun arrays in intermediate and deep water depths for marine mammals during the proposed low-energy seismic survey in the Amundsen Sea off Antarctica.**

Source	Volume (in <sup>3</sup> )	Water Depth (m)	Predicted Distance to Threshold (160 dB re: 1 $\mu$ Pa [rms]) (m)
2 45/105 in <sup>3</sup> GI Airguns	300	100 to 1,000	979
		>1,000	653
1 45/105 in <sup>3</sup> GI Airguns	150	100 to 1,000	503
		>1,000	335
2 105/105 in <sup>3</sup> GI Airguns	420	100 to 1,000	1,044
		>1,000	696
1 105/105 in <sup>3</sup> GI Airguns	210	100 to 1,000	531
		>1,000	354

in<sup>3</sup>=cubic inches, m=meters

An extended exclusion zone of 500 meters (1,640.4 feet) will be enforced for beaked whales and Southern right whales. NMFS Permits and Conservation Division will require this mitigation measure as a precaution as Southern right whales are not expected in the action area. A 500 meter (1,640.4 feet) exclusion zone will also be used for aggregations of six or more large whales (i.e., sperm whale or any baleen whale) or a large whale with a calf (calf is defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult).

### **3.1.6.2 Shut-Down Procedures**

The shut-down of the airgun array requires the immediate de-activation of all individual elements of the airgun array. Any protected species observer on duty will have the authority to delay the start of seismic survey activities or to call for shut-down of the airgun array if a marine mammal is detected within the applicable exclusion zone. When there is certainty regarding the need for mitigation action on the basis of visual detection, the relevant protected species observer must call for such action immediately. The operator must also establish and maintain clear lines of communication directly between protected species observers on duty and crew controlling the airgun array to ensure that shut-down commands are conveyed swiftly while allowing protected species observers to maintain watch. When the airgun array is active (i.e., anytime one or more airgun is active, including during ramp-up) and (1) a marine mammal appears within or enters the applicable exclusion zone the airgun array will be shut-down. When shut-down is called for by a protected species observer, the airgun array will be immediately deactivated and any dispute resolved only following deactivation.



Following a shut-down, airgun array activity will not resume until the marine mammal has cleared the 100 meter (328.1 feet). The animal will be considered to have cleared the 100 meter (328.1 feet) exclusion zone if it is visually observed to have departed the 100 meter (328.1 feet) exclusion zone, or if has not been seen within the 100 meter (328.1 feet) exclusion zone for 15 minutes in the case of small odontocetes and pinnipeds, or 30 minutes in the case of mysticetes and large odontocetes, including sperm whales.

Power-down procedures, which are often standard operating practice for National Science Foundation (high-energy) seismic survey activities, they are not proposed during this low-energy seismic survey because implementing a power-down from a two airgun array to a single airgun will only make a small difference in the size of the exclusion zone, which is not enough to allow continued operation of a single airgun array if a marine mammal enters within the exclusion zone for the two airgun array.

Upon implementation of shut-down, the airgun array may be reactivated after the marine mammal(s) has been observed exiting the applicable exclusion zone (i.e., animal is not required to fully exit the buffer zone where applicable) or following 15 minutes for small odontocetes and pinnipeds and 30 minutes for all mysticetes and large odontocetes (including sperm whales) with no further observation of marine mammal(s). Shut-down of the airgun array will also be required upon observation of a marine mammal species for which authorization has not been granted, or a marine mammal species for which authorization has been granted but the authorized number of takes are met, observed approaching, or within harm and harassment (MMPA Level A and Level B harassment) zones.

In addition to the shut-down procedure described above, the NMFS Permits and Conservation Division's MMPA incidental harassment authorization will require:

- The airgun array will be shut-down if a Southern right whale or beaked whale is observed within or approaching an extended exclusion zone of 500 meters (1,640.4 feet).
- The airgun array will be shut-down if any large whale (defined as a sperm whale or any mysticete [baleen whale]) species with a calf (defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult) or an aggregation of six or more large whales is observed within or approaching an extended exclusion zone of 500 meters (1,640.4 feet).

More details on shut-down procedures can be found in Section 18.1 (Appendix A – NMFS Permits and Conservation Division's proposed incidental harassment authorization) of this consultation.

### ***3.1.6.3 Pre-Clearance and Ramp-Up Procedures***

Ramp-up (sometimes referred to as “soft-start”) means the gradual and systematic increase of emitted sound levels from an airgun array. Ramp-up begins by first activating a single airgun, followed by activating the second airgun after five minutes. The intent of pre-clearance observation (30 minutes) is to ensure no protected species are observed within the buffer zone

prior to the beginning of ramp-up. During pre-clearance is the only time observations of protected species in the buffer zone will prevent operations (i.e., the beginning of ramp-up). The intent of ramp-up is to warn protected species of pending seismic survey activities (if the sound source is sufficiently aversive) and to allow sufficient time for those animals to leave the immediate vicinity prior to the sound source reaching full intensity. A ramp-up procedure, involving a step-wise increase in the number of airguns firing and total airgun array volume until all operational airguns are activated and the full volume is achieved, is required at all times as part of the activation of the airgun array. Ramp-up will also be required after the airgun array is shut-down for any reason longer than 15 minutes. Two protected species observers will be required to monitor during ramp-up. All operators must adhere to the following pre-clearance and ramp-up requirements:

- 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 exclusion zone. A marine mammal is considered to have cleared the exclusion zone if (1) it has been visually observed within the exclusion zone; or (2) if has been observed within the exclusion zone, for 15 minutes (in the case of small odontocetes and pinnipeds) or for 30 minutes (in the case of mysticetes and large odontocetes including sperm and beaked whales).
- Thirty minutes of pre-clearance observation of the exclusion zone and buffer zone is required prior to ramp-up for any shut-down of longer than 30 minutes. This pre-clearance period may occur during any vessel activity. If any marine mammal is observed within or approaching the exclusion zone during the 30 minute pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting the exclusion zone 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).
- The operator must notify a designated protected species observer of the planned start of ramp-up as agreed upon with the lead protected species observer;
- One of the protected species observers conducting pre-clearance observations must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the protected species observer to proceed;
- Ramp-up may not be initiated if any marine mammal is within or approaching the applicable exclusion or buffer zone. If a marine mammal is observed within the applicable exclusion zone or the buffer zone during ramp-up, a shut-down must be implemented as though the full airgun array were operational. Ramp-up may not begin until the animal(s) has been observed exiting the exclusion or buffer zones or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes and pinnipeds, and 30 minutes for all other species [mysticetes and large odontocetes]).
- Ramp-up will begin by activating a single airgun, and the second airgun will be added after a five minute duration. The operator must provide information to the protected species observer documenting that appropriate procedures were followed;

- Two protected species observers must monitor the exclusion and buffer zones during ramp-up, and ramp-up may not be initiated or must cease and the airgun array must be shut-down upon observation of a marine mammals within the applicable exclusion zone.;
- Ramp-up may occur at times of poor visibility, including nighttime, may only occur at times of poor visibility where operational planning cannot reasonably avoid such circumstances. Ramp-up may occur at night and during poor visibility if the exclusion zone and buffer zone have been continually monitoring by protected species observers for 30 minutes prior to ramp-up with no marine mammal detections;
- If the airgun array is shut-down for brief periods (i.e., less than 30 minutes) for reasons other than that described for shut-down (e.g., mechanical difficulty), it may be activated again without ramp-up if protected species observers have maintained constant visual monitoring and no visual detections of marine mammals have occurred within the applicable buffer zone; and
- Testing of the airgun array involving all elements requires normal mitigation protocols (e.g., ramp-up). Testing limited to individual sound source elements or strings of the airgun array does not require ramp-up but does require pre-clearance of 30 minutes.

More details on pre-clearance and ramp-up procedures can be found in Section 18.1 (Appendix A – NMFS Permits and Conservation Division’s proposed incidental harassment authorization) of this consultation.

#### ***3.1.6.4 Vessel-Based Visual Mitigation Monitoring***

Visual monitoring requires the use of trained protected species observers to scan the ocean surface visually for the presence of marine mammals. The area to be scanned visually includes primarily the exclusion zone, but also the buffer zone. The buffer zone means an area beyond the exclusion zone to be monitored for the presence of marine mammals that may enter the exclusion zone. During pre-clearance monitoring (i.e., before ramp-up begins), the buffer zone also acts as an extension of the exclusion zone in that observations of marine mammals within the buffer zone will also prevent airgun array operations from beginning (i.e., ramp-up). The buffer zone encompasses the area at and below the sea surface from the edge of the 0 to 100 meter (0 to 656.24 feet) exclusion zone, out to a radius of 200 meters (656.2 feet) from the edges of the airgun array (100 to 200 meters [1,640.4 to 3,280.8 feet]). Visual monitoring of the exclusion zone and adjacent waters is intended to establish and, when visual conditions allow, maintain zones around the sound source that are clear of marine mammals, thereby reducing or eliminating the potential for injury and minimizing the potential for more severe behavioral reactions for animals occurring close to the vessel. Visual monitoring of the buffer zone is intended to (1) provide additional protection to naïve marine mammals that may be in the area during pre-clearance; and (2) during use of the airgun array, aid in establishing and maintaining the exclusion zone by alerting the visual protected species observer and crew of marine mammals that are outside of, but may approach and enter, the exclusion zone.

The National Science Foundation must use at least three dedicated, trained, NMFS-approved protected species observers. The protected species observers 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. Protected species observer resumes shall be provided to NMFS for approval.

At least one of the visual protected species observers aboard the vessel must have a minimum of 90 days at-sea experience working in that role during seismic survey, with no more than 18 months elapsed since the conclusion of the at-sea experience. One visual protected species observer with such experience shall be designated as the lead for the entire protected species observer team. The lead protected species observer shall serve as the primary point of contact for the vessel operator and ensure all protected species observer requirements per the MMPA incidental harassment authorization are met. To the maximum extent practicable, the experienced protected species observers will be scheduled to be on duty with those protected species observers with appropriate training but who have not yet gained relevant experience.

During seismic survey activities (e.g., any day on which use of the airgun array is planned to occur, and whenever the airgun array is in the water, whether activated or not), a minimum of one visual protected species observers must be on duty and conducting visual observations at all times during daylight hours (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset) and 30 minutes prior to and during nighttime ramp-ups of the airgun array. Visual monitoring of the exclusion and buffer zones must begin no less than 30 minutes prior to ramp-up and must continue until one hour after use of the airgun array ceases or until 30 minutes past sunset. Visual protected species observers shall coordinate to ensure 360 degree visual coverage around the vessel from the most appropriate observation positions, and shall conduct visual observations using reticled binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.

Protected species observers will establish and monitor the buffer and exclusion zones. The buffer and exclusion zones will be based upon the radial distance from the edges of the airgun array (rather than being based on the center of the airgun array or around the vessel itself). During use of the airgun array (i.e., anytime the airgun array is active, including ramp-up), occurrences of marine mammals within the buffer zone (but outside the exclusion zone) will be communicated to the operator to prepare for the potential shut-down of the airgun array.

During use of the airgun array (i.e., anytime the airgun array is active, including ramp-up), occurrences of marine mammals within the buffer zone (but outside the exclusion zone) will be communicated to the operator to prepare for the potential shut-down of the airgun array. Any observations of marine mammals by crew members will be relayed to the protected species observer team. During good conditions (e.g., daylight hours, Beaufort sea state three or less), visual protected species observers will conduct visual observations when the airgun array is not operating (e.g., while the airgun array and streamer are being deployed or recovered from the

water, during transits) for comparison of sighting rates and behavior with and without use of the airgun array and between acquisition periods, to the maximum extent practicable.

During January and February in the action area, darkness or low-light hours are not expected to be encountered; therefore, seismic survey activities will likely be conducted continuously during daylight hours. Visual protected species observers 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 of observation per 24-hour period. However, during off-hours the resting protected species observer may be called for consultation if a second opinion be needed. Other vessel crew will also be instructed to assist in detecting marine mammals and implementing mitigation requirements, if practical. Before the start of the low-energy seismic survey, the crew will be given additional instruction in detecting marine mammals and implementing mitigation measures. Protected species observers will have direct radio contact with bridge and chief scientist during seismic survey activities. The vessel operators, science support personnel, and science party must comply immediately with the protected species observer's call to shut-down the airgun array or for vessel avoidance maneuvers.

When visual protected species observers are stationed on the bridge of the RVIB *Nathaniel B. Palmer*, eye level will be approximately 16.5 meters (54 feet) above sea level, and the position provides an approximate 270 degree view around the research vessel. In addition, there is an aloft observation tower at approximately 24.4 meters (80 feet) above sea level that is protected from the weather and provides a 360 degree view around the research vessel. Visual protected species observers will systematically scan around the research vessel with reticle binoculars and with the naked eye. Reticle binoculars (handheld 7 by 50 Fujinon or equivalent) are equipped with a built-in daylight compass and the range reticle, which will be used to measure distances to animals. Protected species observers will also have optical range finders and night vision devices.

At least one protected species observer will conduct visual monitoring at all times during icebreaking by the RVIB *Nathaniel B. Palmer*. Protected species observer monitoring will likely be limited to the animals in proximity to the ice margin habitat, but visual watch will include the approximately 6.5 kilometers (3.5 nautical miles) monitoring zone (for the 120 dB re: 1 Pa [rms] threshold for non-impulsive sound) during icebreaking.

More details on monitoring can be found in Section 18.1 (Appendix A – NMFS Permits and Conservation Division's proposed incidental harassment authorization) of this consultation.

#### **3.1.6.5 Vessel Strike Avoidance Measures**

Vessel strike avoidance measures are intended to minimize the potential for collisions with marine mammals. NMFS Permits and Conservation Division notes that these requirements do not apply in any case where compliance will 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. These vessel strike avoidance measures include the following:

- The vessel operator (RVIB *Nathaniel B. Palmer*) and crew will maintain a vigilant watch for all marine mammals and slow down or stop or alter course of the vessel, as appropriate and regardless of vessel size, to avoid striking any marine mammal during seismic survey activities as well as transits. A single marine mammal at the water's surface may indicate the presence of submerged animals in the vicinity of the vessel; therefore, precautionary measures should be exercised when an animal is observed. A visual observer aboard the vessel will monitor a vessel strike avoidance zone around the vessel (specific distances detailed below), to ensure the potential for vessel strike is minimized, according to the parameters stated below. Visual observers monitoring the vessel strike avoidance zone can be either third-party protected species observers or crew members, but crew members responsible for these duties will be provided sufficient training to distinguish marine mammals from other phenomena and broadly to identify a marine mammal to broad taxonomic group (i.e., as a large whale or other marine mammal).
- Vessel speeds must be reduced to 18.5 kilometers per hour (10 knots) or less when mother/calf pairs, pods, or large assemblages of marine mammals are observed near the vessel. The vessel operator may use professional judgement as to when such circumstances warranting additional caution are present.
- The vessel (RVIB *Nathaniel B. Palmer*) will maintain a minimum separation distance of 100 meter (328.1 feet) from large whales (i.e., all baleen whales and sperm whales). The following vessel avoidance measures will be taken if a large whale is within 100 meter (328.1 feet) of the vessel:
  - The vessel will reduce speed and shift the engine to neutral, when feasible, and will not engage the engines until the whale has moved outside of the vessel's path and the minimum separation distance has been established.
  - If the vessel is stationary, the vessel will not engage engines until the whale(s) has moved out of the vessel's path and is beyond 100 meters (328.1 feet).
- The vessel will maintain a minimum separation distance of 50 meters (164 feet) from all other marine mammals, with an exception made for animals that approach the vessel.
- When marine mammals are sighted while a vessel is underway, the vessel must take action as necessary to avoid violating the relevant separation distance. If marine mammals are sighted within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until the animal(s) are clear of the vessel's path and the minimum separation distance has been established. If the vessel is stationary, the vessel will not engage engines until the animal(s) has moved out of the vessel's path and beyond the relevant separation distance. This recommendation does not apply to any vessel towing gear.
- If the animal(s) is encountered during transit, the vessel will attempt to remain parallel to the animal's course, avoiding excessive speed or abrupt changes in course.

### ***3.1.6.6 Additional Mitigation Measures Considered***

Additional mitigation measures were considered by the National Science Foundation during the planning phase of the proposed seismic survey activities to reduce the severity of the effects of the action on ESA-listed species. Additional detail is described below in this opinion.

#### ***Sound Source***

The National Science Foundation considered and evaluated whether the research objectives could be met with a smaller sound source for the proposed low-energy seismic survey. The National Science Foundation determined that the scientific objectives for the proposed low-energy seismic survey could not be met using smaller sound sources. Based on experience, the principal investigator has found that this sound source (single airgun or at most two airgun array) is likely to provide the best data to meet the scientific objectives.

#### ***Speed or Course Alteration***

The National Science Foundation will alter the RVIB *Nathaniel B. Palmer*'s speed and course during seismic survey activities if a marine mammal, based on its position and relative motion, appears likely to enter the exclusion zone (100 meters [328.1 feet]). If speed or course alteration is not safe or practical (e.g., without damaging deployed equipment) or, if after alteration, the marine mammal still appears likely to enter the exclusion zone (100 meters [328.1 feet]), further mitigation measures (such as shut-down procedures) will be taken.

### ***3.1.6.7 Reporting***

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

Monitoring and reporting requirements prescribed by NMFS Permits and Conservation Division will contribute improved understanding of one or more of the following:

- Occurrence of marine mammal species or stocks in the area in which take is anticipated (e.g., presence, abundance, distribution, density).
- Nature, scope, or context of likely marine mammal exposure to potential stressors/impacts (individual or cumulative, acute or chronic), through better understanding of (1) action or environment (e.g., source characterization, propagation, ambient noise); (2) affected species (life history, diver patterns); (3) co-occurrence of

marine mammal species with the action; or (4) biological or behavioral context of exposure (e.g., age, calving, or feeding areas).

- Individual marine mammal responses (behavioral or physiological) to acoustic stressors (acute, chronic, or cumulative), other stressors, or cumulative impacts from multiple stressors.
- How anticipated responses to stressors impact either (1) long-term fitness and survival of individual marine mammals; or (2) populations, species, or stocks.
- Effects on marine mammal habitat (e.g., marine mammal prey species, acoustic habitat, or other important physical components of marine mammal habitat).
- Mitigation and monitoring effectiveness.

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

The draft report shall also include geo-referenced time-stamped vessel tracklines for all time periods during which the airgun array were operating. Tracklines shall include points recording any change in the airgun array status (e.g., when the airgun array began operating, when they were turned off, or when they changed from full airgun array to single airgun or vice versa). Geographic information system (GIS) files shall be provided in Esri (a GIS company) shapefile format and include the coordinated universal time (UTC) date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates shall be referenced to the WGS84 geographic coordinate system. In addition to the report, all raw observational data shall be made available to NMFS. The draft report must be accompanied by a certification from the lead protected species observer as to the accuracy of the report, and the lead protected species observer may submit directly to NMFS Permits and Conservation Division a statement concerning implementation and effectiveness of the required mitigation and monitoring measures. A final report must be submitted within 30 days following resolution of any comments on the draft report.

More details on reporting can be found in Section 18.1 (Appendix A – NMFS Permits and Conservation Division’s proposed incidental harassment authorization) of this consultation.



### 3.2 National Marine Fisheries Service's Proposed Action

On July 24, 2019, NMFS Permits and Conservation Division received a request from the National Science Foundation for an incidental harassment authorization to take marine mammals incidental to conducting a low-energy marine seismic survey and icebreaking in the Amundsen Sea off Antarctica. On November 22, 2019, NMFS Permits and Conservation Division deemed the National Science Foundation's application for an incidental harassment authorization to be adequate and complete. The National Science Foundation's request is for take of a small number of 18 species of marine mammals by MMPA Level B harassment. Neither the National Science Foundation, nor NMFS Permits and Conservation Division expects serious injury or mortality to result from the proposed activities, therefore, an incidental harassment authorization is appropriate. The planned low-energy seismic survey is not expected to exceed one year; hence, the NMFS Permits and Conservation Division does not expect subsequent MMPA incidental harassment authorizations will be issued for this 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 after January 21, 2020, so that the National Science Foundation's will have the incidental harassment authorization prior to the start of the proposed low-energy seismic survey and icebreaking. Because the National Science Foundation has tentatively scheduled the proposed low-energy seismic survey to begin on January 25, 2020 and has requested that the incidental harassment authorization be issued by January 23, 2020, the NMFS Permits and Conservation Division has requested the consultation be completed by January 22, 2020.

#### 3.2.1 Proposed Incidental Harassment Authorization

The NMFS Permits and Conservation Division is proposing to issue an incidental harassment authorization authorizing non-lethal "takes" by MMPA Level B harassment of marine mammals incidental to the planned low-energy seismic survey and icebreaking. The incidental harassment authorization will be valid for a period of one year from the date of issuance. The incidental harassment authorization will authorize the incidental harassment of the following threatened and endangered species: 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's planned low-energy seismic survey and icebreaking 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 specified 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 the changes do not affect the previous analyses, mitigation and monitoring requirements, or take estimates (with the exception of reducing the type or amount of take because only a subset of the initially analyzed activities remain to be completed under the renewal); and (2) a preliminary monitoring report showing the results of the required monitoring to date and an explanation showing that the monitoring results do not indicate impacts of a scale or nature not previously analyzed or authorized.
- Upon review of the request for renewal, the status of the affected species or stocks, and any other pertinent information, NMFS Permits and Conservation Division determines that there are no more than minor changes in the activities, the mitigation and monitoring measures will remain the same and appropriate, and the findings in the initial incidental harassment authorization remain valid.

On December 19, 2019, NMFS Permits and Conservation published a notice of proposed incidental harassment authorization and request for comments on proposed incidental harassment authorization and possible renewal in the *Federal Register* (84 FR 69950 to 69978). The public comment period closed on January 21, 2020. Appendix A (see Section 18.1) contains the proposed incidental harassment authorization. The text in Appendix A (see Section 18.1) was taken directly from the proposed incidental harassment authorization provided to us in the consultation initiation package.

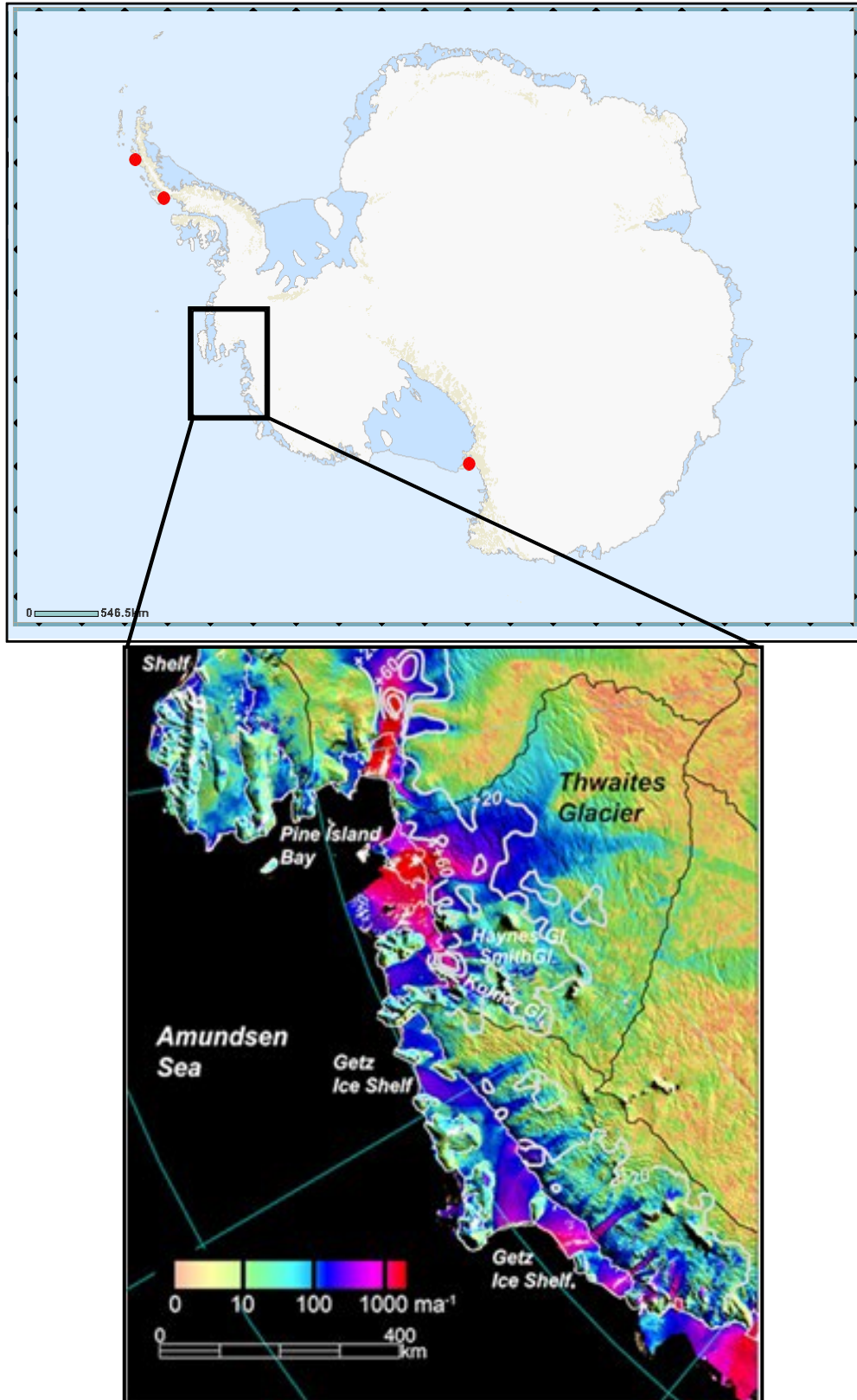
### **3.2.2 Revision to Proposed Incidental Harassment Authorization**

The NMFS Permits and Conservation Division's has made revisions to the proposed incidental harassment authorization since the notice was published in the *Federal Register* on December 19, 2019 (84 FR 69950 to 69978). The revisions are based on public comments received from the Marine Mammal Commission. The revisions to the proposed incidental harassment authorization include modifications to the incidental take estimates of marine mammals (blue whales, fin whales, sei whales, and sperm whales).

## 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).

The proposed action will take place in the Amundsen Sea off Antarctica, between approximately 75.25 to 73.57 degrees South, and 101 to 108.5 degrees West, just north (seaward) of the Thwaites Glacier. The low-energy seismic survey will take place in International Waters. Representative tracklines are shown in Figure 2. The representative tracklines shown in Figure 2 have a total length of approximately 1,600 kilometers (863.9 nautical miles). Some minor deviation of the tracklines, including the order of operations, may occur for reasons such as science drivers, poor data quality, inclement weather, or mechanical issues with the equipment and/or research vessel/icebreaker. The tracklines can occur anywhere within the coordinates noted in Figure 2. The action area will also include the area covered by the RVIB *Nathaniel B. Palmer* while transiting from its port to the seismic survey area, and its return at the conclusion of the seismic survey. The RVIB *Nathaniel B. Palmer* is expected to leave and return to the port of Punta Arenas, Chile. The port locations may be subject to change. We do not anticipate any effects outside the area shown on the maps in Figure 1 and Figure 2.



**Figure 1. Map of the National Science Foundation's low-energy seismic survey in Amundsen Sea off Antarctica for this consultation.**

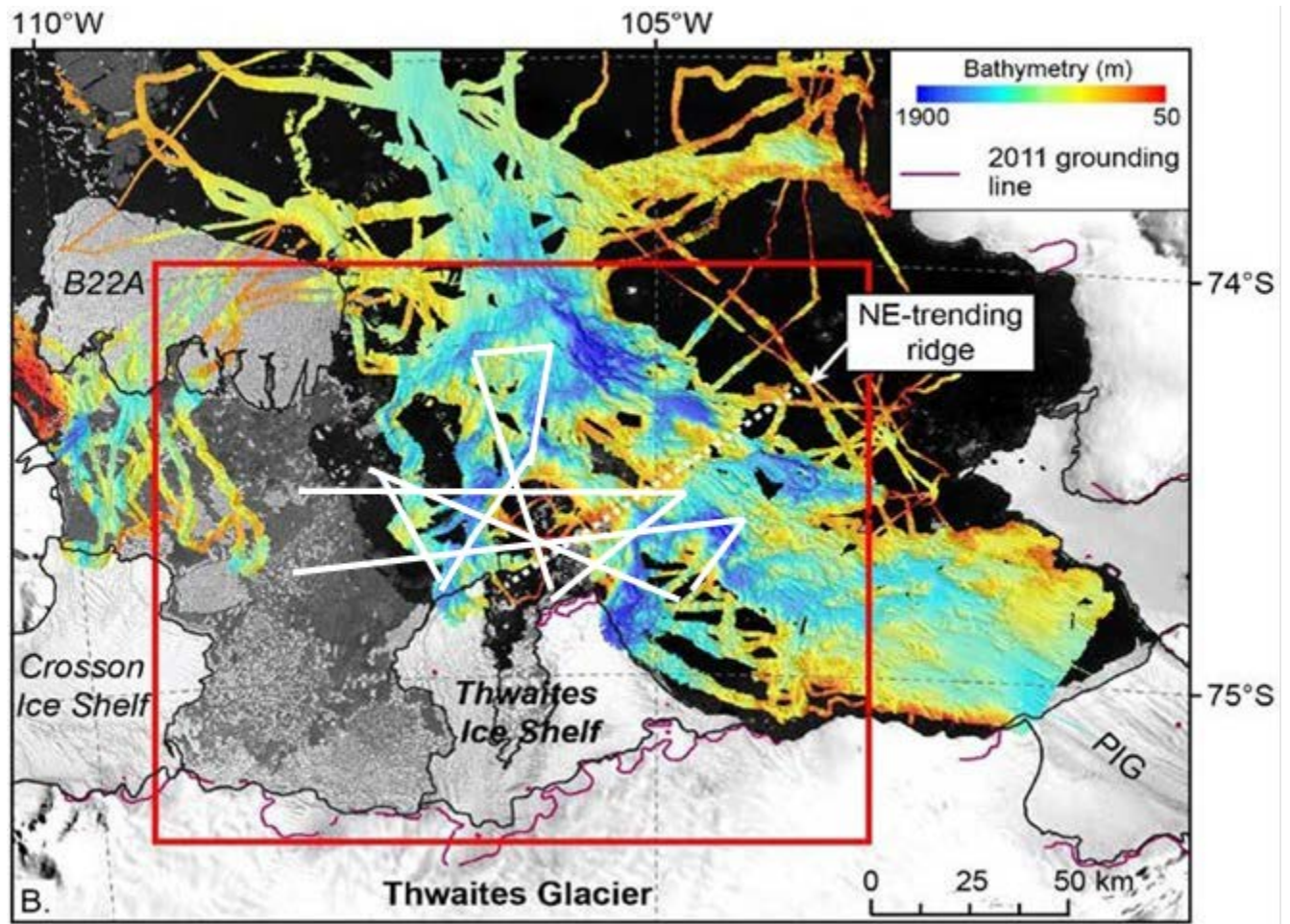


Figure 2. Map of the Thwaites Glacier and approximate tracklines for the National Science Foundation's low-energy seismic survey in Amundsen Sea off Antarctica for this consultation.

## 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 induce an adverse 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, single-beam echosounder, split-beam echosounder, multi-beam echosounder, acoustic Doppler current profiler, and seismic airgun array), entanglement in towed seismic equipment (hydrophone streamer), and icebreaking. Below we provide detailed information on the effects of these potential stressors. Furthermore, the proposed action includes several conservation (monitoring and mitigation) measures described in Section 3.1.6 that are designed to minimize effects that may result from these potential stressors. While we consider all of these conservation 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 5 depicts our effects analysis by stressor for each ESA-listed species considered in this consultation.

**Table 5. ESA-listed species that may be affected by the proposed action and effects determination by stressor for Endangered Species Act-listed species expected to be encountered during the proposed low-energy seismic survey and icebreaking in the Amundsen Sea off Antarctica during January through March 2020.**

Endangered Species Act-listed Species in the Action Area	Overall Determination	Potential Stressors						
		Pollution	Vessel Strike	Vessel Noise, Visual Disturbance	Acoustic Sources			Gear Entanglement
					Echosounder Acoustic Doppler Current Profiler	Seismic Airgun Array	Icebreaking	
Cetaceans								
Blue Whale	LAA	NLAA	NLAA	NLAA	NLAA	LAA	LAA	NLAA
Fin Whale	LAA	NLAA	NLAA	NLAA	NLAA	LAA	LAA	NLAA
Sei Whale	LAA	NLAA	NLAA	NLAA	NLAA	LAA	LAA	NLAA
Southern Right Whale	NLAA	NLAA	NLAA	NLAA	NLAA	NE	NE	NE
Sperm Whale	LAA	NLAA	NLAA	NLAA	NLAA	LAA	LAA	NLAA

NE=No effect, NLAA= Not likely to adversely affect, LAA= Likely to adversely affect



## 5.1 Pollution

The operation of the RVIB *Nathaniel B. Palmer* 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 (Chance et al. 2015; Duce et al. 1991). 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 (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 low-energy seismic survey. While this is expected to reduce the amount of pollution that may result from the proposed action, pollution remains a potential stressor.

## 5.2 Vessel Strike

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 (Brown and Murphy 2010; Laist et al. 2001; NMFS and USFWS 2008; 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 (Conn and Silber 2013; Hazel et al. 2007; Jensen and Silber 2004; Laist et al. 2001; Vanderlaan and Taggart 2007). 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 (marine mammals). In general, the probability of a vessel collision and the associated response depends, in part, on size and speed of the vessel. The RVIB *Nathaniel B. Palmer* has a length of 93.9 meters (308 feet) and the operating speed during seismic data acquisition is typically approximately 8.3 kilometers per hour (4.5 knots) (ranges from 7.4 to 11.8 kilometers per hour [4 to 6 knots]). When not towing seismic survey gear, the RVIB *Nathaniel B. Palmer* typically transits at 26.8 kilometers per hour (14.5 knots). The majority of vessel strikes of large whales occur when vessels are traveling at speeds greater than approximately 18.5 kilometers per hour (10 knots), with faster travel, especially of large vessels (80 meters [262.5 feet] or greater), being more likely to cause serious injury or death (Conn and Silber 2013; Jensen and Silber 2004; Laist et al. 2001; Vanderlaan and Taggart 2007).



Several conservation measures proposed by the NMFS Permits and Conservation Division and/or National Science Foundation will minimize the risk of vessel strike (e.g., use of protected species observers, vessel strike avoidance measures). 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 strike remains 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, single-beam echosounders, split-beam echosounders, multi-beam echosounders, acoustic Doppler current profilers, airgun arrays, and icebreaking 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. The acoustic noise from the single-beam echosounders, split-beam echosounders, multi-beam echosounders, acoustic Doppler current profilers, and icebreaking will be discussed further in Section 5.4.

The research vessel associated with the proposed action may cause visual or auditory disturbances to ESA-listed species that spend time near the water surface, such as marine mammals, which may generally disrupt their behavior. Studies have shown that vessel operations can result in changes in the behavior of marine mammals (Hazel et al. 2007; Holt et al. 2009; Luksenburg and Parsons 2009; Noren et al. 2009; Patenaude et al. 2002; Richter et al. 2003; Smultea et al. 2008). 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 (Blane and Jaakson 1994a; Evans et al. 1992; 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, single-beam echosounders, split-beam echosounders, multi-beam echosounders, acoustic Doppler current 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 in the vicinity of 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. 2007a). 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 (see Section 10.3.2).

Several of the mitigation measures associated with the proposed action such as ramp-up and shut-down 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 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, and more generally disrupt their behavior. In addition to the active sound sources mentioned above, we expect the RVIB *Nathaniel B. Palmer* will add to the local noise environment in the action area due to the research 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 (Kipple and Gabriele 2007; McKenna et al. 2012; Richardson et al. 1995b). Source levels for 593 container ships 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 dB 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  $\mu$ Pa [rms]  $\pm$  standard error) for individual vessels ranged from  $158 \pm 2$  dB (research vessel) to  $186 \pm 2$  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.

Numerous studies of interactions between surface vessels and marine mammals have demonstrated that free-ranging marine mammals 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 (Amaral and Carlson 2005; Au and Green 2000; Bain et al. 2006; Bauer 1986; Bejder et al. 1999; Bejder and Lusseau. 2008; Bejder et al. 2009; Bryant et al. 1984; Corkeron 1995; Erbe 2002c; Félix 2001; Goodwin and Cotton 2004; Lemon et al. 2006; Lusseau 2003; Lusseau 2006; Magalhaes et al. 2002; Nowacek et al. 2001; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005a; Watkins 1986b; Williams et al. 2002; Wursig et al. 1998). However, several authors suggest that the noise generated during motion is probably an important factor (Blane and Jaakson 1994b; Evans et al. 1992; Evans et al. 1994). These studies suggest that the

behavioral responses of marine mammals to surface vessels are similar to their behavioral responses to predators.

#### **5.4 Single-Beam Echosounder, Split-Beam Echosounder, Multi-Beam Echosounder, and Acoustic Doppler Current Profiler**

The single-beam echosounder, split-beam echosounder, multi-beam echosounder, and acoustic Doppler current profiler are four active acoustic systems that will operate during the proposed low-energy seismic survey on the R/V *Nathaniel B. Palmer*. As described above in Section 3.1.4, a single-beam echosounder, split-beam echosounder, multi-beam echosounder, and acoustic Doppler current profiler will be operated continuously during the proposed seismic survey activities, but not during transit to and from the survey area.

The single-beam echosounder, split-beam echosounder, multi-beam echosounder, and acoustic Doppler current profiler (in addition to the airgun array) have the potential to expose ESA-listed marine mammal species to sound levels above the 160 dB re: 1  $\mu$ Pa (rms) threshold for harassment. The single-beam echosounder, split-beam echosounder, multi-beam echosounder, and acoustic Doppler current profiler operate at a frequency of 3.5 or 12 kilohertz, 38 or 120 or 200 kilohertz, 12 kilohertz, and 150 kilohertz, respectively. These frequencies are generally higher frequencies than airgun array operations. These frequencies are within the functional hearing range of baleen whales (7 Hertz to 35 kilohertz), such as blue, fin, and sei whales, as well as sperm whales (150 Hertz to 160 kilohertz) (NOAA 2018). We expect that these mapping systems will produce harmonic components in a frequency range above and below the center frequency similar to other commercial sonars (Deng 2014). Although Todd et al. (1992) found that mysticetes reacted to sonar sounds at 3.5 kilohertz within the 80 to 90 dB re: 1  $\mu$ Pa 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  $\mu$ Pa (rms). Responses included cessation of foraging, increased swimming speed, and directed travel away from the sound 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 single-beam echosounder, split-beam echosounder, multi-beam echosounder, and acoustic Doppler current profiler (Ketten 1997a; Richardson et al. 1995c).

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 single-beam echosounder, split-beam echosounder, multi-beam echosounder, and acoustic Doppler current profiler since these other sound sources will drop off faster than the airgun arrays. In addition, the single-beam echosounder, split-beam echosounder, multi-beam echosounder, and acoustic Doppler current 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 array are expected to effectively cancel out sounds produced by the single-beam echosounder, split-beam echosounder, multi-beam echosounder, and acoustic Doppler current profiler

For the single-beam echosounder, the instrument emits energy in a 30 degree beam from the bottom of the research vessel with a variable time gap. For the multi-beam echosounder, the transmitting beamwidth is very narrow, less than two degrees fore-aft and 150 degrees (maximum) athwartship, and emits a series of nine consecutive 15 millisecond pulses. For the acoustic Doppler current profiler, the instrument will have a 30 degree conically-shaped beam with a maximum ping rate of 0.4 to 0.7 seconds. Given the movement and speed of the research vessel, the intermittent and narrow downward-directed nature of the sounds emitted by the single-beam echosounder, split-beam echosounder, multi-beam echosounder, and acoustic Doppler current profiler will result in no more than one or two brief ping exposures of any individual cetacean, if any exposure were to occur.

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 (Au 2000; Au et al. 2006; Carder and Ridgway 1990; Erbe 2002a; Frazer and Mercado 2000; Goold and Jones 1995a; Levenson 1974; Payne and Payne 1985; Payne 1970; Richardson et al. 1995c; Silber 1986; Thompson et al. 1986; Tyack 1983; Tyack and Whitehead 1983; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997b; Weir et al. 2007a; Winn et al. 1970). The response of a blue whale to 3.5 kiloHertz sonar supports this species' ability to hear this signal as well (Goldbogen 2013). Maybaum (1990; 1993) observed that Hawaiian humpback whales moved away and/or increased swimming speed upon exposure to 3.1 to 3.6 kiloHertz sonar. 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 1977a; Watkins and Schevill 1975b). 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 RVIB *Nathaniel B. Palmer*, 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 RVIB *Nathaniel B. Palmer*'s single-beam echosounder, split-beam echosounder, multi-beam echosounder, and acoustic Doppler current 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 marine mammals. The sonars proposed for use by the RVIB *Nathaniel B. Palmer* differs from sonars used during naval operations, which generally have a longer pulse duration and more horizontal orientation than the more downward-directed single-beam echosounder, split-beam echosounder, multi-beam echosounder, and acoustic Doppler current profiler. The sound energy received by any individuals exposed to the single-beam echosounder, split-beam echosounder, multi-beam echosounder, and acoustic Doppler current profiler 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 single-beam echosounder, split-beam echosounder, multi-beam echosounder, and acoustic Doppler current profiler 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.

## 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 (Deakos and H. 2011; Duncan et al. 2017; Moore et al. 2009b; Moore et al. 2009a; Van Der Hoop et al. 2013b; Van der Hoop et al. 2013a). Marine mammal entanglement, or bycatch, is a global problem that every year results in the death of hundreds of thousands of animals worldwide. Entangled marine mammals 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, death is usually quick, due to drowning. However, large whales, like North Pacific right 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 (Lysiak et al. 2018; Van der Hoop et al. 2017).

The towed hydrophone streamer is rigid and as such will not encircle, wrap around, or in any other way entangle any of the large whales considered during this consultation. We expect the taut cables will prevent entanglement. Furthermore, mysticetes (baleen whales) and possible sperm whales are expected to avoid areas where the airgun array is actively being used, meaning they will also avoid towed gear. Instances of such entanglement events with ESA-listed marine mammals are unknown to us.

## 5.6 Icebreaking

Icebreaking vessels used in the Arctic and Antarctica for activities including research and oil and gas activities that produce louder, but also more variable, sounds than those associated with other vessels of similar power and size during icebreaking activities. The greatest sound generated during icebreaking activities is produced by cavitation of the propeller as opposed to the engines or the ice on the hull; estimated sound source levels for icebreakers range from 164 to 189 dB re: 1  $\mu$ Pa (rms) at 1 meter (Greene and Moore 1995) underneath the waterline.

The only potential stressor that is likely to affect ESA-listed species within the action area are sound fields produced by the seismic airgun array and icebreaking. These stressors and these sound sources associated with the low-energy seismic survey may adversely affect the ESA-listed marine mammals and are further analyzed and evaluated in detail in Section 10.3.

## 6 SPECIES NOT LIKELY TO BE ADVERSELY AFFECTED

This section identifies the ESA-listed species and designated critical habitat under NMFS jurisdiction that may occur within the action areas (as described in Table 5) that are not likely to be adversely affected by the proposed action. NMFS uses two criteria to identify the ESA-listed 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 consequences of 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 or designated critical habitat is not likely to be exposed to the proposed activities, we must also conclude that the species or critical habitat 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 is 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 5 and we summarize our results below.

An action warrants a "may affect, not likely to be adversely affected" 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 ESA-listed species that may be affected, but are not likely to be adversely affected, by the proposed action. For these ESA-listed species and critical habitat, we focus specifically on stressors associated with the National Science Foundation's seismic survey activities and their effects on these species. The effects of other stressors associated with the proposed action, which are not likely to adversely affect ESA-listed species, are evaluated in Section 6. The species potentially occurring within the action area that may be affected, but are not likely to be adversely affected, are listed in Table 5, along with their regulatory status, designated critical habitat, and recovery plan. No designated critical habitat occurs within the action area and therefore none may be affected by the proposed action.

**Table 6. 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
<b>Marine Mammals – Cetaceans</b>			
Southern Right Whale ( <i>Eubalaena australis</i> )	<a href="#">E – 35 FR 8491</a>	-- --	-- --

E=Endangered

## 6.1 Southern Right Whale

ESA-listed cetaceans (Southern right whale) can occur in the action area and may be affected by the stressors associated with the National Science Foundation's proposed low-energy seismic survey activities (see Section 3.1). While the aforementioned Southern right whale can be found in coastal and pelagic habitats within the proposed action area, it is unlikely that Southern right whales will be adversely affected by stressors associated with the proposed action as they are not expected to occur in the portion of the action area where airgun array operations and icebreaking are proposed. Each of the stressors associated with the proposed action, along with our determination on their impacts to ESA-listed marine mammals (particularly cetaceans) within the action area, are discussed below.

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.

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 delineate 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. 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 20 meters (65.6 feet) 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 through April) foraging locations in the Subtropical and Antarctic Convergence zones. Southern right whales have been sighted as far south as 65 degrees South, but generally occur from 22 to 55 degrees South.

From this overview, it is apparent that Southern right whales can be found within the action area. The Southern right whale is not expected to occur in the area of the proposed seismic survey activities and icebreaking as the tracklines of the proposed low-energy seismic survey are further south (between approximately 75.25 to 73.57 degrees South, and 101 to 108.5 degrees West) than their range; however, they may occur in the action area of the port stops and transit. Since the proposed seismic survey activities will take place in a location where we do not expect Southern right whales to be present, we do not expect the animals to be exposed to the potential stressors of acoustic noise from the airgun array and icebreaking. Because the potential for exposure to the potential stressors of acoustic noise from the airgun array and icebreaking is extremely unlikely to occur, we find that the risk from these potential stressor is discountable. Southern right whales may be exposed to the potential stressors of pollution, vessel strike, gear entanglement, and vessel noise during the transit and ports stops of the RVIB *Nathaniel B. Palmer*, which are discussed further below. Therefore, we conclude that the National Science Foundation’s proposed seismic survey activities is not likely to adversely affect ESA-listed Southern right whales and will not be analyzed further in this consultation.



## 6.2 Potential Stressors to Endangered Species Act-Listed Cetaceans

### 6.2.1 Pollution

As stated in Section 5.1, the National Science Foundation proposes to include guidance on the handling and disposal of marine trash and debris during the low-energy seismic survey. The research vessel used during the National Science Foundation-funded low-energy seismic survey has spill-prevention plans, which will allow a rapid response to a spill in the event one occurred. In addition to this, the potential for an oil or fuel spill to emanate from the RVIB *Nathaniel B. Palmer* during the proposed activities is small. 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 RVIB *Nathaniel B. Palmer* 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. 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. Therefore, we conclude that pollution by oil or fuel leakage is not likely to adversely affect ESA-listed species, and will not be analyzed further in this consultation.

### 6.2.2 Vessel Strike

While vessel strikes of marine mammals during seismic survey activities are possible, we are not aware of any definitive case of a marine mammal being struck by a vessel associated with seismic surveys. The RVIB *Nathaniel B. Palmer* will be traveling at generally slow speeds, reducing the amount of noise produced by the propulsion system and the probability of a vessel strike (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). Our expectation of vessel strike for a marine mammal is small due to the hundreds of thousands of kilometers the RVIB *Nathaniel B. Palmer* has traveled without a vessel strike, the general expected movement of marine mammals away from or parallel to the RVIB *Nathaniel B. Palmer*, as well as the generally slow movement of the RVIB *Nathaniel B. Palmer* during most of its travels (Hauser and Holst 2009; Holst 2010; Holst and Smultea 2008). The RVIB *Nathaniel B. Palmer* will have an operating speed of typically 8.3 kilometers per hour (4.5 knots) (generally from 7.4 to 11.8 kilometers per hour [4 to 6 knots]) during seismic data acquisition. When not towing seismic survey gear, the RVIB *Nathaniel B. Palmer* typically transits at 26.8 kilometers per hour (14.5 knots). The operating speed during icebreaking is typically 5.5 to 9.6 kilometers per hour (3 to 5 knots) through ice that is one meter (3.3 feet) thick. In addition, 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 marine mammals in the action area is discountable. Therefore, we conclude that vessel strike is not likely to adversely affect ESA-listed species and will not be analyzed further in this consultation.

### 6.2.3 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 (Amaral and Carlson 2005; Au and Green 2000; Bain et al. 2006; Bauer 1986; Bejder et al. 1999; Bejder and Lusseau. 2008; Bejder et al. 2009; Bryant et al. 1984; Corkeron 1995; Erbe 2002c; Félix 2001; Goodwin and Cotton 2004; Lemon et al. 2006; Lusseau 2003; Lusseau 2006; Magalhaes et al. 2002; Nowacek et al. 2001; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005a; Watkins 1986b; Williams et al. 2002; Wursig et al. 1998). However, several authors suggest that the noise generated during motion is probably an important factor (Blane and Jaakson 1994b; Evans et al. 1992; 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 *Nathaniel B. Palmer* is likely small in the overall regional sound field of the action area. The R/V *Nathaniel B. Palmer*'s passage past ESA-listed marine mammals will be brief, at a distance of at least 100 meters (328.1 feet), and not likely to be significant in impacting any individual's ability to feed, reproduce, or avoid predators. Brief interruptions in communication via masking are possible, but unlikely given the habits of marine mammals to move away from vessels, either as a result of engine noise, the physical presence of the vessel, or both (Lusseau 2006; Mitson and Knudsen 2003). In addition, the R/V *Nathaniel B. Palmer* will travel at slow speeds, reducing the amount of noise produced by the propulsion system (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). The distance between the research vessel and observed marine mammals, per vessel avoidance measures, 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 marine mammals is insignificant. Therefore, we conclude that vessel noise is not likely to adversely affect ESA-listed species and will not be analyzed further in this consultation.

### 6.2.4 Single-Beam Echosounders, Split-Beam Echosounders, Multi-Beam Echosounders, and Acoustic Doppler Current Profilers

We do not expect masking of blue, fin, sei, and sperm whales communication to appreciably occur due to the single-beam echosounder, split-beam echosounder, multi-beam echosounder 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 single-beam echosounder, split-beam echosounder, multi-beam echosounder and acoustic Doppler current profiler are likely to be similar to the other pulsed sources discussed earlier if received at the same levels. Boebel et al. (2006) and Lurton and DeRuiter (2011) concluded that multi-beam echosounders, sub-bottom profilers, and

acoustic Doppler current profilers similar to those to be used during the proposed seismic survey activities presented a low risk for auditory damage or any other injury. Also, we do not expect hearing impairment such as TTS and other physical effects if the animal is in the area, as it will have to pass the transducers at close range and match the research vessel's speed and direction in order to be subjected to sound levels that can cause these effects. We find the probability of adverse impacts to ESA-listed marine mammals from this stressor to be discountable. We are unable to quantify the level of exposure from 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 single-beam echosounder, split-beam echosounder, multi-beam echosounder, and acoustic Doppler current profiler. As discussed earlier, the sound levels produced by the airgun array and icebreaking 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. Therefore, we conclude that single-beam echosounder, split-beam echosounder, multi-beam echosounder and acoustic Doppler current profilers is not likely to adversely affect ESA-listed species and will not be analyzed further in this consultation.

#### **6.2.5 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 could come in direct contact with an ESA-listed marine mammal, 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 seismic equipment. Based upon extensive deployments of this type of 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 marine mammals from this stressor to be discountable. Therefore, we conclude that gear entanglement is not likely to adversely affect ESA-listed species and will not be analyzed further in this consultation.

### **7 SPECIES LIKELY TO BE ADVERSELY AFFECTED**

This section identifies the ESA-listed species that occur within the action area (Figure 1 and Figure 2) that may be affected by the proposed action (Table 7). All of the species potentially occurring within the action area are ESA-listed in Table 7, along with their regulatory status, designated critical habitat, and recovery plan references. As shown in Table 7, the only ESA-listed species that are likely to be adversely affected by the proposed action are ESA-listed

marine mammals. The determinations for the effects of stressors that are not likely to adversely affect ESA-listed marine mammals during the proposed low-energy seismic survey are discussed in Section 5. Other stressors are discussed in more detail in Section 10.3.

**Table 7. Threatened and endangered species that may be affected by the National Science Foundation’s proposed action of a low-energy marine seismic survey in the Amundsen Sea off Antarctica.**

Species	ESA Status	Critical Habitat	Recovery Plan
<b>Marine Mammals – Cetaceans</b>			
Blue Whale ( <i>Balaenoptera musculus</i> )	<a href="#">E – 35 FR 18319</a>	-- --	<a href="#">07/1998</a> <a href="#">10/2018 - Draft</a>
Fin Whale ( <i>Balaenoptera physalus</i> )	<a href="#">E – 35 FR 18319</a>	-- --	<a href="#">07/2010</a> <a href="#">75 FR 47538</a>
Sei Whale ( <i>Balaenoptera borealis</i> )	<a href="#">E – 35 FR 18319</a>	-- --	<a href="#">12/2011</a> <a href="#">76 FR 43985</a>
Sperm Whale ( <i>Physeter macrocephalus</i> )	E – <a href="#">35 FR 18319</a>	-- --	<a href="#">12/2010</a> <a href="#">75 FR 81584</a>

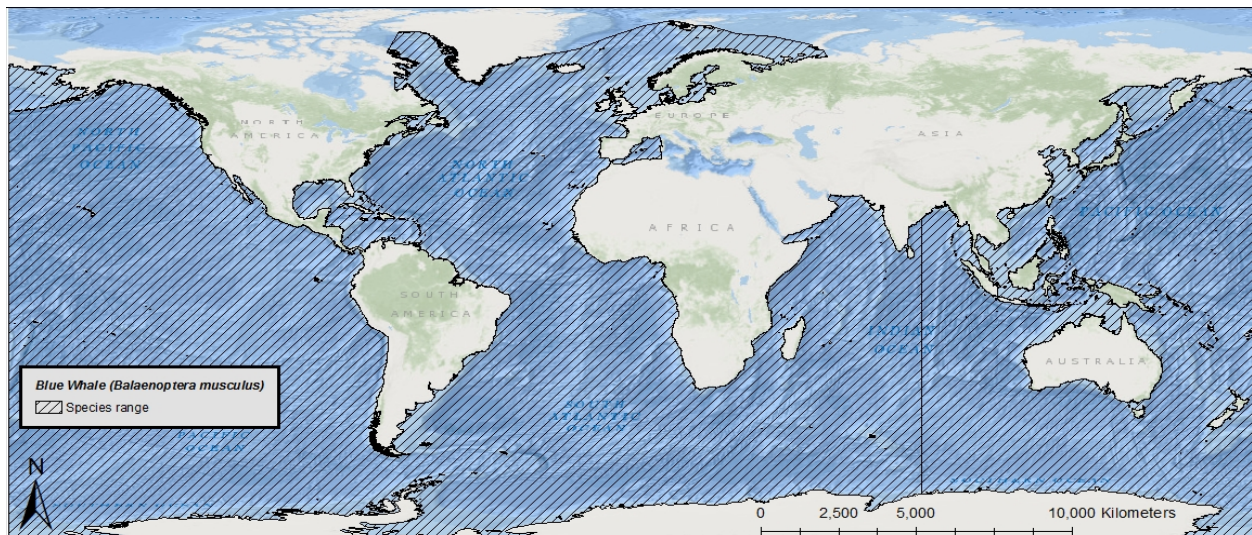
E=Endangered

## 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 proposed or designated 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 marine mammals, and aquatic habitat 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 3).



**Figure 3. 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 are 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. 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. 2018; Hayes et al. 2018; Muto et al. 2018), 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 U.S. waters: the Eastern North Pacific Ocean ( $N = 1,647$ ;  $N_{\min}=1,551$ ), Central North Pacific Ocean ( $N=133$ ;  $N_{\min}=63$ ), 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 2007b)]. While no range-wide 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 the Eastern North Pacific stock shows no signs of population growth since the early 1990s, perhaps because the population is nearly at carry capacity (Carretta et al. 2018). 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 2007b).

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 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Stock populations 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, blue whale 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 off 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. breviceauda*) seem to be segregated. The subspecies *B. m. intermedia* occurs in relatively high latitudes south of the “Antarctic Convergence” (located between 48 degrees South and 61 degrees South latitude) and close to the ice edge. The subspecies *B. m. breviceauda* is typically distributed north of the Antarctic Convergence.

### 8.1.3 Vocalizations and Hearing

Blue whale vocalizations tend to be long (greater than 20 seconds), low frequency (less than 100 Hertz) signals (Thomson and Richardson 1995), with a range of 12 to 400 Hertz and dominant energy in the infrasonic range of 12 to 25 Hertz (Ketten 1998; McDonald et al. 2001; McDonald et al. 1995a; 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 sweeping 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  $\mu$ Pa at 1 meter (Aburto et al. 1997; Berchok et al. 2006; Clark and Gagnon 2004; Cummings and Thompson 1971; Ketten 1998; McDonald et al. 2001; 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 than 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 whales (less than 30 meters [98.4 feet]), while deeper diving whales (greater than 50 meters [164 feet]) were likely feeding and calling less.

Although general characteristics of blue whale calls are shared in distinct regions (McDonald et al. 2001; Mellinger and Clark 2003; Rankin et al. 2005; Thompson et al. 1996), 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 (Berchok et al. 2006; Mellinger and

Clark 2003; 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 song dominates blue whale calling (Hildebrand et al. 2011; Hildebrand et al. 2012; Oleson et al. 2007c).

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 (Mellinger and Clark 2003; Payne and McVay 1971). 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, Indian, Pacific, and Southern Oceans. Many possible explanations for the shifts exist but none has 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) (Edds-Walton 1997; Oleson et al. 2007b; Payne and Webb 1971; Thompson et al. 1992). 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 (Edds-Walton 1997; Payne and Webb 1971). 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 (Ketten 1997b; Richardson et al. 1995b). Based on vocalizations and anatomy, blue whales are assumed to predominantly hear low-frequency sounds below 400 Hertz (Croll et al. 2001; Oleson et al. 2007c; Stafford and Moore 2005). 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 harvested from the late 19<sup>th</sup> to mid-20<sup>th</sup> 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 threatened by vessel 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.

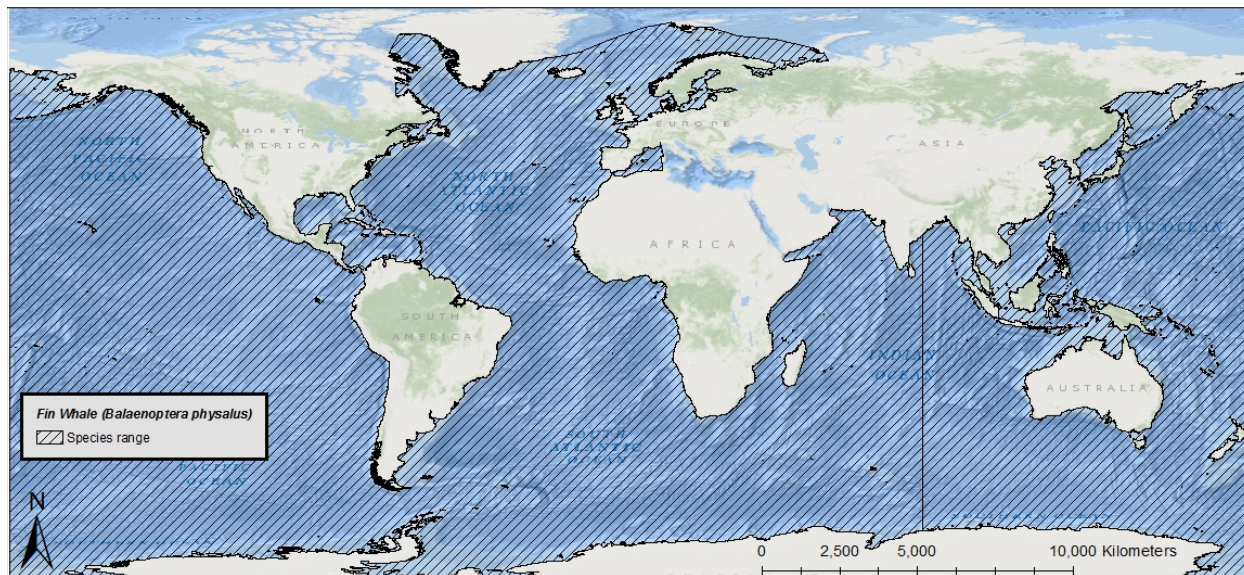
#### **8.1.6 Recovery Goals**

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 of this consultation. See the 1998 Final Recovery Plan for the blue whale for complete down listing/delisting criteria for each of the following recovery 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. patachonica* (a pygmy form) in the Southern Hemisphere (Figure 4).



**Figure 4. 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. 2018; Hayes et al. 2018; Muto et al. 2018) 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 through 1975. Of the three to seven stocks thought to occur in the North Atlantic Ocean (approximately 50,000 individuals), one occurs in U.S. waters, where NMFS' best estimate of abundance is 1,618 individuals ( $N_{\min}=1,234$ ); however, this may be an underrepresentation as the entire range of the stock was not surveyed (Palka 2012b). There are three stocks in U.S. Pacific Ocean waters: Northeast Pacific ( $N=3,168$ ;  $N_{\min}=2,554$ ), Hawaii (approximately 154 individuals,  $N_{\min}=75$ ) and California/Oregon/Washington (approximately 9,029 individuals,  $N_{\min}=8,127$ ) (Nadeem et al. 2016a). The International Whaling Commission (IWC) also recognizes the China Sea stock of fin whales, found in the Northwest Pacific Ocean, which currently lacks an abundance estimate (Reilly et al. 2013b). 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 U.S. 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. 2016a). 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 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 ocean 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 Vocalizations and Hearing

Fin whales produce a variety of low frequency sounds in the 10 to 200 Hertz range (Edds 1988; Thompson et al. 1992; Watkins 1981; Watkins et al. 1987). 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 (Clark et al. 2002; Patterson and Hamilton 1964). The most typically recorded call is a 20 Hertz pulse lasting about one second, and reaching source levels of  $189 \pm 4$  dB re: 1  $\mu$ Pa at 1 meter (Charif et al. 2002; Clark et al. 2002; Edds 1988; Garcia et al. 2018; Richardson et al. 1995b; Sirovic et al. 2007; Watkins 1981; Watkins et al. 1987). 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. (1995a) 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  $189 \pm 5.8$  dB re: 1  $\mu$ Pa 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 and upsweep vocalizations of 34 to 150 Hertz, and songs of 17 to 25 Hertz (Cummings and Thompson 1994; Edds 1988; Garcia et al. 2018; Watkins 1981). In general, source levels for fin whale vocalizations are 140 to 200 dB re: 1  $\mu$ Pa at 1 meter (see also Clark and Gagnon 2004; as compiled by Erbe 2002b). 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 (Thompson et al. 1992; Watkins et al. 1987).

Although their function is still in doubt, low frequency fin whale vocalizations travel over long distances and may aid in long distance communication (Edds-Walton 1997; Payne and Webb 1971). 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 (Ketten 1997b; Richardson et al. 1995b). 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 1997b). 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 commercial whaling program, and Iceland’s formal objection to the International Whaling Commission’s ban on commercial whaling. Additional threats include vessel strikes, reduced prey availability due to overfishing or climate change, and sound. 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**

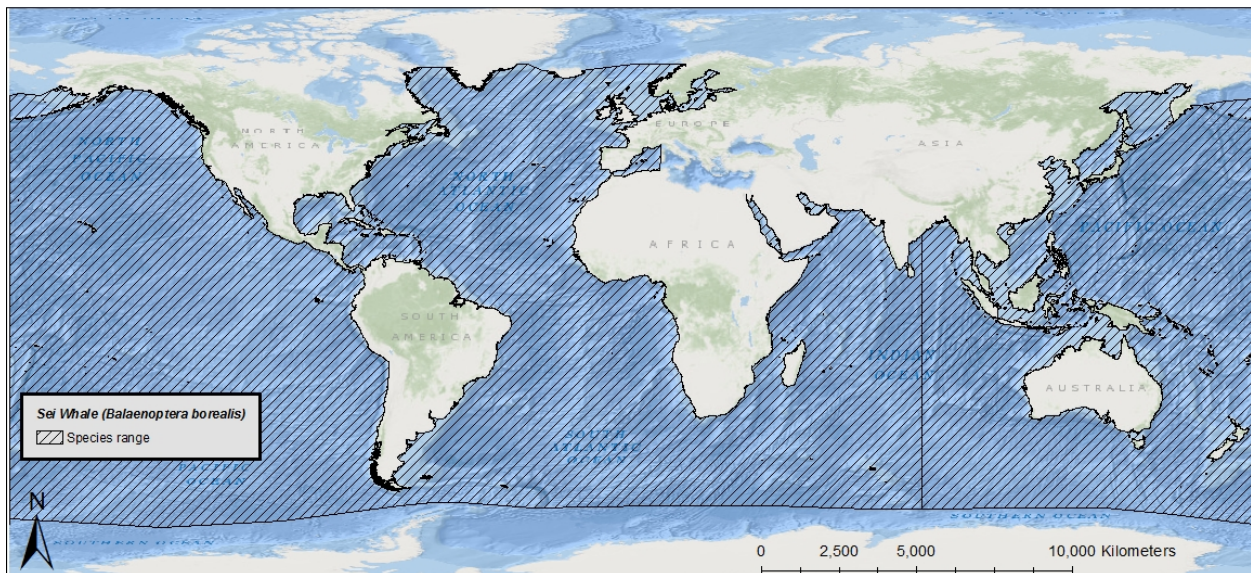
In response to the current threats facing the species, NMFS developed goals to recover fin whale populations. These threats will be discussed in further detail in the *Environmental Baseline* section of this consultation. See the 2010 Final Recovery Plan for the fin whale for complete downlisting/delisting 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 5).



**Figure 5. 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. 2018; Hayes et al. 2018; Muto et al. 2018), 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 sub-species 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 2016b; 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 ( $N=391$ ,  $N_{\min}=204$ ), 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; Huijser et al. 2018; Kanda et al. 2011; Kanda et al. 2006; Kanda et al. 2015; Kanda et al. 2013).

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

### **8.3.3 Vocalizations 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 1995). (Tremblay et al. 2019) recorded 50 to 30-Hertz triplet and singlet downsweeps and 82 to 34-Hertz downsweeps from sei whales in the western North Atlantic, suggesting that sei whales may produce songs. Source levels of  $189 \pm 5.8$  dB re: 1  $\mu$ Pa at 1 meter have been established for sei whales in the northeastern Pacific Ocean (Weirathmueller et al. 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 (Ketten 1997b; Richardson et al. 1995b). 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 1997b). 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 vessel 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.

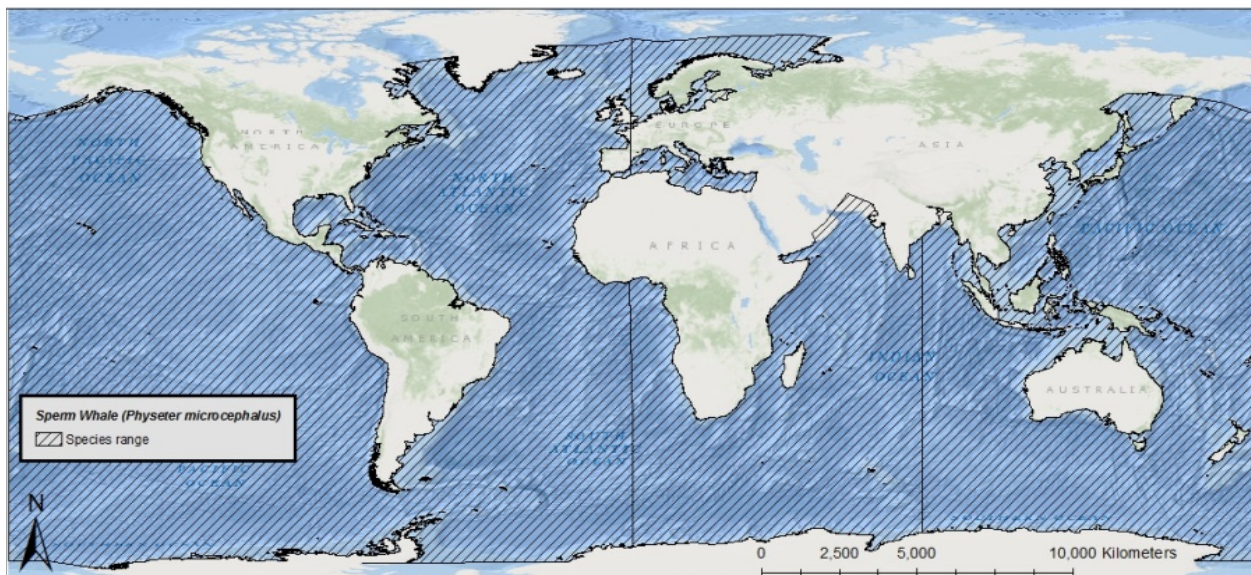
### 8.3.6 Recovery Goals

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 of this consultation. 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 Sperm Whale

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



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

The sperm whale is the largest toothed whale and distinguishable from other whales by its extremely large head, which takes up 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. 2018; Hayes et al. 2018; Muto et al. 2018), and status review (NMFS 2015) were used to summarize the life history, population dynamics and status of the species as follows.

#### **8.4.1 Life History**

The average lifespan of sperm whales is estimated to be at least 50 years (Whitehead 2009a). They have a gestation period of one to one and a half years, and calves nurse for approximately two years, though they may begin to forage for themselves within the first year of life (Tønnesen et al. 2018). Sexual maturity is reached between seven and 13 years of age for females with an average calving interval of four to six years. Male sperm whales reach full sexual maturity in their 20s. 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).

#### **8.4.2 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 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 2009a). The higher estimates may be approaching population sizes prior to commercial whaling, the reason for ESA listing. There are no reliable estimates for sperm whale abundance across the entire Atlantic Ocean. However, estimates are available for two of three U.S. stocks in the Atlantic Ocean, the Northern Gulf of Mexico stock, estimated to consist 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 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 of 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 4,559 individuals ( $N_{\min}=3,478$ ). 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.

Ocean-wide genetic studies indicate sperm whales have low genetic diversity, suggesting a recent bottleneck, but strong differentiation between matrilineally related groups (Lyrholm and Gyllenstein 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 degrees, only adult males venture into the higher latitudes near the poles.

### **8.4.3 Vocalizations 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 1999b). Sperm whales typically produce short duration repetitive broadband clicks with frequencies below 100 Hertz to greater than 30 kiloHertz (Watkins 1977b) 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. 2007b). The source levels of clicks can reach 236 dB re: 1  $\mu$ Pa at 1 meter, although lower source level energy has been suggested at around 171 dB re: 1  $\mu$ Pa at 1 meter (Goold and Jones 1995b; Mohl et al. 2003; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997a). Most of the energy in sperm whale clicks is concentrated at around 2 to 4 kiloHertz and 10 to 16 kiloHertz (Goold and Jones 1995b; Weilgart and Whitehead 1993). 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  $\mu$ Pa 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 (Goold and Jones 1995b; Miller et al. 2004; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997a; Whitehead and Weilgart 1991). 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 (Laplanche et al. 2005; Miller et al. 2004). 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 (Rendell and Whitehead 2004; Weilgart and Whitehead 1997a). 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 (Pavan et al. 2000; Weilgart and Whitehead 1997a). 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 1997a). 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 AEP tests 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 et al. 1985b; Watkins and Schevill 1975c). In the Caribbean Sea, Watkins et al. (1985b) 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. 1985b). 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 (André et al. 1997). Aaron et al. (2007) observed that the acoustic signal from the cavitation of a fishing vessel's propeller (110 dB re:  $1 \mu\text{Pa}^2\text{-second}$  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 1995b). 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).

#### **8.4.4 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. Continued threats to sperm whale populations include vessel strikes, entanglement in fishing gear, competition for resources due to overfishing, population, loss of prey and habitat due to climate change, and sound. The species' large population size shows that it is somewhat resilient to current threats.

#### **8.4.5 Critical Habitat**

No critical habitat has been designated for the sperm whale.

#### **8.4.6 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 of this consultation. 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” refers to the condition of the ESA-listed species or its designated critical habitat in the action area, without the consequences of the ESA-listed species or designated critical habitat caused by the proposed action. 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. The consequences to ESA-listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 C.F.R. §402.02; 84 FR 44976 published August 27, 2019). In this section, we discuss the environmental baseline within the action area as it applies to species that are likely to be adversely affected by the proposed action.

A number of human activities have contributed to the status of populations of ESA-listed marine mammals 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 interactions (vessel strike and whale watching), fisheries (fisheries interactions), pollution (marine debris, pesticides and contaminants, and hydrocarbons), aquatic nuisance species, anthropogenic sound (vessel sound and commercial shipping, aircraft, seismic surveys, and marine construction), and scientific research activities.

## 9.1 Climate Change

There is a large and growing body of literature on past, present, and future impacts of global climate change, exacerbated and accelerated by human activities. Effects of climate change include sea level rise, increased frequency and magnitude of severe weather events, changes in air and water temperatures, and changes in precipitation patterns, all of which are likely to impact ESA resources. NOAA's climate information portal provides basic background information on these and other measured or anticipated climate change effects (see <https://climate.gov>).

In order to evaluate the implications of different climate outcomes and associated impacts throughout the 21<sup>st</sup> century, many factors have to be considered. The amount of future greenhouse gas emissions is a key variable. Developments in technology, changes in energy generation and land use, global and regional economic circumstances, and population growth must also be considered.

A set of four scenarios was developed by the Intergovernmental Panel on Climate Change (IPCC) to ensure that starting conditions, historical data, and projections are employed consistently across the various branches of climate science. The scenarios are referred to as representative concentration pathways (RCPs), which capture a range of potential greenhouse gas emissions pathways and associated atmospheric concentration levels through 2100 (IPCC 2014). The RCP scenarios drive climate model projections for temperature, precipitation, sea level, and other variables: RCP2.6 is a stringent mitigation scenario; RCP2.5 and RCP6.0 are intermediate scenarios; and RCP8.5 is a scenario with no mitigation or reduction in the use of fossil fuels. The IPCC future global climate predictions (2014 and 2018) and national and regional climate predictions included in the Fourth National Climate Assessment for U.S. states and territories (2018) use the RCP scenarios.

The increase of global mean surface temperature change by 2100 is projected to be 0.3 to 1.7 degrees Celsius under RCP2.6, 1.1 to 2.6 degrees Celsius under RCP4.5, 1.4 to 3.1 degrees Celsius under RCP6.0, and 2.6 to 4.8 degrees Celsius under RCP8.5 with Arctic region warming more rapidly than the global mean under all scenarios (IPCC 2014). The Paris Agreement aims to limit the future rise in global average temperature to 2 degrees Celsius, but the observed acceleration in carbon emissions over the last 15 to 20 years, even with a lower trend in 2016, has been consistent with higher future scenarios such as RCP8.5 (Hayhoe et al. 2018) .

The globally-averaged combined land and ocean surface temperature data, as calculated by a linear trend, show a warming of approximately 1 degrees Celsius from 1901 through 2016 (Hayhoe et al. 2018). The *IPCC Special Report on the Impacts of Global Warming* (2018) (IPCC 2018) noted that human-induced warming reached temperatures between 0.8 and 1.2 degrees Celsius above pre-industrial levels in 2017, likely increasing between 0.1 and 0.3 degrees Celsius per decade. Warming greater than the global average has already been experienced in many regions and seasons, with most land regions experiencing greater warming than over the ocean (Allen et al. 2018).

Annual average temperatures have increased by 1.8 degrees Celsius across the contiguous U.S. since the beginning of the 20<sup>th</sup> century with Alaska warming faster than any other state and twice as fast as the global average since the mid-20<sup>th</sup> century (Jay et al. 2018). Global warming has led to more frequent heatwaves in most land regions and an increase in the frequency and duration of marine heatwaves (IPCC 2018). Average global warming up to 1.5 degrees Celsius as compared to pre-industrial levels is expected to lead to regional changes in extreme temperatures, and increases in the frequency and intensity of precipitation and drought (IPCC 2018).

Several of the most important threats contributing to the extinction risk of ESA-listed species, particularly those with calcium carbonate skeleton such as corals and mollusks as well as species for which these animals serve as prey or habitat, are related to global climate change. The main concerns regarding impacts of global climate change on coral reefs and other calcium carbonate habitats generally, and on ESA-listed corals and mollusks in particular, are the magnitude and the rapid pace of change in greenhouse gas concentrations (e.g., carbon dioxide and methane) and atmospheric warming since the Industrial Revolution in the mid-19<sup>th</sup> century. These changes are increasing the warming of the global climate system and altering the carbonate chemistry of the ocean (ocean acidification (IPCC 2014)). As carbon dioxide concentrations increase in the atmosphere, more carbon dioxide is absorbed by the oceans, causing lower pH and reduced availability of calcium carbonate. Because of the increase in carbon dioxide and other greenhouse gases in the atmosphere since the Industrial Revolution, ocean acidification has already occurred throughout the world's oceans, including in the Caribbean Sea, and is predicted to increase considerably between now and 2100 (IPCC 2014). These impacts are particularly concerning for those animals that serve as prey for ESA-listed species.

Ocean acidification negatively affects organisms such as crustaceans, crabs, mollusks, and other calcium carbonate-dependent organisms such as pteropods (free-swimming pelagic sea snails and sea slugs), the latter being important part of the food web in North Pacific Ocean waters. Some studies in the nutrient-rich regions have found that food supply may play a role in determining the resistance of some organisms to ocean acidification (Markon et al. 2018; Ramajo et al. 2016). Reduction in prey items can create a collapse of the zooplankton populations and thereby result in potential cascading reduction of prey at various levels of the food web, thereby reducing the availability of the larger prey items of marine mammals.

The Atlantic Ocean appears to be warming faster than all other ocean basins except perhaps the southern oceans (Cheng et al. 2017). In the western North Atlantic Ocean surface temperatures have been unusually warm in recent years (Blunden and Arndt 2016). A study by (Polyakov et al. 2009) suggest that the North Atlantic Ocean overall has been experiencing in general warming trend over the last 80 years of  $0.031 \pm 0.0006$  degrees Celsius per decade in the upper 2,000 meters (6,561.7 feet) of the ocean. Additional consequences of climate change include increased ocean stratification, decreased sea-ice extent, altered patterns of ocean circulation, and decreased ocean oxygen levels (Doney et al. 2012). Since the early 1980s, the annual minimum sea ice extent (observed in September each year) in the Arctic Ocean has decreased at a rate of

11 to 16 percent per decade (Jay et al. 2018). Further, ocean acidity has increased by 26 percent since the beginning of the industrial era (IPCC 2014) and this rise has been linked to climate change. Climate change is also expected to increase the frequency of extreme weather and climate events including, but not limited to, cyclones, tropical storms, heat waves, and droughts (IPCC 2014).

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 (Evans and Bjørge 2013; IPCC 2014; Kintisch 2006; Learmonth et al. 2006b; Macleod et al. 2005; McMahon and Hays 2006; Robinson et al. 2005). 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. For example, in sea turtles, sex is determined by the ambient sand temperature (during the middle third of incubation) with female offspring produced at higher temperatures and males at lower temperatures within a thermal tolerance range of 25 to 35 degrees Celsius (Ackerman 1997). Increases in global temperature could skew future sex ratios toward higher numbers of females (NMFS and USFWS 2007aa; NMFS and USFWS 2007bb; NMFS and USFWS 2013aa; NMFS and USFWS 2013bb; NMFS and USFWS 2015). These impacts will be exacerbated by sea level rise. This loss of habitat because of climate change could be accelerated due to a combination of other environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Antonelis et al. 2006; Baker et al. 2006).

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, forage fish), ultimately affecting primary foraging areas of ESA-listed species including marine mammals, sea turtles, and fish. 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, leatherback turtles were predicted to gain core habitat area, whereas loggerhead turtles and blue whales were predicted to experience losses in available core habitat. McMahon and Hays (2006) predicted increased ocean temperatures will expand the distribution of leatherback turtles into more northern latitudes. 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). Willis-Norton et al.

(2015) acknowledged there will be both habitat loss and gain, but overall climate change could result in a 15 percent loss of core pelagic habitat for leatherback turtles in the eastern South Pacific Ocean.

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 (Clapham et al. 1999; Payne et al. 1986; Payne et al. 1990). 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 Elliott 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 caused by the Southern oscillation in the Pacific Ocean, which leads to El Niño and La Niña events, the Pacific decadal oscillation, and the North Atlantic oscillation. These climatic events can alter habitat conditions and prey distribution for ESA-listed species in the action areas (Beamish 1993; Hare and Mantua 2001; Mantua et al. 1997); (Beamish 1993; Benson and Trites 2002; Hare and Mantua 2001; Mantua et al. 1997; Mundy and Cooney 2005; Stabeno et al. 2004). 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 North Atlantic oscillation is a large-scale, dynamic phenomenon that exemplifies the relationship between the atmosphere and the ocean. The North Atlantic oscillation has global significance as it affects sea surface temperatures, wind conditions, and ocean circulation of the North Atlantic Ocean (Stenseth et al. 2002). The North Atlantic oscillation is an alteration in the intensity of the atmospheric pressure difference between the semi-permanent high-pressure center over the Azores Islands and the sub-polar low-pressure center over Iceland (Stenseth et al. 2002). Sea-level atmospheric pressure in the two regions tends to vary in a “see-saw” pattern – when the pressure increases in Iceland it decreases in the Azores and vice-versa (i.e., the two systems tend to intensify or weaken in synchrony). The North Atlantic oscillation is the



dominant mode of decadal-scale variability in weather and climate in the North Atlantic Ocean region (Hurrell 1995).

Since ocean circulation is wind and density driven, it is not surprising to find that the North Atlantic oscillation appears to have a direct effect on the position and strength of important North Atlantic Ocean currents. The North Atlantic oscillation influences the latitude of the Gulf Stream Current and accounts for a great deal of the interannual variability in the location of the current; in years after a positive North Atlantic oscillation index, the north wall of the Gulf Stream (south of New England) is located farther north (Taylor et al. 1998). Not only is the location of the Gulf Stream Current and its end-member, the North Atlantic Current, affected by the North Atlantic oscillation, but the strength of these currents is also affected. During negative North Atlantic oscillation years, the Gulf Stream System (i.e., Loop, Gulf Stream, and North Atlantic Currents) not only shifted southward but weakened, as witnessed during the predominantly negative North Atlantic oscillation phase of the 1960s; during the subsequent 25-year period of predominantly positive North Atlantic oscillation, the currents intensified to a record peak in transport rate, reflecting an increase of 25 to 33 percent (Curry and McCartney 2001). The location and strength of the Gulf Stream System are important, as this major current system is an essential part of the North Atlantic climate system, moderating temperatures and weather from the U.S. to Great Britain and even the Mediterranean Sea region. Pershing et al. (2001) also found that the upper slope-water system off the east coast of the U.S. was affected by the North Atlantic oscillation and was driven by variability in temperature and transport of the Labrador Current. During low North Atlantic oscillation periods, especially that seen in the winter of 1996, the Labrador Current intensified, which led to the advance of cold slope water along the continental shelf as far south as the mid-Atlantic Bight in 1998 (Greene and Pershing 2003; Pershing et al. 2001). Variability in the Labrador Current intensity is linked to the effects of winter temperatures in Greenland and its surroundings (e.g., Davis Strait, Denmark Strait), on sea-ice formation, and the relative balance between the formation of deep and intermediate water masses and surface currents.

A strong association has been established between the variability of the North Atlantic oscillation and changes affecting various trophic groups in North Atlantic marine ecosystems on both the eastern and western sides of the basin (Drinkwater et al. 2003; Fromentin and Planque 1996). For example, the temporal and spatial patterns of *Calanus* copepods (zooplankton) were the first to be linked to the phases of the North Atlantic oscillation (Fromentin and Planque 1996; Stenseth et al. 2002). When the North Atlantic oscillation index was positive, the abundance of *Calanus* copepods in the Gulf of Maine increased, with the inverse true in years when the North Atlantic oscillation index was negative (Conversi et al. 2001; Greene et al. 2003a). This pattern is opposite off the European coast (Fromentin and Planque 1996). Such a shift in copepod patterns has a tremendous significance to upper-trophic-level species, including the North Atlantic right whale, which feeds principally on *Calanus finmarchicus*. North Atlantic right whale calving rates are linked to the abundance of *Calanus finmarchicus*; when the abundance is high, the calving rate remains stable but fell in the late 1990s when the abundance of its favored

copepod also declined (Greene et al. 2003b). When the North Atlantic oscillation index is low with subsequently warmer water temperatures off Labrador and the Scotian Shelf, recruitment of cod is higher; direct links to the North Atlantic oscillation phase have also been found for recruitment in the North Atlantic of herring, two tuna species, Atlantic salmon (*Salmo salar*), and swordfish (*Xiphias gladius*) (Drinkwater et al. 2003).

The Pacific decadal oscillation is the leading mode of variability in the North Pacific Ocean and operates over longer periods than either El Niño or La Niña/Southern Oscillation events and is capable of altering sea surface temperature, surface winds, and sea level pressure (Mantua and Hare 2002; Stabeno et al. 2004). During positive Pacific decadal oscillations, the northeastern Pacific experiences above average sea surface temperatures while the central and western Pacific Ocean undergoes below-normal sea surface temperatures (Royer 2005). Warm Pacific decadal oscillation regimes, as occurs in El Niño events, tends to decrease productivity along the U.S. west coast, as upwelling typically diminishes (Childers et al. 2005; Hare et al. 1999). Recent sampling of oceanographic conditions just south of Seward, Alaska has revealed anomalously cold conditions in the Gulf of Alaska from 2006 through 2009, suggesting a shift to a colder Pacific decadal oscillation phase. More research needs to be done to determine if the region is indeed shifting to a colder Pacific decadal oscillation phase in addition to what effects these phase shifts have on the dynamics of prey populations important to ESA-listed cetaceans throughout the Pacific action area. A shift to a colder decadal oscillation phase would be expected to impact prey populations, although the magnitude of this effect is uncertain.

The Indian Ocean Dipole, which is also known as the Indian Niño, is an irregular oscillation of sea surface temperature in which the western Indian Ocean becomes alternately warmer and then colder than the eastern part of the ocean (Saji et al. 1999). The Indian Ocean dipole, only identified recently in 1999, is one aspect of the general cycle of global climate, interacting with similar phenomena like the El Niño Southern Oscillation in the Pacific Ocean. As in the Pacific decadal oscillation and North Atlantic oscillation, the Indian Ocean dipole fluctuates between phases of positive, negative, and neutral conditions. During a positive Indian Ocean dipole, the western Indian Ocean experiences higher than normal sea surface temperature and greater precipitation while cooler sea surface temperature occur in the eastern Indian Ocean, often leading to droughts on land in the region (Saji et al. 1999). The negative phase of the Indian Ocean dipole brings about the opposite conditions, with warmer sea surface temperatures and greater precipitation in the eastern Indian Ocean and cooler and drier conditions in the western Indian Ocean. The Indian Ocean dipole also affects the strength of monsoons over the Indian subcontinent. An average of four positive and negative Indian Ocean dipole events occurs during each 30-year period, with each Indian Ocean dipole event lasting about six months. However, since 1980 there have been 12 positive Indian Ocean dipoles with no negative Indian Ocean dipole events from 1992 until late in 2010, when a strong negative event began (Nakamura et al. 2009). This strong negative Indian Ocean dipole event coupled with a strong La Niña event in the western Pacific Ocean to cause catastrophic flooding in parts of Australia. In 1998, an El Niño even interacted with a positive Indian Ocean dipole event with devastating effect on

Western Indian Ocean corals: 75 to 99 percent of live corals were lost in the western Indian Ocean during this event (Graham et al. 2006).

In addition to period variation in weather and climate patterns that affect oceanographic conditions in the action area, longer term trends in climate change and/or variability also 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 (Kintisch 2006; Learmonth et al. 2006a; Macleod et al. 2005; McMahon and Hays 2006; Robinson et al. 2005). Climate change can influence reproductive success by altering prey availability, as evidenced by the low success of Northern elephant seals (*Mirounga angustirostris*) during El Niño periods (McMahon and Burton 2005) as well as data suggesting that sperm whale females have lower rates of conception following periods of unusually warm sea 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

Large whale population numbers in the action area have historically been impacted by aboriginal hunting and 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). From 1864 to 1985, at least 2.4 million baleen whales (excluding minke 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>. The Japanese whaling fleet left the International Whaling Commission in December 2018 and plans to resume commercial whaling in July 2019.

Norway and Iceland take whales commercially at present, either under objection to the moratorium decision or under reservation to it. These countries establish their own catch limits but must provide information on those catches and associated scientific data to the International Whaling Commission. The Russian Federation has also registered an objection to the moratorium decision but does not exercise it. The moratorium is binding on all other members of the International Whaling Commission. Norway takes minke whales in the North Atlantic Ocean within its Exclusive Economic Zone, and Iceland takes minke whales and fin whales in the North Atlantic Ocean, within its Exclusive Economic Zone (IWC 2012).

Under current International Whaling Commission regulations, aboriginal subsistence whaling is permitted for Denmark (Greenland, fin and minke whales, *Balaenoptera* spp.), the Russian Federation (Siberia, gray, and bowhead [*Balaena mysticetus*] whales), St. Vincent and the Grenadines (Bequia, humpback whales [*Megaptera novaeangliae*]) and the U.S. (Alaska, bowhead and gray whales [*Eschrichtius robustus*]). It is the responsibility of national governments to provide the International Whaling Commission with evidence of the cultural and subsistence needs of their people. The Scientific Committee provides scientific advice on safe catch limits for such stocks (IWC 2012). Based on the information on need and scientific advice, the International Whaling Commission then sets catch limits, recently in five-year blocks.

Scientific permit whaling has been conducted by Japan and Iceland. In Iceland, the stated overall objective of the research program was to increase understanding of the biology and feeding ecology of important cetacean species in Icelandic waters for improved management of living and marine resources based on an ecosystem approach. While Iceland state that its program was intended to strengthen the basis for conservation and sustainable use of cetaceans, it noted that it was equally intended to form a contribution to multi-species management of living resources in Icelandic waters. Although these whaling activities operate outside of the action area, the whales killed in these whaling expeditions are part of the populations of whales (e.g., fin, sei, and sperm) occurring within the action area for this consultation.

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 large cetacean 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 whaling and subsistence activities can be seen below in Table 8 (IWC 2017a; IWC 2017b; IWC 2017c).

**Table 8. Endangered Species Act-listed marine mammal 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	-- --

Many of the whaling numbers reported represent minimum catches, as illegal or underreported catches are not included. For example, recently uncovered Union of Soviet Socialist 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 in the Southern Ocean 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 threatened or 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 Southern 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 the humpback whale 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 Interactions**

Within the action area, vessel interactions pose a threat to ESA-listed marine mammals. Vessel interactions can come in the form of vessel strike and whale watching.

### **9.4.1 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 (Boren et al. 2001; Constantine 2001; Mann et al. 2000; Nowacek 2001; Samuels et al. 2000). 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 affected the species (Hoyt 2001).

Vessel strikes are considered a serious and widespread threat to ESA-listed marine mammals (especially large whales) and are the most well-documented “marine road” interaction with large whales (Pirota 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 region, blue whales are especially susceptible where shipping lanes overlap with common feeding areas, as they do in the Santa Barbara Channel (Redfern 2013). As vessels to 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 mortalities associated with vessel strikes, especially for less buoyant species such as blue, humpback, and fin whales (Rockwood et al. 2017). Rockwood et al. (2017) modeled vessel strike mortalities of blue, humpback, and fin whales off California using carcass recovery rates of five and 17 percent and conservatively estimated that vessel strike mortality may be as high as 7.8, 2.0, and 2.7 times the recommended limit for blue, humpback, and fin whale stocks in this area, respectively.

Of 11 species of cetaceans known to be threatened by vessel strikes in the northern hemisphere, fin whales are the mostly commonly struck species, but North Atlantic right, gray, humpback, and sperm whales are also struck (Laist et al. 2001; Vanderlaan and Taggart 2007). In some areas, one-third of all fin whale and North Atlantic right whale strandings appear to involve vessel strikes (Laist et al. 2001). Vessel traffic within the action area can come from both private (e.g., commercial, recreational) and federal vessel (e.g., military, research), but traffic that is most likely to result in vessel strikes comes from commercial shipping.

#### **9.4.2 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 marine mammals 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 marine mammals (Au and Green 2000; Corkeron 1995; Erbe 2002c; Felix 2001; Magalhaes et al. 2002; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005b; Watkins 1986a; Williams et al. 2002). 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, through 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 marine mammals in general from vessel approaches associated with whale watching. The seismic survey trackline that approaches closest to what is generally the Antarctic coastline will be at least 6 kilometers (3.2 nautical miles) from the northern edge of the Thwaites Eastern Ice Shelf (a floating extension of Thwaites Glacier). Given the proposed seismic survey activities will occur in a remote area away from a populated continent and not occur within approximately 25 kilometers (13.5 nautical miles) of land (Clark Island is the nearest ice-free land), few (if any) whale watching vessels will be expected to co-occur with the proposed action's research vessel.

Ecotourism vessels may traverse the action area. The annual number of tourists visiting Antarctica continues to increase to tens of thousands annually, with most tourists visiting the West

Antarctic Peninsula region. Tour operators follow whale watching guidelines similar to those used in the United States.

## **9.5 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 marine mammals 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 marine mammals.

Fisheries can 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. Marine mammals 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, whether natural or human-caused, may affect the survival and recovery of several populations.

### **9.5.1 Fisheries Interactions**

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 marine mammals 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 2014b).

Marine mammals 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. 2010b). 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 marine mammals may face threats from derelict fishing gear.



In addition to these direct impacts, cetaceans may also be subject to indirect impacts from fisheries. Marine mammals 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). Thus, competition with humans for prey is a potential concern. Reductions in fish populations, whether natural or human-caused, may affect the survival and recovery of ESA-listed marine mammal populations. Even species that do not directly compete with human fisheries could be indirectly affected by fishing activities through changes in ecosystem dynamics. However, in general the effects of fisheries on whales through changes in prey abundance remain unknown in the action area.

## **9.6 Pollution**

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

### **9.6.1 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. Marine mammals 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 morality for ESA-listed species in the action area. Entanglement can also result in drowning for air breathing marine species including marine mammals. 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 Southern 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 2014a; 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 2014b).

Given the limited knowledge about the impacts of marine debris on marine mammals, it is difficult to determine the extent of the threats that marine debris poses to marine mammals. However, marine debris is consistently present and has been found in marine mammals in and near the action area. 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. 2010a). 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. (2010a) 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. Marine mammals can mistakenly consume these wastes containing elevated levels of toxins instead of their prey. It is expected that marine mammals 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.

### **9.6.2 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 (Garrett 2004; Grant and Ross 2002; Hartwell 2004; Iwata 1993). 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 (Garrett 2004; Grant and Ross 2002; 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 marine mammal 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 (Grant and Ross 2002; Mearns 2001).

Numerous factors can affect concentrations of persistent pollutants in marine mammals, such as age, sex and birth order, diet, and habitat use (Mongillo et al. 2012). In marine mammals, 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 marine mammals in the action area through the duration of the project, the level of risk and degree of impact is unknown.

### 9.6.3 Hydrocarbons

There has never been a large-scale oil spill in the action area, but numerous small-scale vessel spills likely occur. A nationwide study examining vessel oil spills from 2002 through 2006 found that over 1.8 million gallons of oil were spilled from vessels in all U.S. waters (Dalton and Jin 2010). In this study, “vessel” included numerous types of vessels, including barges, tankers, tugboats, and recreational and commercial vessels, demonstrating that the threat of an oil spill can come from a variety of vessel types. Below we review the effects of oil spills on marine mammals more generally. Much of what is known comes from studies of large oil spills such as the *Deepwater Horizon* oil spill since no information exists on the effects of small-scale oil spills within the action area.

Exposure to hydrocarbons released into the environment via oil spills and other discharges pose risks to marine species. Marine mammals 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 marine mammals to petroleum products causes changes in behavior and may directly injure animals (Geraci 1990).

Perhaps the most famous oil spill in U.S. history occurred in the Gulf of Alaska when, in 1989 the *Exxon Valdez* released at least 11 million gallons of Alaska crude oil into one of the largest and most productive estuaries in North America. The Alaska Department of Environmental Conservation estimated that 149 kilometers (92.6 miles) of shoreline was heavily oiled and 459 kilometers (285.2 miles) were at least lightly oiled. Oil spills, both small and large, occur widely

along U.S. shores at refining and transfer facilities and extraction sites. The *Exxon Valdez* oil spill was the worst in U.S. history until the 2010 *Deepwater Horizon* event.

The *Deepwater Horizon* oil spill in the Gulf of Mexico in 2010 led to the exposure of tens of thousands of marine mammals to oil, causing reproductive failure, adrenal disease, lung disease, and poor body condition. Sea turtles were also impacted, being mired and killed by oil at the water's surface. Exposure also occurred via ingestion, inhalation, and maternal transfer of oil compounds to embryos; these effects are more difficult to assess, but likely resulted in sub-lethal effects and injury (Deepwater Horizon Trustees 2016).

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.

As noted above, to our knowledge the past and present impacts of oil spills on ESA-listed species (blue, fin, sei whale, and sperm whale) within the action area are limited to those associated with small-scale vessel spills. Nevertheless, we consider the documented effects of oil spills outside the action area, such as the *Deepwater Horizon* oil spill, examples of the possible impacts that oil spill can have on ESA-listed species.

## 9.7 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 (Pughiuc 2010; Raaymakers 2003; Raaymakers and Hilliard 2002; Terdalkar et al. 2005). 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 marine mammals in the action area through the duration of the project. Therefore, the level of risk and degree of impact to ESA-listed marine mammals is unknown.

## **9.8 Anthropogenic Sound**

The ESA-listed 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 (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 species have the potential to be impacted by either increased levels of anthropogenic-induced background sound or high intensity, short-term anthropogenic sounds.

The addition of anthropogenic sound to the marine environment is a known stressor that can possibly harm marine animals or significantly interfere with their normal activities (NRC 2005). Within the action area, ESA-listed marine mammals may be impacted by anthropogenic sound in various ways. For example, 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 marine mammals to sounds produced by boats and vessels, as well as other sound sources such as helicopters and fixed-wing aircraft, and dredging and construction (reviewed in Gomez et al. 2016; and Nowacek et al. 2007). 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 marine mammals, 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 (McDonald et al. 2006a; Parks 2003; Parks 2009a). 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 marine mammals, information is not currently available to determine the potential population level effects of anthropogenic sound levels in the marine environment (MMC 2007). 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 marine mammals at the population or species scale remain uncertain, although recent efforts have made progress establishing frameworks to consider such effects (NAS 2017).

### **9.8.1 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 (Hildebrand 2009b; McKenna et al. 2012; NRC 2003b). 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. 2012a). The broadband sounds from large vessels may interfere with important biological functions of odontocetes, including foraging (Blair et al. 2016; Holt 2008). 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.

Individuals 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:  $\mu\text{Pa}^2\text{-s}$  at 1 meter for fast-moving (greater than 37 kilometers per hour [20 knots]) supertankers to 140 dB re:  $\mu\text{Pa}^2\text{-s}$  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:  $1 \mu\text{Pa}$  at 1 meter) source levels (Erbe 2002c; 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). 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). Although little information is available on potential effects of multiple commercial and recreational sonars to cetaceans, the distribution of these sounds would 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).

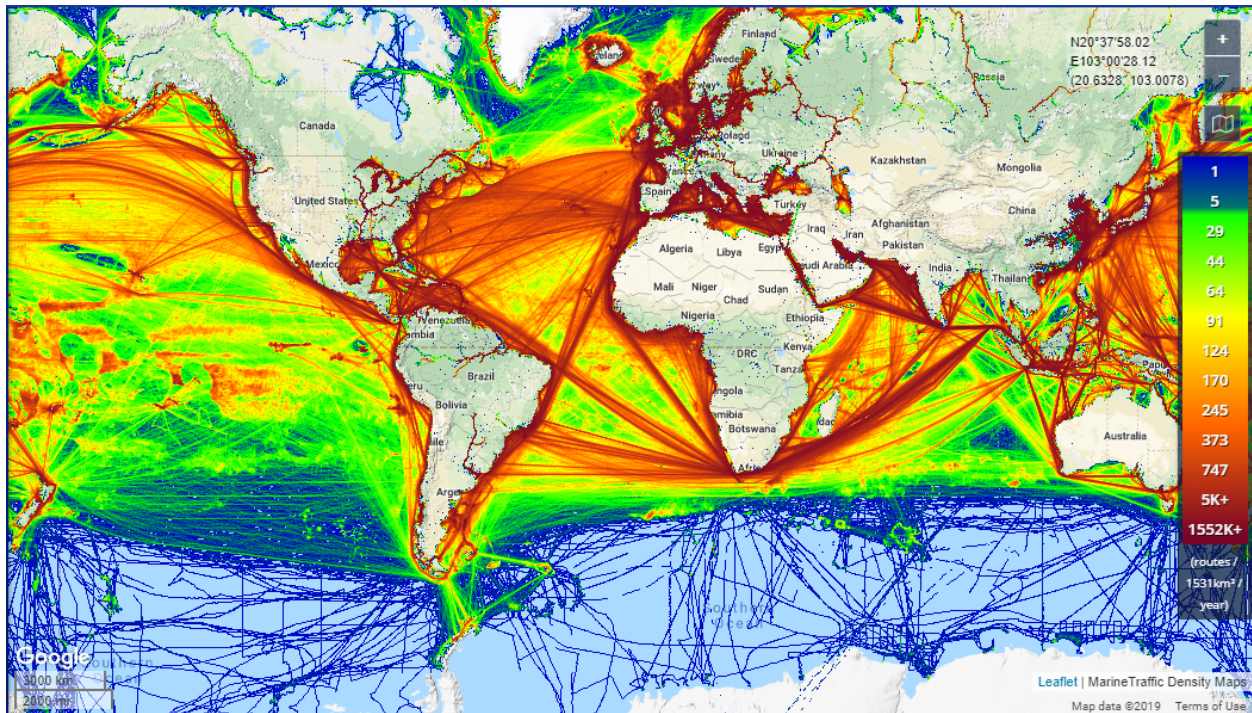


Image retrieved from Marine Traffic (2019).

**Figure 7. Map of global vessel traffic density in 2017.**

### 9.8.2 Aircraft

Aircraft within the action area may consist of small commercial or recreational airplanes or helicopters, to large commercial airliners. These aircraft produce a variety of sounds that can potentially enter the water and impact marine mammals. 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 dB 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 airplanes 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 far from a populated area and has sparse aircraft traffic.

### 9.8.3 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 marine mammals 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., seismic surveys involving the use of airguns with the potential to take marine mammals are generally 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 seismic survey 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 for research purposes have occurred in Antarctic waters since 1976. From 1976 through 2011, 15 countries have performed 128 multi-channel seismic surveys with tracklines totaling 363,801 kilometers (196,436.8 nautical miles) of data acquisition. The National Science Foundation funded and conducted low-energy seismic surveys on the RVIB *Nathaniel B. Palmer* in the Dumont d'Urville Sea and Scotia Sea in 2014 and Ross Sea in 2015. There are three known high-energy seismic surveys and one low-energy seismic survey for research purposes scheduled to occur in the North Pacific Ocean (off Oregon, Washington, Canada, and Alaska) and Gulf of Mexico (off Cuba) in 2020. These are funded by the National Science Foundation. Each of these seismic surveys include a MMPA incidental take authorization and are each subject to a separate ESA section 7 consultation. This action is the subject of a separate ESA section 7 consultation. The finalized consultation resulted in a "no jeopardy" opinion.

### 9.8.4 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 marine mammals (NRC 2003a). While most of these activities are



coastal, offshore construction does occur. All or some of these activities may occur within the action area and can affect ESA-listed marine mammals.

## **9.9 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 Southern Ocean, some of which extend into portions of the action area for the proposed action. Marine mammals 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 marine mammals in the action area from a variety of research activities.

Authorized research on ESA-listed marine mammals 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 marine mammals.

There have been numerous research permits issued since 2009 under the provisions of both the MMPA and ESA authorizing scientific research on marine mammals all over the world, including for 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.

Additional “take” is likely to be authorized in the future as additional permits are issued. It is noteworthy that although the numbers tabulated below represent the maximum number of “takes” authorized in a given year, monitoring and reporting indicate that the actual number of “takes” rarely approach the number authorized. Therefore, it is unlikely that the level of exposure indicated below has or will occur in the near term. However, our analysis assumes that these “takes” will occur since they have been authorized. It is also noteworthy that these “takes” are distributed across the Southern Ocean. Although marine mammals are generally wide-ranging, we do not expect many of the authorized “takes” to involve individuals that will also be “taken” under the proposed low-energy seismic survey, icebreaking, and research activities.

## **9.10 Impact of the Baseline on Endangered Species Act-Listed Species**

Collectively, the baseline described above has had, and likely continue to have, lasting impacts on the ESA-listed species 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 impact of 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, it 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 is discussed in the *Integration and Synthesis* (Section 11).

## 10 EFFECTS OF THE ACTION

Section 7 regulations define “effects of the action” as all consequences to ESA-listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (50 C.F.R. §402.02). Section 7 regulations (50 C.F.R. §402.17) elaborate on this definition as follows:

- *Activities that are reasonably certain to occur* – A conclusion of reasonably certain to occur must be based on clear and substantial information, using the best scientific and commercial data available. Factors to consider when evaluating whether activities caused by the proposed action (but no part of the proposed action) or activities reviewed under cumulative effects are reasonably certain to occur include, but are not limited to: (1) past experiences with activities that have resulted from actions that are similar in scope, nature, and magnitude to the proposed action; (2) existing plans for the activity; and (3) any remaining economic, administrative, and legal requirements necessary for the activity to go forward.

- *Consequences caused by the proposed action* – To be considered an effect of a proposed action, a consequence must be caused by the proposed action (i.e., the consequence would not occur but for the proposed action and is reasonably certain to occur). A conclusion of reasonably certain to occur must be based on clear and substantial information, using the best scientific and commercial data available. Considerations for determining that a consequence to the species or critical habitat is not caused by the proposed action include, but are not limited to: (1) the consequence is so remote in time from the action under consultation that it is not reasonably certain to occur; or (2) the consequence is so geographically remote from the immediate area involved in the action that it is not reasonably certain to occur; or (3) the consequence is only reached through a lengthy causal chain that involves so many steps as to make the consequence not reasonably certain to occur.

This effects analyses 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 (give 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 will 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 actions are:

1. Pollution by oil or fuel leakage;
2. Vessel strike;
3. Vessel noise;
4. Entanglement in towed hydrophone streamer;

5. Sound fields produced by the single-beam echosounder, split-beam echosounder, multi-beam echosounder; and acoustic Doppler current profiler;
6. Sound fields produced by the airgun array; and
7. Sound fields produced by icebreaking.

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 and habitats affected by these activities. These species and habitats were discussed in Sections 6, 6.2.5, and 8. Stressors (i.e., sound fields produced by the airgun array and icebreaking) that are likely to adversely affect ESA-listed species are discussed in the *Exposure and Response Analysis* sections.

During consultation we determined that sound fields produced by the airgun array and icebreaking may adversely affect ESA-listed species by introducing acoustic energy introduced into the marine environment. This stressor and the likely effects on ESA-listed species are discussed starting in Section 10.3.2.

## **10.2 Mitigation to Minimize or Avoid Exposure**

As described in the *Description of the Proposed Action* (Section 3), the National Science Foundation'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, shut-down 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 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 probable exposure. The *Response Analysis* also considers information on the potential stranding and the potential effects on the prey of ESA-listed marine mammals 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 ( $3.9 \times 10^{13}$  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). Another stressor of concern is the acoustic impacts from icebreaking, which will be discussed further below.

In this section, we quantify the likely exposure of ESA-listed species to sound from the airgun array and icebreaking. For this consultation, the National Science Foundation and NMFS Permits and Conservation Division estimated exposure to the sounds from the airgun array and icebreaking that will result in take, as defined under the MMPA, for all marine mammal 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 incidental take authorization 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 marine mammal 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 marine mammals, 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 harassments to estimate the number ESA-listed marine mammals 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 icebreaking and may involve a wide range of behavioral responses for ESA-listed marine mammals 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 species.

Our exposure analysis relies on two basic components: (1) information on species distribution (i.e., density or occurrence within the action area), and (2) information on the level of exposure to sound (i.e., acoustic thresholds) at which species are likely to be affected (i.e., exhibit some response). Using this information, and information on the proposed low-energy seismic survey (e.g., active acoustic sound source specifications, area or volume of water that will be ensonified at certain sound levels, trackline locations, days 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 and icebreaking 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 Marine Mammals**

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

During the proposed action, ESA-listed marine mammals may be exposed to sound from the airgun array and icebreaking. The National Science Foundation and NMFS Permits and Conservation Division provided estimates of the expected number of ESA-listed marine mammals exposed to received levels greater than or equal to 160 dB re: 1  $\mu$ Pa (rms) or 120 dB re: 1  $\mu$ Pa (rms) for the airgun array and icebreaking sound sources, respectively. Our exposure estimates stem from the best available information on marine mammal densities and a predicted radial distance (GI=Generator Injector, m=meters, dB=decibels

Table 12 and Table 13) based on isopleths corresponding to harm and harassment thresholds along tracklines for the low-energy seismic survey and/or icebreaking conditions. Based upon information presented in the *Response Analysis*, ESA-listed marine mammals exposed to these sound sources could be harmed, exhibit changes in behavior, suffer stress, or even strand. No ESA instances of harm (i.e., MMPA Level A harassment) are expected or authorized under the proposed action due to the small isopleths predicted and the implementation of mitigation measures.

#### **10.3.1.2 Exposure to Airgun Arrays**

The National Science Foundation applied acoustic thresholds to determine at what point during exposure to the airgun arrays marine mammals 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 provided an estimate of the number of marine mammals that will be exposed to levels of sound in which they should be considered “taken” under the MMPA during the proposed low-energy seismic survey. We used the same values to determine the type and extent of take for ESA-listed marine mammals. An estimate of the number of marine mammals that will be exposed to sounds from the airgun array is also included in the National Science Foundation’s biological assessment. The National Science Foundation and NMFS Permits and Conservation Division did not provide any exposure or take estimates from sound sources other than the airgun array (except icebreaking, which is discussed further below), although other equipment producing sound will be used during airgun

array operations (e.g., the single-beam echosounder, split-beam echosounder, multi-beam echosounder, and acoustic Doppler current profiler).

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 marine mammals 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 and icebreaking. Therefore, the NMFS Permits and Conservation Division did not expect additional exposure from sound sources other than the airgun array and icebreaking. We agree with this assessment and similarly focus our analysis on exposure from the airgun array and icebreaking. The single-beam echosounder, split-beam echosounder, multi-beam echosounder, and acoustic Doppler current profiler are 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 that was informed by comments received during the public comment period that was required on the proposed incidental harassment authorization. The exposure analysis does not include estimates of the number of ESA-listed marine mammals likely to be exposed to received levels at MMPA Level A harassment thresholds due to the small ensonified areas and the anticipated effectiveness of monitoring and mitigation measures (i.e., proposed exclusion and buffer zones, shut-down procedures, ramp-up procedures, visual monitoring by NMFS-approved protected species observers, and vessel strike avoidance measures).

In this section, we describe the National Science Foundation and NMFS Permits and Conservation Division's analytical methods to estimate the number of ESA-listed marine mammal 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 marine mammals are expected to exhibit a response that may be considered take under the ESA such as harassment, then utilize these thresholds to calculate ensonified areas, and finally, either multiply these areas by data on marine mammal density or use the sound field in the water column as a surrogate to estimate the number of marine mammals exposed to sounds generated by the airgun array and icebreaking.



For our ESA section 7 consultation, we evaluated both the National Science Foundation and the NMFS Permit and Conservation Division's exposure estimates of the number of ESA-listed marine mammals that will be "taken" relative to the definition of MMPA Level B harassment, which we have adopted to evaluate harassment of ESA-listed marine mammals 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 marine mammals. Below we describe the exposure analysis for ESA-listed marine mammals.

### ***Acoustic Thresholds***

To determine at what point during exposure to airgun arrays (and other active acoustic sources such as icebreaking) marine mammals are considered "harassed" under the MMPA, NMFS applies certain acoustic thresholds. These thresholds are used in the development of radii for buffer and exclusion zones around a sound source and the necessary mitigation requirements necessary to limit marine mammal exposure to harmful levels of sound (NOAA 2018). The references, analysis, and methodology used in the development of these thresholds are described in *NOAA 2018 Revision to Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NOAA 2018), which is available online at <https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-acoustic-technical-guidance>. 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  $\mu$ Pa (rms) for impulsive sound sources and 120 dB re: 1  $\mu$ Pa (rms) for non-impulsive sound sources. These values are based on observations of behavioral responses of mysticetes, but is used for all marine mammals 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 marine mammals that are proposed in the incidental harassment authorization for the airgun array operations during the low-energy seismic survey and icebreaking.

For physiological responses to active acoustic sources, such as TTS and PTS, the NMFS Permits and Conservation Division relied on NMFS' recently issued technical guidance for auditory injury of marine mammals (NOAA 2018). Unlike NMFS' 160 dB re: 1  $\mu$ Pa (rms) threshold for MMPA Level B harassment (behavioral) (which does not include TTS or PTS), these TTS and PTS auditory thresholds differ by marine mammal species hearing group (Table 9 and Table 10). Furthermore, these acoustic thresholds are a dual metric 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 exposure criteria incorporate 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 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 new  $SEL_{cum}$  thresholds, NMFS developed an optional user spreadsheet that includes tools to help predict a simple isopleth that can be used in conjunction with marine mammal density or occurrence to facilitate the estimation of take numbers.

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 (see Table 9 and Table 10) 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  $\mu$ Pa (rms) or 120 dB re: 1  $\mu$ Pa (rms) acoustic threshold is classified as MMPA Level B harassment, which will also be considered harassment. Among 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.

**Table 9. Functional hearing groups, generalized hearing ranges, and acoustic thresholds identifying the onset of permanent threshold shift and temporary threshold shift for marine mammals 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 $LE_{LF,24h}$ : 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 $LE_{MF,24h}$ : 185 dB	224 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 was chosen based on approximately 65 dB threshold from normalized composite audiogram, with the exception for lower limits for low frequency cetaceans (Southall et al. 2007a) (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 ( $L_{pk}$ ) has a reference value of 1  $\mu$ Pa, and cumulative sound exposure level (LE) has a reference value of 1  $\mu$ Pa<sup>2</sup>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.

**Table 10. Functional hearing groups, generalized hearing ranges, and acoustic thresholds identifying the onset of permanent threshold shift and temporary threshold shift for marine mammals exposed to non-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	199 dB (SEL weighted)	179 dB (SEL weighted)
Mid-Frequency Cetaceans (Dolphins, Toothed Whales, Beaked Whales, Bottlenose Whales) (LE,MF,24 Hour)	150 Hertz to 160 kiloHertz	198 dB (SEL weighted)	178 dB (SEL weighted)

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 was chosen based on approximately 65 dB threshold from normalized composite audiogram, with the exception for lower limits for low frequency cetaceans (Southall et al. 2007a) (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 ( $L_{pk}$ ) has a reference value of  $1 \mu Pa$ , and cumulative sound exposure level (LE) has a reference value of  $1 \mu Pa^2s$ . 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 marine mammals associated with the sounds from the airgun array.

### ***Modeled Sound Fields of the Airgun Array***

In this section, we first evaluate the likelihood that marine mammals will be exposed to sound fields from the low-energy seismic survey at or above 160 dB re:  $1 \mu Pa$  (rms) based upon the information described above, and the acoustic thresholds correlating to the onset of PTS or TTS provided in Table 9. If we find that such exposure above any particular threshold is likely, we then estimate the number of instances in which we expect marine mammals to be exposed to these sound levels, based on the ensonified areas at or above these sound levels and information on marine mammal density.

The methodologies for estimating the number of ESA-listed species that might be exposed to the sound field used by the National Science Foundation and NMFS Permits and Conservation

Division were largely the same. Both estimated the number of marine mammals predicted to be exposed to sound levels that will result in harassment and harm (MMPA Level A and Level B harassment) by using radial distances to predicted isopleths. Both used those radial distances to calculate the ensonified area around the airgun array for the 160 dB re: 1  $\mu$ Pa (rms) zone, which corresponds to the harassment (MMPA Level B harassment) threshold for ESA-listed marine mammals. The area estimated to be ensonified in a single day of the seismic survey activities is then calculated, based on the areas predicted to be ensonified around the airgun array and the estimated trackline distance traveled by the RVIB *Nathaniel B. Palmer* per day. To account for possible delays during the seismic survey (e.g., weather, equipment malfunction) and additional seismic survey activities, a 25 percent contingency was added to the number of exposures using the quantitative method devised by the National Science Foundation and used by the NMFS Permits and Conservation Division. The product is multiplied by 1.25 to account for the additional 25 percent contingency. This calculation assumes 100 percent turnover of individuals within the ensonified area on a daily basis, that is, each individual exposed to the seismic survey activities is a unique individual.

Based on information provided by the National Science Foundation and Lamont-Doherty Earth Observatory, we have determined that marine mammals 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 Lamont-Doherty Earth Observatory, the National Science Foundation provided sound source levels of the airgun array (

Table 11) and estimated distances for the 160 dB re: 1  $\mu$ Pa (rms) sound levels as well as MMPA Level A harassment thresholds generated by the airgun array configurations and water depth. The predicted and modeled radial distances for the various MMPA Level A and B harassment thresholds for marine mammals for the RVIB *Nathaniel B. Palmer*'s airgun arrays can be found in GI=Generator Injector, m=meters, dB=decibels

Table 12 and Table 13. Because of the uncertainty of the sound source level needed to be used during airgun array operations due to potentially poor environmental conditions, predicted distances for the largest GI airgun array (two by 105/105 cubic inch) were used to calculate takes for the proposed action. Although this is a conservative approach, the differences among the predicted distances of the other proposed airgun array sound source levels are nominal.

**Table 11. Modeled sound source levels for the Research Vessel/Icebreaker *Nathaniel B. Palmer*'s two Generator Injector airgun array.**

Functional Hearing Group	2 GI Airgun Array (Peak SPL <sub>flat</sub> )	2 GI Airgun Array (SEL <sub>cum</sub> )	Predicted Distance to Threshold (Peak SPL <sub>flat</sub> ) (m)	Predicted Distance to Threshold (SEL <sub>cum</sub> ) (m)
Low Frequency Cetaceans (L <sub>pk</sub> flat: 219 dB; LE,LF,24h: 183 dB)	219 dB	209.6801 dB	7.55	31.1
Mid Frequency Cetaceans (L <sub>pk</sub> flat: 230 dB; LE,MF,24h: 185 dB)	230 dB	209.5954 dB	1.58	0.0

GI=Generator Injector, m=meters, dB=decibels

**Table 12. Predicted radial distances in meters from the Research Vessel/Icebreaker *Nathaniel B. Palmer* seismic sound sources to isopleth corresponding to greater than or equal to 160 dB re: 1  $\mu$ Pa (rms) threshold.**

Source	Volume (in <sup>3</sup> )	Maximum Tow Depth (m)	Water Depth (m)	Predicted Distance to Threshold (160 dB re: 1 $\mu$ Pa [rms]) (m) <sup>1</sup>
2 by 45/105 in <sup>3</sup> GI Airguns	300	3	100 to 1,000 >1,000	979 653
1 by 45/105 in <sup>3</sup> GI Airguns	150	3	100 to 1,000 >1,000	503 335
2 by 105/105 in <sup>3</sup> GI Airguns	420	3	100 to 1,000 >1,000	1,044 696
1 by 105/105 in <sup>3</sup> GI Airguns	210	3	100 to 1,000 >1,000	531 354

in<sup>3</sup>=cubic inches, m=meters, GI=Generator Injector, <sup>1</sup>Distances for depths 100 to 1,000 meters are deep water values with a 1.5 times correction factor. Distances for depths greater than 1,000 meters (3,281 feet) are based on Lamont-Doherty Earth Observatory's model results.

**Table 13. Modeled radial distances in meters from the Research Vessel/Icebreaker *Nathaniel B. Palmer*'s two Generator Injector airgun array corresponding to harm (Marine Mammal Protection Act Level A harassment) thresholds.**

Functional Hearing Group	SEL <sub>cum</sub> Threshold (dB)	2 GI Airgun Array Distance (m)	Peak SPL <sub>flat</sub> Threshold (dB)	2 GI Airgun Array Distance (m)	Exclusion Zone for all Water Depths (m)
Low Frequency Cetaceans (L <sub>pk</sub> flat: 219 dB; LE,LF,24 <sub>h</sub> : 183 dB)	183	31.1	219	7.55	31.1
Mid Frequency Cetaceans (L <sub>pk</sub> flat: 230 dB; LE,MF,24 <sub>h</sub> : 185 dB)	185	0	230	1.58	1.58

dB=Decibel, GI=Generator Injector

Note: The largest distances of the dual criteria (SEL<sub>cum</sub> or Peak SPL<sub>flat</sub>) 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 overestimated 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.

Because of the uncertainty of the sound source level needed to be used during operations due to potentially poor environmental conditions, predicted distances determined for the largest airgun array (two by 105/105 cubic inch GI airguns) were used to calculate takes for the proposed action. Although this is a conservative approach, the differences among the predicted distances of the other proposed airgun arrays are nominal.

#### ***Exposure Estimates (Marine Mammal Occurrence – 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 marine mammal 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.

In developing the National Science Foundation's biological assessment and incidental harassment authorization application, they utilized estimates of cetacean densities in the action area. NMFS Permits and Conservation Division concurred with these data and included additional information. Densities were estimated using sightings and effort during aerial- and

vessel-based surveys conducted in and adjacent to the action area. The three major sources of animal abundance included the U.S. Navy Marine Species Density Database (U.S. Navy 2012a), Ainley et al. (2007), and Gohl (2010). Data sources and density calculations are described in detail in Attachment B of the National Science Foundation's incidental harassment authorization application. For some marine mammal species, the densities derived from past surveys may not be representative of the densities that will be encountered during the proposed seismic survey activities and icebreaking. Density estimates for each marine mammal species are found in Table 14. The approach used here is based on the best available data.

The low-energy seismic survey will be contained in approximately 8,400 square kilometers (2,449 square nautical miles) in the Amundsen Sea along 1,600 kilometers (863.9 nautical miles). The ensonified area (for the 160 dB re: 1  $\mu$ Pa [rms] harassment threshold) is estimated to be approximately 3,738.23 square kilometers (1,089.9 square nautical miles), based on the maximum 1,600 kilometers (863.9 nautical mile) length of the low-energy seismic survey multiplied by the maximum area anticipated to be ensonified to the predicted 160 dB re: 1  $\mu$ Pa (rms) distance around the planned tracklines (1.044 kilometers [3,425 feet] times two in intermediate water and 0.696 kilometers [2,283 feet] times two in deep water. Water depths will range from 100 to 1,000 meters (328.1 to 3,280.8 feet) in 65 percent of the tracklines and depths greater than 1,000 meters (3,280 feet) in 35 percent of the tracklines.

To determine exposures, the National Science Foundation and NMFS Permits and Conservation Division calculated harm and harassment (MMPA Level B harassment) by using the radial distances from the airgun array to the predicted isopleths corresponding to the harassment (MMPA Level B harassment). The majority of the proposed low-energy seismic survey (approximately 65 percent) will be conducted in waters between 100 to 1,000 meters (328.1 to 3,281 feet) deep. The remaining portion (approximately 35 percent) of the proposed low-energy seismic survey will be conducted in waters greater than 1,000 meters (3,281 feet) deep. The methodology picked a trackline that will be conducted on a typical day of seismic survey activities, with proportions occurring in intermediate (100 to 1,000 meters [328.1 to 3,281 feet]) and deep (greater than 1,000 meters [3,281 feet]) water, which are representative of the entire proposed low-energy seismic survey. The area estimated to be ensonified in a single day (200 kilometers [108 nautical miles]) of the seismic survey is then calculated, based on the areas predicted to be ensonified around the airgun array and representative trackline distances traveled per day. The ensonified areas were then multiplied by the number of survey days. The product is then multiplied by 1.25 to account for the additional 25 percent contingency (e.g., eight days times 1.25 days equals ten days) as well as uncertainties in the density estimates used to estimate take. This results in an estimate of the total area (square kilometers) expected to be ensonified to the ESA harm and harassment thresholds. The total area ensonified at 160 dB re: 1  $\mu$ Pa (rms) is 3,738.23 square kilometers (1,089.9 square nautical miles), which was calculated by multiplying the harassment (MMPA Level B harassment) buffer zone widths for the airgun array configuration in intermediate and deep water depths by the trackline distance and adding "endcaps" to both ends of the trackline. The number of marine mammals that can be exposed to



the sounds from the airgun array on one or more occasions is estimated for the calculated marine area along with the expected density of animals in the area. Summing exposures along all of the tracklines yields the total exposures for each species for the proposed action for the two GI airgun array configuration for the seismic survey activities. The method also yields exposures for each seismic survey trackline on a daily basis. Based on the small anticipated isopleths for harm (MMPA Level A harassment) and in consideration of the proposed mitigation measures, take by harm (MMPA Level A harassment) is not expected to occur and has not been proposed to be authorized by the NMFS Permits and Conservation Division. The estimated exposure of ESA-listed marine mammals at the ESA harassment (MMPA Level B harassment threshold during the National Science Foundation's seismic survey on the RVIB *Nathaniel B. Palmer* in the Amundsen Sea off Antarctica can be found in Table 17. The approach assumes that no marine mammals will move away or toward the trackline in response to increasing sound levels before the levels reach the specific thresholds as the RVIB *Nathaniel B. Palmer* approaches. The extent to which marine mammals will move away from the sound source is difficult to quantify and is, therefore, not accounted for in the take estimates.

**Table 14. Densities of Endangered Species Act-listed marine mammals in the action area during National Science Foundation's low-energy seismic survey in the Amundsen Sea off Antarctica.**

Species	Density (Number per km <sup>2</sup> )	Mean Group Size
Blue Whale	0.0000510 <sup>1</sup>	2 to 3
Fin Whale	0.0072200 <sup>1</sup>	1 to 2
Sei Whale	0.0002550 <sup>1</sup>	6
Sperm Whale	0.0169934 <sup>2</sup>	10 (plus young)

km<sup>2</sup>=square kilometers, <sup>1</sup>=(U.S. Navy 2012a), <sup>2</sup>=Ainley et al. (2007)

*Total Ensonified Area***Table 15. Relevant isopleths, daily ensonified area, number of survey days, percent increase, and total ensonified areas during the National Science Foundation's low-energy seismic survey in the Amundsen Sea off Antarctica.**

Criteria	Distance Per Day (km)	Radius (km)	Area (km <sup>2</sup> )	Endcaps (km <sup>2</sup> )	Daily Ensonified Area (km <sup>2</sup> )	Total Survey Days	25 Percent Increase (Days)	Total Ensonified Area (km <sup>2</sup> )
<b>ESA Harassment</b>								
160 dB (100 to 1,000 m)	130	1.04	271.4	3.42	274.86	8	10	2,748.62
160 dB (>1,000 m)	70	0.7	97.4	1.52	98.96	8	10	989.61
<b>ESA Harm</b>								
LF Cetaceans – Blue Whale, Fin Whale, and Sei Whale	200	0.03	12.44	0	12.44	8	10	124.43
MF Cetaceans – Sperm Whale	200	0	0.63	0	0.63	8	10	6.32
All Depths	-- --	-- --	-- --	-- --	-- --	-- --	-- --	3,738.23

m=meters, km<sup>2</sup>=square kilometers, LF=low frequency, MF=mid-frequency

**Table 16. Total ensonified areas for ESA-listed marine mammals in the action area during National Science Foundation’s low-energy seismic survey in the Amundsen Sea off Antarctica.**

Species	160 dB re: 1 $\mu$ Pa (rms) Ensonified Area (km <sup>2</sup> )	Potential Harm Ensonified Area (km <sup>2</sup> )
Blue Whale	3,738.23	164.63
Fin Whale	3,738.23	164.63
Sei Whale	3,738.23	164.63
Sperm Whale	3,738.23	164.63

km<sup>2</sup>=square kilometers

**Table 17. Estimated exposure of Endangered Species Act-listed marine mammals calculated by the National Science Foundation and National Marine Fisheries Service Permits and Conservation Division to the airgun array during the low-energy seismic survey in the Amundsen Sea off Antarctica.**

Species	Potential Permanent Threshold Shift and Harm	Potential Temporary Threshold Shift and Behavioral Harassment	Total (Adjusted for Group Size)
Blue Whale	0	1	1
Fin Whale	0	27	27
Sei Whale	0	1	3
Sperm Whale	0	63	63

Blue, fin, sei, and sperm whales of all age classes are likely to be exposed during the proposed seismic survey activities and icebreaking. Given that the proposed low-energy seismic survey will be conducted in January through March, we expect that most animals will be on or migrating to/from their feeding grounds. 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 and icebreaking while they are transiting through the action area. We will normally assume that sex distribution is even for blue, fin, and sei whales and sexes are exposed at a relatively equal level. However, sperm whales in the action area likely consist of more males than females in the group. Therefore, we expect a male bias to sperm whale exposure. For sperm whales, exposure for adult male sperm whales is expected to be higher 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).

It should be noted that the proposed exposure numbers by harassment (MMPA Level B harassment) are expected to be conservative for several reasons. First, in the calculations of estimated exposure, 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, marine mammals 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 harm (MMPA Level A harassment). However, the extent to which marine mammals 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, austral summer densities were either not available or the same as for other seasons.

#### **10.3.1.3 Exposure to Icebreaking**

Icebreakers produce more noise while breaking ice than vessels of comparable size due, primarily, to the sound of propeller cavitation (Richardson et al. 1995a). Icebreakers commonly back and ram into heavy ice until losing momentum to make way. The highest noise levels usually occur while backing full astern in preparation to ram forward through the ice. Overall, the noise generated by an icebreaker pushing ice is 10 to 15 dB greater than the noise produced by the vessel underway in open water (Richardson et al. 1995a). In general, the Antarctic and Southern Ocean is a noisy environment. Calving and grounding icebergs as well as the break-up of ice sheets, can produce a large amount of underwater noise. Little information is available about the increase in sound levels due to icebreaking. Icebreaking is considered to be a continuous sound and the current threshold for harassment (MMPA Level B harassment) by continuous sound is a received sound level of 120 dB re: 1  $\mu$ Pa (rms) (SPL).

Non-icebreaking vessels, as well as natural sounds such as those from sea ice motion and marine mammal flukes hitting the water's surface, also present similar sound impacts. Underwater noise from various vessels, including tug boats, oceanographic research vessels, and fisheries research vessels in open water, as well as icebreakers traversing sea ice, often exceed 120 dB re: 1  $\mu$ Pa (rms).

Data characterizing the sound source level generated by icebreaking by the RVIB *Nathaniel B. Palmer* is not available. Therefore, data for icebreaking noise generated by the United States Coast Guard Cutter (USCGC) *Healy* was used for exposure estimates of ESA-listed marine mammals (Roth et al. 2013). The RVIB *Nathaniel B. Palmer* is a smaller vessel and has less icebreaking capability than the USCGC *Healy*. Therefore, the sound source levels from icebreaking generated by the RVIB *Nathaniel B. Palmer* are expected to be lower than the conservative sound source levels estimated and measured for the USCGC *Healy*. Using a propagation model of  $20 \log R$  (spherical spreading) with a sound source level of 196.2 dB re: 1

$\mu\text{Pa}$  at 1 meter (rms) for the harassment threshold for continuous sound, the National Science Foundation and NMFS Permits and Conservation Division calculated that sound levels will decay to 120 dB re: 1  $\mu\text{Pa}$  (rms) at a distance of 6,456.54 meters (21,182.9 feet) from the sound source for cetaceans.

The RVIB *Nathaniel B. Palmer* is designed for continuous passage at 5.5 to 9.26 kilometers per hour (3 to 5 knots) through ice 1 meter (3.3 feet) thick. During this cruise, the RVIB *Nathaniel B. Palmer* will typically encounter first- or second-year ice while avoiding thicker ice floes, particularly large intact multi-year ice, whenever possible. In addition, the research vessel/icebreaker will follow leads when possible while following the seismic survey tracklines. As the RVIB *Nathaniel B. Palmer* moves through the ice, the research vessel/icebreaker will cause the ice to part and travel alongside the hull. This ice typically returns to fill the wake as the research vessel/icebreaker passes. The effects are transitory, hours at most, and localized, constrained to a relatively narrow swath approximately 10 meters (32.8 feet) to each side of the research vessel/icebreaker.

The RVIB *Nathaniel B. Palmer*'s maximum beam is 18.2 meters (59.7 feet). Applying the maximum estimated amount of icebreaking (approximately 500 kilometers [269.9 nautical miles]), to the corridor opened by the research vessel/icebreaker, we anticipate that a maximum of 24.7 square kilometers (7.2 square nautical miles) of ice may be disturbed. This represents a very small amount of the total ice present in the Amundsen Sea off Antarctica. Typically, the general method for icebreaking is for the research vessel to push through the ice. It is not driven up on top of the ice until the weight of the vessel breaks the ice. The noise generated by icebreaking is expected to have a frequency range of 25 Hertz to 12.8 kiloHertz and 167 to 189 dB re: 1  $\mu\text{Pa}$  (rms) at 1 meter.

**Table 18. Modeled bins for icebreaking in 8/10 ice coverage on the United States Coast Guard Cutter *Healy*.**

Frequency (Hz)	Source Level (dB)
25	189
50	188
100	189
200	190
400	188
800	183
1,600	177
3,200	176
6,400	172
12,800	167

Hz=Hertz, dB=decibels

We only expect ESA-listed species to be exposed to sound levels that will result in harassment (MMPA Level B harassment) from icebreaking. We do not expect any ESA-listed species to be exposed to sound levels that would result in harm (MMPA Level A harassment) from icebreaking given that the sound source level of 196.2 dB re: 1  $\mu$ Pa (rms) is lower than the continuous threshold (198 and 199 dB) for mid-frequency and low-frequency cetaceans (NOAA 2018).

The number of marine mammals that may be present and potentially disturbed by icebreaking are based on available data of marine mammal sightings in the action area. Takes by harassment are calculated by multiplying the expected presence (i.e., density) of marine mammals within the action area by the ensonified area from icebreaking where the received sound levels will be greater than or equal to 120 dB re: 1  $\mu$ Pa (rms). The National Science Foundation anticipates that the linear distance of icebreaking activities will not exceed approximately 445 kilometers (240.3 nautical miles) (48 hours at 9.26 kilometers per hour). Assuming the maximum distance that will receive a sound level of greater than or equal to 120 dB re: 1  $\mu$ Pa (rms) will be 6.456 kilometers (3.5 nautical miles), the potential total ensonified area by icebreaking is approximately 7,509.49 square kilometers (2,189.4 square nautical miles) (two times 6.456 square kilometers times 445 kilometers). While the number of animals that may be encountered within the ice margin habitat will be expected to be less than open water habitat, the estimates in

Table 20 used the estimated density of animals for the open water habitat and represent conservative take estimates. It is important to note that these calculations assume the RVIB *Nathaniel B. Palmer* will be traveling in a straight line, which is unlikely, but was used to calculate the potential maximum amount of sea ice by icebreaking during the proposed action.

**Table 19. Estimated ensonified area from the Research Vessel/Icebreaker *Nathaniel B. Palmer* during icebreaking in the Amundsen Sea off Antarctica.**

Distance per Day (km)	Radius (km)	Area (Diameter) (km)	Endcap (km <sup>2</sup> )	Daily Ensonified Area	Number of Days	25 Percent Buffer (Days)	Total Estimated Ensonified Area (km <sup>2</sup> )
223	6.456	12.91	130.87	3,003.8	2	2.5	7,509.49

km=kilometers, km<sup>2</sup>=square kilometers

**Table 20. Estimated exposure of Endangered Species Act-listed marine mammals calculated by the National Science Foundation and National Marine Fisheries Service Permits and Conservation Division during icebreaking in the Amundsen Sea off Antarctica.**

Species	Estimated Ensonified Area (km <sup>2</sup> )	Estimated Density of Animals (Number per km <sup>2</sup> )	Potential Harassment (Adjusted for Group Size)
Blue Whale	7,509.49	0.0000510	1
Fin Whale	7,509.49	0.0072200	54
Sei Whale	7,509.49	0.0002550	2 (3)
Sperm Whale	7,509.49	0.0169934	128

km<sup>2</sup>=square kilometers

### *Exposures as a Percentage of Population*

**Blue Whale** – The estimated exposure of the regional population (approximately 5,000) of blue whales is a total of two (one harassment from the airgun array and one harassment from icebreaking), which is approximately 0.04 percent of the regional population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are not likely to be harmed or harassed given the mitigation measures that will be implemented. Because of the large range of this species compared to the relatively small size of the National Science Foundation’s action area, combined with the relatively short duration of the seismic survey activities and icebreaking, it is more likely that there will be multiple takes of a smaller number of individuals that will occur within the action area.

**Fin Whale** – The estimated exposure of the regional population (approximately 38,200) of fin whales is a total of 81 (27 harassment from the airgun array and 54 harassment from icebreaking), which is approximately 0.21 percent of the regional population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are not likely to be harmed or harassed given the mitigation measures that will be implemented. Because of the large range of this species compared to the relatively small size of the National Science Foundation and Lamont-Doherty Earth Observatory’s action area, combined with the relatively short duration of the seismic survey activities and icebreaking, it is more likely that there will be multiple takes of a smaller number of individuals that will occur within the action area.

**Sei Whale** – The expected exposure of the regional population (approximately 10,000) of sei whales is a total of six (three harassment from the airgun array and three harassment from icebreaking), which is approximately 0.06 percent of the regional population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are not likely to be harmed or harassed given the mitigation



measures that will be implemented. Because of the large range of this species compared to the relatively small size of the National Science Foundation's action area, combined with the relatively short duration of the seismic survey activities and icebreaking, it is more likely that there may be multiple takes of a smaller number of individuals that will occur within the action area.

**Sperm Whale** – The estimated exposure of the regional population (approximately 12,069) of sperm whales is a total of 191 (63 harassment from the airgun array and 128 harassment from icebreaking), which is approximately 1.58 percent of the regional population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are not likely to be harmed or harassed given the mitigation measures that will be implemented. Because of the large range of this species compared to the relatively small size of the National Science Foundation's action area, combined with the relatively short duration of the seismic survey activities and icebreaking, it is more likely that there may be multiple takes of a smaller number of individuals that will occur within the action area.

### 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 marine mammals 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 marine mammals 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 Marine Mammals to Acoustic Sources*

##### *Marine Mammals and Hearing Thresholds*

Exposure of marine mammals 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 result from exposure to a single pulse or from the accumulated effects of multiple pulses, in which case each pulse need not be as loud as a single pulse to have the same accumulated effect. Instances of 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 (Kastak 2005; Ketten 2012; Schlundt 2000)).

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, humpback, and sei 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 9) (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 dB re: 1  $\mu$ Pa (rms) in order to produce a low-level TTS from a single pulse (Southall et al. 2007c). PTS is expected at levels approximately 6 dB greater than TTS levels on a peak-pressure basis, or 15 dB greater on an SEL basis than TTS (Southall et al. 2007c). In terms of exposure to the RVIB *Nathaniel B. Palmer'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 dB re: 1  $\mu$ Pa (peak) (Caldwell and Dragoset 2000). If an individual experienced exposure to several airgun pulses of approximately 219 dB for low-frequency cetaceans, 230 dB for mid-frequency cetaceans, or 202 dB for high-frequency cetaceans, PTS could occur. Marine mammals (cetaceans) will have to be within certain modeled radial distances specified in GI=Generator Injector, m=meters, dB=decibels

Table 12 and Table 13 from the RVIB *Nathaniel B. Palmer's* single or two GI 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 the form of ESA harm (i.e., PTS) is not expected (see Section 14).

Ranges to some behavioral impacts can take place at distances exceeding 100 kilometers (54 nautical miles), although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. Behavioral reactions will be short-term, likely lasting the duration of the exposure, and long-term consequences for individuals or populations are unlikely.

Overall, we do not expect TTS to occur to any ESA-listed marine mammals as a result of exposure to the airgun array for several reasons. We expect that most individuals will move away from the airgun array as it approaches; however, a few individuals may be exposed to sound levels that may result in TTS, but we expect the probability to be low. As the seismic survey proceeds along each transect trackline and approaches ESA-listed individuals, the sound intensity increases, individuals will experience conditions (stress, loss of prey, discomfort, etc.) that 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 will move away and therefore unlikely to accumulate more injurious levels. Furthermore, mitigation measures will be in place to initiate a shut-down if individuals enter or are about to enter the 100 meter (328.1 feet) exclusion zone during full airgun array operations, which is beyond the distances believed to have the potential for PTS in any of the ESA-listed marine mammals as described above. As stated in the *Exposure Analysis*, each individual is expected to be potentially be exposed to 160 dB re: 1  $\mu$ Pa (rms) levels. We do not expect this to produce a cumulative TTS or other physical injury for several reasons. We expect that individuals will recover from TTS between each of these exposures, we expect monitoring to produce some degree of mitigation such that exposures will be reduced, and (as stated above), we expect individuals, to generally move away at least a short distance as received sound levels increase, reducing the likelihood of exposure that is biologically meaningful. In summary, we do not expect animals to be present for a sufficient duration to accumulate sound pressure levels that will lead to the onset of TTS.

### ***Marine Mammals 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).

The sound frequency of airgun array sounds and vocalizations of ESA-listed marine mammals, particularly baleen whales and to some extent sperm whales overlaps to an extent. The proposed

low-energy 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 (1 to 125 Hertz for the RVIB *Nathaniel B. Palmer*'s airgun array). Any masking that might occur will likely 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 RVIB *Nathaniel B. Palmer* are planned to occur over the course of approximately 60 days (i.e., approximately eight days of airgun array operations, approximately two days of icebreaking, approximately two days of contingency time, and approximately 16 days of transit).

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. Nieukirk et al. (2012) analyzed ten 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. The RVIB *Nathaniel B. Palmer*'s airgun array will emit an approximately 0.02 second pulse when fired approximately every five seconds. Therefore, pulses will not "cover up" the vocalizations of ESA-listed marine mammals to a significant extent (Madsen et al. 2002b). We address the response of ESA-listed marine mammals stopping vocalizations as a result of airgun sound in the *Marine Mammals 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 can apparently add significantly to acoustic background (Guerra et al. 2011), potentially interfering with the ability of animals to hear otherwise detectable sounds in their environment.

The sound localization abilities of marine mammals 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 (*Orcinus orca*),

empirical evidence confirms that masking depends strongly on the relative directions of arrival of sound signals and the masking sound (Bain and Dahlheim 1994; Bain et al. 1993; Bain 1993; Bain 1994; Dubrovskiy 2004). Toothed whales and probably other marine mammals 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 1975; Au et al. 1974; Au 1974; Lesage 1999; Moore 1990; Romanenko and Kitain 1992; Romanenko 1992; Thomas 1990). A few marine mammal species increase the source levels or alter the frequency of their calls in the presence of elevated sound levels (Au 1993; Dahlheim 1987; Foote 2004; Holt et al. 2009; Holt 2009; Lesage 1999; Lesage 1993; Parks 2009a; Parks 2009b; Parks et al. 2007b; Parks 2007; Terhune 1999).

These data demonstrating adaptations for reduced masking pertain mainly to the very high frequency echolocation signals of toothed whales. There is less information about the existence of corresponding mechanisms at moderate or low frequencies or in other types of marine mammals. For example, Zaitseva et al. (1980) found that, for the bottlenose dolphin, the angular separation between a sound source and a masking noise source had little effect on the degree of masking when the sound frequency was 18 kilohertz, in contrast to the pronounced effect at higher frequencies. Studies have noted direction hearing at frequencies as low as 0.5 to 2 kilohertz in several marine mammals, including killer whales (Richardson et al. 1995a). This ability may be useful in reducing masking at these frequencies.

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 marine mammals 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 toothed whales (e.g., 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, toothed whales are not expected to experience significant masking during the period of time the airgun arrays are producing sound for the proposed action.

### ***Marine Mammals and Behavioral Responses***

We expect the greatest response of marine mammals 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). Marine mammal 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 (Costa et al. 2016; Fleishman et al. 2016; Francis and Barber 2013; New et al. 2014; NRC 2005). Although some studies are available which address responses of ESA-listed marine mammals considered in this opinion directly, additional studies to other related whales (such as bowhead and gray whales) are relevant in determining the responses expected by species under consideration.

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). Habitat abandonment due to anthropogenic noise exposure has been found in terrestrial species (Francis and Barber 2013). Because of the similarities in hearing anatomy of terrestrial and marine mammals, we expect it possible for ESA-listed marine mammals to behave in a similar manner as terrestrial mammals when they detect a sound stimulus. For additional information on the behavioral responses marine mammals exhibit in response to anthropogenic noise, including non-ESA-listed marine mammal species, see the *Federal Register* notice of the proposed incidental harassment authorization (84 FR 69950) as well as one of several reviews (e.g., Gomez et al. 2016; Southall et al. 2007b).

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 (Greene Jr et al. 1999; Jochens et al. 2006; Madsen et al. 2002b; McDonald et al. 1993; McDonald et al. 1995b; Nieu Kirk et al. 2004; Richardson et al. 1986a; Smulter et al. 2004; Tyack et al. 2003). However, humpback whale males increasingly stopped vocal displays on Angolan breeding grounds as received seismic airgun levels increased (Cerchio 2014). Some blue, fin, and sperm whales stopped calling for short and long periods apparently in response to airguns (Bowles et al. 1994; Clark and Gagnon 2006; McDonald et al. 1995b). 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). The survey area affected was estimated to be about 100,000 square kilometers (29,155.3 square nautical miles) (Castellote et al. 2012b). 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 dB re: 1  $\mu$ Pa (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 dB re: 1  $\mu$ Pa (rms), but did not change at received levels of 99 to 108 dB re: 1  $\mu$ Pa (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 dB re: 1  $\mu$ Pa<sup>2</sup>-s over the course of ten minutes (Blackwell et al. 2015). Once sound levels exceeded approximately 127 dB re: 1  $\mu$ Pa<sup>2</sup>-s over ten minutes, call rates began to decline and at approximately 160 dB re: 1  $\mu$ Pa<sup>2</sup>-s over ten minutes, bowhead whales appeared ceased 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 2009a; Parks and Clark 2007; Parks et al. 2007a; Parks et al. 2007b; Parks et al. 2011a; Parks et al. 2011b; Parks et al. 2012; Parks et al. 2009; 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 dB re: 1  $\mu$ Pa (peak-to-peak) (Madsen et al. 2002a; McCall Howard 1999). For the species considered in this consultation, some exposed individual ESA-listed marine mammals may cease calling or otherwise alter their vocal behavior in response to the RVIB *Nathaniel B. Palmer's* airgun array during the seismic survey activities. The effect is expected to be temporary and brief given the research vessel is constantly moving when the airgun array is active. Animals may resume or modify calling at a later time or location away from the RVIB *Nathaniel B. Palmer's* airgun array during the course of the proposed low-energy 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 dB re: 1  $\mu$ Pa (rms) (the level used in this opinion to determine the extent of acoustic effects for marine mammals) 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 (Harris et al. 2007; Malme and Miles 1985; Malme et al. 1984a; Miller et al. 1999; Miller et al. 2005; Richardson et al. 1995b; Richardson et al. 1995a; Richardson et al. 1999). Migrating bowhead whales show strong avoidance reactions to received 120 to 130 dB re: 1  $\mu$ Pa (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 dB re: 1  $\mu$ Pa [rms]) (Harris et al. 2007; Ljungblad et al. 1988; Miller et al. 1999; Miller et al. 2005; Richardson et al. 1995b; Richardson et al. 1995a; Richardson et al. 1999; Richardson et al. 1986a; Richardson et al. 1986b). Nations et al. (2009) also found that bowhead whales were displaced during migration in the Beaufort Sea during active seismic surveys. In fact, as mentioned previously, the available data indicate that most, if

not all, baleen whale species exhibit avoidance of active seismic airguns (Barkaszi et al. 2012; Castellote et al. 2012a; Castellote et al. 2012b; Gordon et al. 2003; NAS 2017; Potter et al. 2007; Southall et al. 2007a; Southall et al. 2007b; Stone et al. 2017; Stone and Tasker 2006). 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 though they tolerate repeat exposures, they may still experience a stress response. However, we expect the presence of the protected species observers and the shut-down that will occur if a marine mammal were present in the exclusion zone will lower the likelihood that marine mammals will be exposed to sounds 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 dB re: 1  $\mu$ Pa (rms) (Bain and Williams 2006; Gailey et al. 2007; Johnson et al. 2007a; Malme and Miles 1985; Malme et al. 1984a; Malme et al. 1987; Malme et al. 1986; Meier et al. 2007; Würsig et al. 1999; Yazvenko et al. 2007). Migrating gray whales began to show changes in swimming patterns at approximately 160 dB re: 1  $\mu$ Pa (rms) and slight behavioral changes at 140 to 160 re: 1  $\mu$ Pa (rms) (Malme and Miles 1985; Malme et al. 1984a; Malme et al. 1984b). 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. (2007b) 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 mitigation measures that will be implemented for this proposed action, we expect some of the ESA-listed marine mammal 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 dB re: 1  $\mu$ Pa (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. 2000a; McCauley et al. 1998). A startle response occurred as low as 112 dB re: 1  $\mu$ Pa (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 dB re: 1  $\mu$ Pa (rms). Changes in course and speed generally occurred at estimated received levels of 157 to 164 dB re: 1  $\mu$ Pa (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 dB re: 1  $\mu$ Pa<sup>2</sup>-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 detectable 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 dB re: 1  $\mu$ Pa (rms) and no clear evidence of avoidance was apparent at received levels up to 172 dB re: 1  $\mu$ Pa (rms) (Malme et al. 1984a; 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 et al. 2017; Stone and Tasker 2006). 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 2005b). When spotted at the average sighting distance, individuals will have likely been exposed to approximately 169 dB re: 1  $\mu$ Pa (rms) (Moulton and Miller 2005a).

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; Madsen et al. 2006; Miller et al. 2009; Moulton and Miller 2005b; Stone 2003; Stone et al. 2017; Stone and Tasker 2006; Weir 2008). Detailed study of sperm whales in the Gulf of Mexico suggests some alteration in foraging from less than 130 to 162 dB re: 1  $\mu$ Pa peak-to-peak, although other behavioral reactions were not noted by several authors (Gordon et al. 2006; Gordon et al. 2004; 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 (Jochens and Biggs 2004; Jochens 2003; Mate et al. 1994).

Johnson and Miller (2002) noted possible avoidance at received sound levels of 137 dB re: 1  $\mu$ Pa. Other anthropogenic sounds, such as pingers and sonars, disrupt behavior and vocal patterns (Goold 1999a; Watkins et al. 1985a; Watkins and Schevill 1975a). 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. Breitzke et al. (2008) found that source levels were approximately 30 dB re: 1  $\mu$ Pa lower at 1 kiloHertz and 60 dB re: 1  $\mu$ Pa lower at 80 kiloHertz compared to dominant frequencies during a seismic source calibration. Another odontocete, bottlenose dolphins, progressively reduced their vocalizations as an airgun array came closer and got louder (Woude 2013). Reactions of sperm whales to impulse noise likely vary depending on the activity at the 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 marine mammals 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 also 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.

### ***Marine Mammals 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 effects. Other possible responses to impulsive sound sources like airgun arrays include neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage (Cox et al. 2006; Southall et al. 2007b; Tal et al. 2015; Zimmer and Tyack 2007), but similar to stress, these effects are not readily observable. Importantly, these more severe physical and physiological responses have been associated with explosives and/or mid-frequency tactical sonar, but not seismic airguns. We do not expect ESA-listed marine mammals to experience any of these more severe physical and physiological responses as a result of the proposed seismic survey activities.

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 (Busch and Hayward 2009; Gregory and Schmid 2001; Gulland et al. 1999; St. Aubin and Geraci 1988; St. Aubin et al. 1996; Thomson and Geraci 1986). These hormones subsequently can cause short-term weight loss, the liberation of glucose into the bloodstream, impairment of the immune and nervous systems, elevated heart rate, body temperature, blood pressure, and alertness, and other responses (Busch and Hayward 2009; Cattet et al. 2003b; Cattet et al. 2003a; Costantini et al. 2011; Dickens et al. 2010; Dierauf and Gulland 2001; Elftman et al. 2007; Fonfara et al. 2007; Kaufman and Kaufman 1994; Mancina et al. 2008; Noda et al. 2007; Thomson and Geraci 1986). 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; Cowan 2008; Herraiez et al. 2007). 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 (Gardiner and Hall 1997; Hunt et al. 2006; Keay et al. 2006; Romero et al. 2008; St. Aubin et al. 1996). 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 generally increase stress indicators in mammals (Kight and Swaddle 2011). Romano et al. (2004) found beluga whales and bottlenose dolphins exposed to a seismic watergun (up to 228 dB re: 1  $\mu$ Pa m peak-to-peak and single pure tones (up to 201 dB re: 1  $\mu$ Pa) 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. 2012a; Rolland et al. 2012b). 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 (NMFS 2006a; NRC 2003b). 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 dB re: 1  $\mu$ Pa (rms) threshold, will experience a stress response, which may also be associated with an overt behavioral response. However, since in all cases 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. 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 dB 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. It is noteworthy that although various exposures to loud sound appear to have adverse results, exposure to music largely appears to result in beneficial effects in diverse taxa. Clearly, the impacts of even loud sounds are complex and not universally negative (Kight and Swaddle 2011). Given the available data, and the short duration of exposure to sounds generated by airgun arrays, we do not anticipate any effects to the reproductive and metabolic physiology of ESA-listed marine mammals.

It is possible that an animal's prior exposure to sounds from seismic surveys influences its future response. 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 1997; André 1997; Gordon et al. 2006). We do not believe sensitization will occur based upon the lack of severe responses previously observed in marine mammals exposed to sounds from seismic surveys that will be expected to produce a more intense, frequent, and/or earlier response to subsequent exposures (see *Response Analysis*). With this said, seismic survey activities can lead to a potential for cetaceans to habituate to sounds from airgun arrays which may lead to additional energetic costs or reductions in foraging success (Nowacek et al. 2015). Nevertheless, the proposed action will take place over a little more than approximately 60 days (approximately eight days of airgun array operations, approximately two days of icebreaking, and approximately 16 days of transit); minimizing the likelihood that sensitization 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.

### ***Marine Mammals and Strandings***

There is some concern regarding the coincidence of marine mammal 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. 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 (Creel 2005; Fair and Becker 2000; Kerby et al. 2004; Moberg 2000; Romano et al. 2004). At present, the factors of airgun arrays from seismic surveys that may contribute to marine mammal strandings are unknown and we have no evidence to lead us to believe that aspects of the airgun array proposed for use will cause marine mammal strandings.

We do not expect ESA-listed marine mammals to strand as a result of the proposed low-energy seismic survey. The low-energy seismic survey will take place in the Amundsen Sea off Antarctica, and the closest approach to the coastline of Antarctica will be approximately 6 kilometers (3.2 miles) from land (the northern edge of the Thwaites Eastern Ice Shelf, which is a floating extension of Thwaites Glacier). The nearest ice-free land is on Clark Island, which is 25 kilometers (13.5 nautical miles) from the edge of the survey area. If exposed to seismic survey activities, we expect ESA-listed marine mammals will have sufficient space in the open ocean to move away from the sound source and will not be likely to strand.

### ***Marine Mammal Prey***

Seismic surveys may also have indirect, adverse effects on ESA-listed marine mammals by affecting their prey (including larval stages) through lethal or sub-lethal damage, stress responses, or alterations in their behavior or distribution. Such prey include fishes (blue, fin, sei, and sperm whales), zooplankton (blue, fin, and sei whales), cephalopods (sperm whales), and

other invertebrates such as crustaceans, molluscs, and jellyfish (blue whales). In a recent, fairly exhaustive review, Carroll et al. (2017) summarized the available information on the impact seismic surveys have on fishes and invertebrates. In many cases, species-specific information on the prey of ESA-listed marine mammals is not available. Until more specific information becomes available, we expect that the prey of ESA-listed marine mammals will respond to sound associated with the proposed action in a similar manner to those fishes and invertebrates described below [information derived from Carroll et al. (2017) unless otherwise noted].

Like with marine mammals, it is possible that seismic surveys can cause physical and physiological responses, including direct mortality, in fishes and invertebrates. In fishes, such responses appear to be highly variable, and depend on the nature of the exposure to seismic survey activities, as well as the species in question. Current data indicate that possible physical and physiological responses include hearing threshold shifts, barotraumatic ruptures, stress responses, organ damage, and/or mortality. For invertebrates, research is more limited, but the available data suggest that exposure to seismic survey activities can result in anatomical damage and mortality in some cases. In crustaceans and bivalves, there are mixed results with some studies suggesting that seismic surveys do not result in meaningful physiological and/or physical effects, while others indicate such effects may be possible under certain circumstances. Furthermore, even within studies there are sometimes differing results depending on what aspect of physiology one examines (e.g., Fitzgibbon et al. 2017). In some cases, the discrepancies likely relate to differences in the contexts of the studies. For example, in a relatively uncontrolled field study Parry et al. (2002) did not find significant differences in mortality between oysters that were exposed to a full seismic airgun array and those that were not, but a recent study by Day et al. (2017) in a more controlled setting did find significant differences in mortality between scallops exposed to a single airgun and a control group that received no exposure. However, the increased mortality documented by Day et al. (2017) was not significantly different from the expected natural mortality. All available data on echinoderms suggests they exhibit no physical or physiological response to exposure to seismic survey activities. Based on the available data, as reviewed by, we assume that some fishes and invertebrates may experience physical and physiological effects, including mortality, but in most cases, such effects are only expected at relatively close distances to the sound source. However, recent evidence indicates that airgun arrays may lead to significant mortality of zooplankton out to approximately 1.2 kilometers (0.6 nautical miles) (McCauley et al. 2017).

The prey of ESA-listed marine mammals may also exhibit behavioral responses if exposed to active seismic airgun arrays. Based on the available data, as reviewed by Carroll et al. (2017), considerable variation exists in how fishes behaviorally respond to seismic survey activities, with some studies indicating no response and other noting startle or alarm responses and/or avoidance behavior. However, no effects to foraging or reproduction have been documented. Similarly, data on the behavioral response of invertebrates suggests that some species may exhibit a startle response, but most studies do not suggest strong behavioral responses. For example, a recent study by Charifi et al. (2017) found that oyster appear to close their valves in response to low

frequency sinusoidal sounds. In addition, Day et al. (2017) recently found that when exposed to seismic airgun array sounds, scallops exhibit behavioral responses such as flinching, but none of the observed behavioral responses were considered to be energetically costly. As with marine mammals, behavioral responses by fishes and invertebrates may also be associated with a stress response.

Based on the available data, we anticipate seismic survey activities will result in temporary and minor reduction in the availability of prey for ESA-listed species near the airgun array immediately following the use of active seismic sound sources. This may be due to changes in prey distributions (i.e., due to avoidance) or abundance (i.e., due to mortality) or both. However, we do not expect this to have a meaningful immediate impact on ESA-listed marine mammals since as described above, we believe that in most cases, ESA-listed marine mammals will avoid closely approaching the airgun array when active, and as such will not be in areas where prey have been effected. However, even though we do not anticipate significant immediate adverse effects, this is not to say that long-term aggregate effects to populations of ESA-listed species prey are not possible if one considers the effect of the proposed seismic survey activities in space and time. We further consider these long term, aggregate effects in our *Risk Analysis*.

### ***Responses of Marine Mammal Prey***

Seismic surveys may also have indirect, adverse effects on prey availability through lethal or sub-lethal damage, stress responses, or alterations in their behavior or distribution. Studies described herein provide extensive support for this, which is the basis for later discussion on implications for ESA-listed marine mammals. Unfortunately, species-specific information on the prey of ESA-listed marine mammals is not generally available. Until more specific information is available, we expect that teleost, cephalopod, and krill prey of ESA-listed marine mammals considered in this opinion will react in manners similar to those fish 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 survey 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 shots 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 shots from seismic airguns had no effect on the escape response of *C. finmarchicus*. They conclude that the effects of shots from seismic airguns are much less than reported by McCauley et al. (2017). The reduced energy of the proposed seismic airgun arrays (210 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) will 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 affect copepod prey within the action area less than that reported in McCauley et al. (2017). While the proposed low-energy seismic survey may temporarily alter copepod or crustacean abundance in the proposed action, we expect such effects to be insignificant because most copepods will be near the surface where the sound from airgun arrays is expected to be relatively low and the high turnover rate of zooplankton and ocean circulation will minimize any effects.

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 (Bjarti 2002; D'Amelio 1999; Falk and Lawrence 1973; Hassel et al. 2003; Holliday et al. 1987; Kostyuchenko 1973; La Bella et al. 1996; McCauley et al. 2000a; McCauley et al. 2000b; McCauley et al. 2003; Popper et al. 2005; Santulli et al. 1999). Lethal effects, if any, are expected within a few meters of the airgun array (Buchanan et al. 2004; Dalen and Knutsen 1986). 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 (Davidsen et al. 2019; Fewtrell 2013a). 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). We expect that if fish 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 and available as prey for marine mammals.

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 dB re: 1  $\mu$ Pa) 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 dB re: 1  $\mu$ Pa<sup>2</sup>-second, but pike did show 10 to 15 dB of hearing loss with recovery within one day (Popper et al. 2005). Caged pink snapper (*Pelates spp.*) have experienced PTS when exposed over 600 times to received sound levels of 165 to 209 dB re: 1  $\mu$ Pa peak-to-peak. 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 dB re: 1  $\mu$ Pa (Falk and Lawrence 1973).

By far the most common response by fishes 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. Although received sound levels were not reported, caged *Pelates spp.*, pink snapper, and trevally (*Caranx ignobilis*) generally exhibited startle, displacement, and/or grouping responses upon exposure to airguns (Fewtrell 2013a). This effect generally persisted for several minutes, although subsequent exposures to the same individuals did not necessarily elicit a response (Fewtrell 2013a).

Startle responses were observed in rockfish at received airgun levels of 200 dB re: 1  $\mu$ Pa 0-to-peak and alarm responses at greater than 177 dB re: 1  $\mu$ Pa 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 dB re: 1  $\mu$ Pa 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 kilometers (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 dB re: 1  $\mu$ Pa 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 dB re: 1  $\mu$ Pa) 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; 2000a) 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 dB re: 1  $\mu$ Pa (rms), but responses tended to decrease over time suggesting habituation. As with previous studies, 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 dB re: 1  $\mu$ Pa 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 dB re: 1  $\mu$ Pa 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 dB re: 1  $\mu$ Pa 0-to-peak (Dalen and Knutsen 1986; Engås et al. 1996; Engås et al. 1993; Løkkeborg 1991; Løkkeborg and Soldal 1993; Turnpenny et al. 1994).

Increased swimming activity in response to airgun exposure on fish, as well as reduced foraging activity, is supported by data collected by Løkkeborg et al. (2012). Bass did not appear to vacate during a shallow-water seismic survey with received sound levels of 163 to 191 dB re: 1  $\mu$ Pa 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.

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 dB re: 1  $\mu$ Pa (rms) by first ejecting ink and then moving rapidly away from the area (Fewtrell 2013b; McCauley et al. 2000a; McCauley et al. 2000b). 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 dB re: 1  $\mu$ Pa (rms). Tenera Environmental (2011) reported that Norris and Mohl (1983, summarized in Mariyasu et al. 2004) observed lethal effects in squid (*Loligo vulgaris*) at levels of 246 to 252 dB 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  $157 \pm 5$  dB re: 1  $\mu$ Pa. 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  $157 \pm 5$  dB re: 1  $\mu$ Pa, with peak levels at 175 dB re: 1  $\mu$ Pa. 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 study observed abnormalities in larval scallops after exposure to low frequency noise in tanks (de Soto et al. 2013).

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 dB peak-to-peak pressure (Christian 2013; Payne et al. 2013). However, feeding did increase in exposed individuals (Christian 2013; 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 dB re: 1  $\mu$ Pa (rms) isopleths could vacate the area and/or dive to greater depths.

The overall response of fishes and squids is to exhibit startle responses 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, we do not expect krill to experience effects from sounds of airguns. Although humpback whales consume fish regularly, we expect that any disruption to their prey will be temporary, if at all. 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 dB re: 1  $\mu$ Pa (rms) isopleths could vacate the area and/or dive to greater depths. We do not expect indirect effects from airgun array operations through reduced feeding opportunities for ESA-listed marine mammals to be sufficient to reach a significant level. Effects are likely to be temporary and, if displaced, both marine mammals and their prey will re-distribute back into the action area once seismic survey activities have passed or concluded.

### ***Marine Mammal Response to Icebreaking***

Few studies have been conducted to evaluate the potential interference of icebreaking noise with marine mammal vocalizations. Erbe and Farmer (1998) measured masked hearing thresholds of a captive beluga whale. They reported that the recording of a Canadian Coast Guard Ship (CCGS)

*Henry Larsen*, ramming ice in the Beaufort Sea, masked recordings of beluga vocalizations at a noise to signal pressure ratio of 18 dB, when the sound pressure level was eight times as high as the call pressure. Erbe and Farmer (2000) also predicted when icebreaker noise will affect beluga whales through software that combined a sound propagation model and beluga whale impact threshold models. They again used the data from the recording of the CCGS *Henry Larsen* in the Beaufort Sea and predicted that masking of beluga whale vocalizations can extend between 40 and 71 kilometers (21.6 to 38.3 nautical miles) near the water's surface. Lesage et al. (1999) report that beluga whales changed their call type and call frequency when exposed to vessel noise. It is possible that the beluga whales adapt to the ambient noise levels and are able to communicate despite the sound. Given the documented reaction of beluga whales to vessels and icebreakers it is highly unlikely that beluga whales will remain in the proximity of vessels where vocalizations will be masked.

Beluga whales (an ESA-listed species [Cook Inlet distinct population segment]) have been documented swimming rapidly away from vessels and icebreakers in the Canadian high Arctic when a vessel approaches to within 35 to 50 kilometers (18.9 to 27 nautical miles), and they may travel up to 80 kilometers (43.2 nautical miles) from the vessel's track (Richardson et al. 1995a). It is expected that beluga whales avoid icebreakers as soon as they detect the vessels (Cosens and Dueck 1993). However, the reactions of beluga whales to vessels vary greatly and some animals may become habituated to high levels of ambient noise (Erbe and Darmber 2000).

There is little information about the effects of icebreakers on baleen whales. Migrating bowhead whales (an ESA-listed species) appeared to avoid an area around a drill site by greater than 25 kilometers (13.5 nautical miles) where an icebreaker was working in the Beaufort Sea. There was intensive icebreaking daily in support of the drilling activities (Brewer and Hall 1993). Migrating bowhead whales also avoided a nearby drill site at the same time of year where little icebreaking was being conducted (LGL and Greeneridge 1987). It is unclear as to whether the drilling activities, icebreaking, or the ice itself might have been the cause for the animal's diversion. Bowhead whales are not expected to occur in the proposed action area.

Blue, fin, sei, and sperm whales in the area of icebreaking are expected to demonstrate varying levels of response to the noise generated by icebreaking. These include changes in behavior from mild responses such as tail slapping to stronger responses with higher energetic costs such as abandoning feeding and swimming away rapidly. There could also be TTS and PTS affecting the hearing of these animals, although modeling results and exposure analysis for this consultation concluded that only behavioral changes are likely as a result of noise from icebreaking. Depending on the severity of the threshold shift and whether it is a temporary or permanent, an animal's ability to find prey and flee from predators may be affected, resulting in adverse effects to the animal with fitness consequences. Noise from icebreaking is also likely to affect prey species, potentially leading to changes in abundance and distribution of prey and foraging resources for animals; however, these are not expected to cause significant or long-term consequences for individual marine mammals or their populations.

## 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 one blue whale, 27 fin whales, three sei whales, and 63 sperm whales (see Table 17), to be exposed to the airgun array within 160 dB re: 1  $\mu$ Pa (rms) ensonified areas during the seismic survey activities. We expect up to one blue whale, 54 fin whales, three sei whales, and 128 sperm whales (see

Table 20), to be exposed to within 120 dB re: 1  $\mu$ Pa (rms) ensonified areas during the icebreaking.

When we do not expect individual ESA-listed animals (marine mammals) 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 animals 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) and icebreaking, as described above, we do not expect any mortality to occur 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 marine mammals. Harassment is not expected to have more than short-term effects on individual ESA-listed marine mammal species (blue, fin, sei, and sperm whales). While exempted, harm under the ESA is not expected to occur with high probability given the mitigation measures (e.g., shut-down procedures) in place for the proposed seismic survey activities to protect ESA-listed species. As such we do not expect ESA-listed marine mammals 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. No designated critical habitat for these species will be adversely affected by the seismic survey activities and icebreaking associated with the proposed action.

## 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 an ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the *Species Not Likely to be Adversely Affected* (Section 6), *Species Likely to be Adversely Affected* (Section 6.2.5), 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 threatened and endangered species 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 Southern Ocean (Amundsen Sea off Antarctica) is expected because of the National Science Foundation's seismic survey activities and icebreaking 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<sup>th</sup> to mid-20<sup>th</sup> 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 vessel strikes, entanglement in fishing gear, pollution, harassment due to whale watching, and reduced prey abundance and habitat degradation due to climate change.

There are three stocks of blue whales designated under the MMPA in U.S. waters: the Eastern North Pacific Ocean (approximately 1,647 individuals [minimum number of individuals  $N_{\min}=1,551$ ]), the Central Pacific Ocean (approximately 133 individuals [ $N_{\min}=63$ ]), and Western North Atlantic Ocean (approximately 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 interval 1,160 to 4,500) (Branch 2007a). While no range-wide 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 based on photographic mark-recapture (Jenner 2008).

Current estimates indicate the Eastern North Pacific stock shows no signs of population growth since the early 1990s, perhaps because the population is nearly at carrying capacity (Carretta et al. 2018). 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 2007a). 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.

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 two individuals harassed (one from the airgun array and one from icebreaking) as a result of the proposed seismic survey activities and icebreaking. Because we do not anticipate a reduction in numbers or reproduction of blue whales as a result of the proposed seismic survey activities and icebreaking 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 icebreaking 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 Southern Ocean (Amundsen Sea off Antarctica) is expected because of the National Science Foundation's seismic survey activities and icebreaking and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

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 commercial whaling program, and Iceland's formal objection to the International Whaling Commission's ban on commercial whaling. Additional threats include vessel strikes, reduced prey availability due to overfishing or climate change, and sound. The species' overall large population size may provide some resilience to current threats, but trends are largely unknown.

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 through 1975. Of the three to seven stocks in the North Atlantic Ocean (approximately 50,000 individuals), one designated under the MMPA that occurs in U.S. 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 2012a). There are three stocks designated under the MMPA in U.S. Pacific Ocean waters: Northeast Pacific [approximately 3,168 [ $N_{\min}=2,554$ ], Hawaii (approximately 154 [ $N_{\min}=75$ ]) and California/Oregon/Washington (approximately 9,029 [ $N_{\min}=8,127$ ]) (Nadeem et al. 2016b). 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. 2013a).



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 U.S. 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. 2016b). 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.

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 81 individuals harassed (27 from the airgun array and 54 from icebreaking) as a result of the proposed seismic survey activities and icebreaking. Because we do not anticipate a reduction in numbers or reproduction of fin whales as a result of the proposed seismic survey activities and icebreaking 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 icebreaking 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 Southern Ocean (Amundsen Sea off Antarctica) is expected because of the National Science Foundation's seismic survey activities and icebreaking and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

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 vessel 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 are relatively low abundance estimates.

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 2016a; 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 designated under the MMPA occur in U.S. waters: Nova Scotia (approximately 357 [ $N_{\min}=236$ ]), Hawaii (approximately 178 [ $N_{\min}=93$ ]), and Eastern North Pacific (approximately 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.

No reduction in numbers is anticipated as part of the proposed actions. There are expected to be six individuals harassed (three from the airgun array and three from icebreaking) as a result of the proposed seismic survey activities and icebreaking. 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 icebreaking 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 icebreaking 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 in the wild.

#### **11.4 Sperm Whale**

No reduction in the distribution of sperm whales from the Southern Ocean (Amundsen Sea off Antarctica) is expected because of the National Science Foundation's seismic survey activities and icebreaking and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

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. Continued threats to sperm whale populations include vessel strikes, entanglement in fishing gear, competition for resources due to overfishing, loss of prey and habitat due to climate change, and sound. The species' large population size shows that it is somewhat resilient to current threats.

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 2009b). The higher estimates may be approaching population sizes prior to commercial whaling, the reason for ESA listing. There are no reliable estimates for sperm whale abundance across the entire Atlantic Ocean. However, estimates are available for two of three U.S. stocks designated under the MMPA in the Atlantic Ocean, the Northern Gulf of Mexico stock, estimated to consist 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 designated under the MMPA 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 4,559 individuals ( $N_{\min}=3,478$ ). 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.

No reduction in numbers is anticipated as part of the proposed actions. There are expected to be 191 individuals harassed (63 from the airgun array and 128 from icebreaking) as a result of the proposed seismic survey activities and icebreaking. 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 icebreaking 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 icebreaking 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 aspects 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 interactions (vessel strikes and whale watching), fisheries (fisheries interactions), pollution (marine debris, pesticides and contaminants, and hydrocarbons), 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 marine mammals.

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, tribal, 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. Potential non-Federal or private actions reasonably certain to occur within the action area include Antarctic research conducted by other national programs (e.g., British Antarctic Survey), fisheries activities, and vessel-based tourism.

## 13 CONCLUSION

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

## 14 INCIDENTAL TAKE STATEMENT

Section 9 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 has 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 seismic survey activities are likely to harass ESA-listed cetaceans.

ESA section 7(b)(4) states that take of ESA-listed cetaceans 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 tentative period of January 22, 2020, through January 21, 2021 (valid for a period of one year from the date of issuance), under the MMPA, the incidental take of ESA-listed marine mammals 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 of 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 marine mammals 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 the airgun array source levels occur, reinitiation of consultation will be necessary.

We and NMFS Permits and Conservation Division anticipates the proposed low-energy seismic survey in the Amundsen Sea off Antarctica is likely to result in the incidental take of ESA-listed marine mammals by harassment (Table 21). Behavioral harassment (MMPA Level B harassment) is expected to occur at received levels at or above 160 dB re: 1  $\mu$ Pa (rms) for ESA-

listed marine mammals. For all species of ESA-listed marine mammals, this incidental take will result from exposure to acoustic energy during airgun array operations and will be in the form of harassment (MMPA Level B harassment), and is not expected to result in the death or injury of any individuals that will be exposed. It is believed that no harm or PTS (MMPA Level A harassment) will be incurred in these marine mammals as a result of the proposed low-energy seismic survey activities, because of the constant movement of both the RVIB *Nathaniel B. Palmer* and of the marine mammals in the action area, the fact that the research vessel is not expected to remain in any one area in which individual marine mammals will be expected to concentrate for an extended period of time (i.e., since the duration of exposure to loud sounds will be relatively short), and the implementation of monitoring and mitigation measures. Also, as described above, we expect that marine mammals will be likely to move away from a sound source that represents an aversive stimulus, especially at levels that will be expected to result in PTS, given sufficient notice of the RVIB *Nathaniel B. Palmer*'s approach due to the research vessel's relatively low speed when conducting seismic surveys.

**Table 21. Estimated amount of incidental take of Endangered Species Act-listed marine mammals authorized in the Amundsen Sea off Antarctica by the incidental take statement.**

Species	Authorized Incidental Take by Harassment (Potential Temporary Threshold Shift and Behavioral) by Seismic Survey Activities	Authorized Incidental Take by Harassment (Potential Temporary Threshold Shift and Behavioral) by Icebreaking	Total Authorized Incidental Take by Harassment (Adjusted for Group Size)
Blue Whale	1	1	2
Fin Whale	27	54	81
Sei Whale	3	3	6
Sperm Whale	63	128	191

## 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 result in jeopardy to the species or destruction or adverse modification of critical habitat.

## 14.3 Reasonable and Prudent Measures

The measures described below are nondiscretionary, and must be undertaken by the 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 species, NMFS will issue a statement that specifies the impact of any incidental taking of threatened or endangered species. To minimize such impacts, reasonable and prudent measures, and term 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 and icebreaking 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, 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 icebreaking and threatened and endangered species of marine mammals.

#### 14.4 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA and regulations issued pursuant to section 4(d), 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 e-mail at [cathy.tortorici@noaa.gov](mailto: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 cetaceans as well as reduce harassment related to the authorized seismic survey activities and icebreaking.

1. We recommend that the National Science Foundation promote and fund research examining the potential effects of seismic surveys and/or icebreaking on ESA-listed sea turtle, fish, and invertebrate species.
2. 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.
3. We recommend that the National Science Foundation model potential impacts to ESA-listed species, validate assumptions, through refinements of current models and use of other relevant models, validate assumptions used in effects analyses, and seek information and higher quality data for use in such efforts.
4. We recommend that the National Science Foundation conduct a sound source verification in the study area (and future locations) to validate predicted and modeled isopleth distances to ESA harm and harassment thresholds and incorporate the results of that study into buffer and exclusion zones prior to starting seismic survey activities and/or icebreaking.
5. 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 MMPA incidental take authorizations for seismic surveys.
6. We recommend the National Science Foundation use (and NMFS Permits and Conservation Division require in MMPA incidental take authorizations) thermal imaging cameras, in addition to binoculars (Big-Eye and handheld) and the naked eye, for use during daytime and nighttime visual observations and test their effectiveness at detecting ESA-listed species.



7. We recommend the National Science Foundation use the Marine Mammal Commission's recommended method for estimating the number of cetaceans in the vicinity of seismic surveys based on the number of groups detected for post-seismic survey activities take analysis and use in monitoring reports.
8. We recommend the National Science Foundation 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.
9. We recommend the National Science Foundation utilize real-time cetacean sighting services such as the WhaleAlert application (<http://www.whalealert.org/>). We recognize that the research vessel may not have reliable internet access during operations far offshore, but nearshore, where many of the cetaceans considered in this opinion are likely found in greater numbers, we anticipate internet access may be better. Monitoring such systems will help plan seismic survey activities and transits to avoid locations with recent ESA-listed cetacean sightings, and may also be valuable during other activities to alert others of ESA-listed cetaceans within the area, which they can then avoid.
10. We recommend the National Science Foundation submit their monitoring data (i.e., visual sightings) by Protected Species Observers to the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations online database so that it can be added to the aggregate marine mammal, seabird, sea turtle, and fish observation data from around the world.
11. We recommend the vessel operator and other relevant vessel personnel (e.g., crew members) on the RVIB *Nathaniel B. Palmer* 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' Office of Protected Resources, ESA 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 National Science Foundation and NMFS Permits and Conservation Division should notify the ESA Interagency Cooperation Division of any conservation recommendations they implement in their final action.

## 16 REINITIATION NOTICE

This concludes formal consultation for the National Science Foundation's proposed low-energy marine seismic survey by the RVIB *Nathaniel B. Palmer* in the Amundsen Sea off Antarctica

and NMFS Permits and Conservation Division's issuance of an incidental harassment authorization for the proposed low-energy marine seismic survey pursuant to section 101(a)(5)(D) of the MMPA. As 50 C.F.R. §402.16 states, reinitiation of formal consultation is required and shall be requested by the Federal agency or by NMFS, where discretionary Federal involvement or control over the action has been retained or is authorized by law and:

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 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 listed species or 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.

If the amount of tracklines, location of tracklines, acoustic characteristics of the airgun arrays, or any other aspect of the proposed action changes in such a way that the incidental take of ESA-listed species can be greater than estimated in the incidental take statement of this opinion, then (3.) above may be met and reinitiation of consultation may be necessary.

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## 18 APPENDICES

### 18.1 Appendix A – Proposed Incidental Harassment Authorization

The text below was taken directly from the proposed incidental harassment authorization provided to us in the consultation initiation package from the NMFS Permits and Conservation Division, in the notice of proposed incidental harassment authorization and request for comments published in the *Federal Register* on December 19, 2019 (84 FR 69950), as well as from revisions after the public comment period. The final incidental harassment authorization may have minor changes that will not affect this opinion.

#### INCIDENTAL HARASSMENT AUTHORIZATION

The National Science Foundation (NSF) Office of Polar Programs, on behalf of the University of Houston, 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 low-energy marine geophysical survey and icebreaking activity in the Amundsen Sea, 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 and icebreaking activities associated with the THwaites Offshore Research (THOR) Project in the Amundsen Sea, Antarctica.
3. General Conditions
  - (a) A copy of this IHA must be in the possession of the NSF, the vessel operator and other relevant personnel, the lead protected species observer (PSO), and any other relevant designees of NSF 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 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.
  - (e) The NSF 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 Measures

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

- (a) NSF must employ 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), 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 (EZ) and buffer zone – PSOs shall establish and monitor applicable exclusion and buffer zones. These zones shall be based upon the radial distance from the edges 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 (i.e., anytime the acoustic source is active, including ramp-up), occurrence of marine mammals within the relevant buffer zone (but outside the exclusion zone) should be communicated to the operator to prepare for the potential shutdown of the acoustic source (when required).
  - (i) Two exclusion zones are defined, depending on the species and context. A standard exclusion zone encompassing the area at and below the sea surface out to a radius of 100 meters from the edges of the airgun array (0-100 m) is defined. For special circumstances, the exclusion zone encompasses an extended distance of 500 meters (0-500 m). These circumstances include observation of the following:
    - (A) All beaked whales 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).
  - (ii) During pre-clearance monitoring (i.e., before ramp-up begins), the buffer zone acts as an extension of the exclusion zone in that observations of marine mammals within the buffer zone would also preclude airgun operations from beginning (i.e., ramp-up). For all marine mammals (except where superseded by the extended 500-m exclusion zone), the buffer zone encompasses the area at and below the sea surface from the edge of the 0-100 meter exclusion zone out to a radius of 200 meters from the edges of the airgun array (100-200 m). The buffer zone is not applicable when the exclusion zone is greater than 100 meters, i.e., the observational focal zone is not increased beyond 500 meters.
- (e) Pre-Clearance and Ramp-up – A ramp-up procedure, involving a step-wise increase in the number of airguns firing and total active array volume until all operational airguns are activated and the full volume is achieved, is required at all times as part of the activation of the acoustic source. A 30-minute pre-clearance observation period must occur prior to the start of ramp-up. NSF must adhere to the following pre-clearance and ramp-up requirements:
  - (i) The operator must notify a designated PSO of the planned start of ramp-up as agreed upon with the lead PSO; the notification time should not be less than 60 minutes prior to the planned ramp-up.
  - (ii) Ramp-ups must be scheduled so as to minimize the time spent with source activated prior to reaching the designated run-in.
  - (iii) A designated PSO must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the

- PSO to proceed.
- (iv) During pre-clearance and ramp-up, two PSOs must monitor the relevant EZs and buffer zone. Ramp-up must not be initiated if any marine mammal is within the applicable exclusion zone or the buffer zone. If a marine mammal is observed within the exclusion zone or the buffer zone during the 30-minute pre-clearance period, ramp-up must not begin until the animal(s) has been observed exiting the zones or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes and pinnipeds and 30 minutes for all other species).
  - (v) Ramp-up must begin by activating a single airgun of the smallest volume in the array and shall continue by activating additional airguns at five-minute intervals until the full array is active.
  - (vi) Ramp-up must cease and the source shut down upon observation of marine mammals within the applicable exclusion zone. Once ramp-up has begun, observations of marine mammals within the buffer zone do not require shutdown.
  - (vii) If the acoustic source is shut down for brief periods (i.e., less than 30 minutes) for reasons other than implementation of prescribed mitigation (e.g., mechanical difficulty), 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 applicable exclusion zone. For any longer shutdown, pre-clearance observation and ramp-up are required. For any shutdown at night or in periods of poor visibility (e.g., BSS 4 or greater), ramp-up is required.
  - (viii) 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 relevant zones have been continually monitored by PSOs for 30 minutes prior to ramp-up with no marine mammal detections.
- (f) Shutdown requirements – When the airgun array is active (i.e., anytime one or more airguns is active, including during ramp-up) and a marine mammal appears within or enters the applicable exclusion zone, the acoustic source must be shut down.
- (i) Any PSO on duty has the authority to delay the start of survey operations or 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) Upon implementation of shutdown, the source may be reactivated after the marine mammal(s) has been observed exiting the applicable exclusion zone or following a 30-minute clearance period with no further detection of the marine mammal(s).
- (v) 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 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, to the maximum extent practicable, attempt to maintain a minimum separation distance of 50 m from all other marine mammals. 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.

## 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) NSF 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 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;
  - (viii) 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. 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, NSF must immediately cease the specified activities and immediately report the incident to the NMFS 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 NSF to determine what measures are necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. NSF must not resume their activities until notified by NMFS.
  - (iii) In the event that NSF 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), NSF 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(c)(i) of this IHA. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with NSF to determine whether additional mitigation measures or modifications to the activities are appropriate.

- (iv) In the event that NSF 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), NSF must report the incident to NMFS Office of Protected Resources (301-427-8401) within 24 hours of the discovery. NSF must photograph 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 (*e.g.*, reduction in pile size) 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,  
Director, Office of Protected Resources,  
National Marine Fisheries Service.

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Date

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

Species	Calculated Level B Take Seismic	Calculate d Level B Take Icebreaki ng	Authoriz ed Total Take <sup>a</sup>
<b><i>Low-frequency cetaceans</i></b>			
Blue whale	1	1	2
Fin whale	27	54	81
Humpback whale	1	1	40 <sup>c</sup>
Antarctic minke whale	2149	4318	6467
Common (dwarf) minke whale	2149	4318	6467
Sei whale	1	2	6 <sup>b</sup>
<b><i>Mid-frequency cetaceans</i></b>			
Arnoux's beaked whale	23	47	70
Killer whale	1067	2144	3211
Layard's beaked whale	2	5	7
Long-finned pilot whale	29	59	88
Southern bottlenose whale	25	51	76
Sperm whale	63	128	191
Gray's beaked whale	1	2	3
<b><i>Phocids</i></b>			
Crabeater seal	28	57	2000 <sup>d</sup>
Leopard seal	0	0	50 <sup>d</sup>
Ross seal	0	0	10 <sup>d</sup>

Southern Elephant Seal	8897	7748	16645
Weddell seal	0	1	100 <sup>d</sup>

**Table 2 — Level B - Predicted Distances to the Level B Threshold (160 re  $1\mu\text{Pa}_{\text{rms}}$  isopleths)**

Source and volume ( $\text{cm}^3$ )[ $\text{in}^3$ ]	Tow depth (m)	Water depth (m) <sup>1</sup>	Predicted 160 re $1\mu\text{Pa}_{\text{rms}}$ (m) isopleth <sup>2</sup>
2 x 45/105 $\text{in}^3$ (300 $\text{in}^3$ ) GI guns	3	100-1000	979
		>1000	653
1 x 45/105 $\text{in}^3$ (150 $\text{in}^3$ ) GI guns	3	100-1000	503
		>1000	335
2 x 105/105 $\text{in}^3$ (420 $\text{in}^3$ ) GI guns	3	100-1000	1044
		>1000	696
1 x 105/105 $\text{in}^3$ (210 $\text{in}^3$ ) GI guns	3	100-1000	531
		>1000	354

<sup>1</sup> No seismic operations would be conducted in shallow depths (0-100 m [0-328 ft]).

<sup>2</sup> RMS radii is based on LDEO modeling and empirical measurements. Radii for 100-1000 m (328-3280 ft) depth values = deep water values \* 1.5 correction factor.